Mobile phone text messaging data collection on care-seeking for childhood diarrhoea and pneumonia in rural China: a mixed methods study

Helena Maria Marcella Theodora van Velthoven

Global eHealth Unit
Department of Primary Care and Public Health
School of Public Health
Imperial College London

A thesis submitted for the degree of Doctor of Philosophy

2014

Abstract

Background. Health information systems are inadequate in many countries. For childhood diarrhoea and pneumonia specifically, the leading infectious causes of child mortality worldwide, current data collection methods are not providing sufficient information for surveillance. The collection of health data could be greatly assisted with the use of mobile devices (mHealth). Mobile phone text messaging is widely used, but its potential for health data collection has not yet been realised.

Aim. To explore the application of mHealth-based collection of information relevant to childhood diarrhoea and pneumonia in rural China.

Methods. A mixed methods approach was used: (i) a survey and semi-structured interviews to assess the usage of mobile phones by caregivers of young children; (ii) cognitive interviews, usability testing and a cluster randomised cross-over study to determine the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia; and (iii) researchers' observations and structured interviews with participants of the cross-over study to evaluate factors influencing participation in mHealth-based studies.

Results. Many of the 1854 survey participants (1620; 87.4%) used mobile phones. Of 1014 participants in the cross-over study, 662 (65.3%) responded to the first text message. Of 651 participants willing to participate, 356 (54.7%) completed the text messaging survey. Overall, text message data were moderately to substantially equivalent to face-to-face data. The text messaging survey was acceptable to parents, but grandparents were often unable to use text messages. Among many factors influencing participation were trust, perceived usefulness and ease of use.

Conclusions. Text messaging can be applied to collect data on care-seeking for childhood diarrhoea and pneumonia in rural China, but several questions remain, including how to improve accuracy and response rates. Further work needs to advance innovative mHealth-based data collection methods that can improve health surveillance, enhance implementation of appropriate interventions and ultimately save children's lives.

Table of contents

Please see next pages for a Detailed table of contents.

Detailed table of contents

Declaration of originality

The work contained in this thesis is my own, unless otherwise referenced. I led the conception and design of the studies, participated in the field work, conducted the analyses and wrote all the study texts. A team of the following researchers made a substantial contribution to the conception and design of the studies, analysis of the data and provided critical comments on written texts. Specifically, they made the following contributions:

- Supervisors:
  - Dr Josip Car (first supervisor, Imperial College London) provided guidance and support, and funding for the PhD;
  - Prof Igor Rudan (second supervisor, University of Edinburgh) provided guidance and support, and funded meetings in Edinburgh;

- Collaborating researchers at the Capital Institute of Pediatrics in China:
  - Assoc Prof Yanfeng Zhang provided guidance and support, and funding for the field work in China;
  - Wei Wang (statistician) provided statistical advice, conducted randomisation, conducted statistical analyses, organised field work for the survey and cross-over study, provided translations and conducted structured interviews;
  - Ye Li (Master's student) conducted, translated and analysed semi-structured, cognitive and local terms interviews, managed text messages during the cross-over study, analysed error rate outcome, and conducted, translated and analysed structured interviews;
  - Xiaozhen Du (Master's student) organised fieldwork for the survey and cross-over study and conducted and analysed structured interviews;
  - Qiong Wu (research assistant) reviewed the Chinese literature, gave advice on household surveys, assisted in sending text messages and conducted structured interviews;
  - Li Chen (research associate) gave advice on household surveys and provided translations.

Copyright declaration

The copyright of this thesis rests with the author and is made available under a *Creative Commons Attribution Non-Commercial No Derivatives licence*. Researchers are free to copy, distribute or transmit the thesis on the condition that they attribute it, that they do not use it for commercial purposes and that they do not alter, transform or build upon it. For any reuse or redistribution, researchers must make clear to others the licence terms of this work.

List of Abbreviations

CI= Confidence Interval

HIV/AIDS= Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome

IR= Prof Igor Rudan

JC= Dr Josip Car

LC= Li Chen

MDG= Millennium Development Goal

MH= Michelle Helena (PhD candidate)

MWU= Mann-Whitney U

n= number in subgroup

N= number in total group

ORS= Oral Rehydration Salts

Q= quartile

QQ= Chinese instant messaging programme

QW= Qiong Wu

SIM= Subscriber Identity Module

WW= Wei Wang

χ^2= Chi-square

XD= Xiaozhen Du

¥= Yuan, the written form of Chinese currency; ¥10 equals about £1 [1]

YL= Ye Li

YZ= Yanfeng Zhang

List of Definitions

Children= the focus of this thesis is on children aged up to five years old, because child health programmes focus on all children from birth to 59 months (under five years of age), including neonates (birth to 28 days), infants (birth to 11 months) and older children (12 to 59 months)

Hukou= Chinese household register; Chinese citizens either have a rural or urban *Hukou* (see section 3.2.4)

Classification of countries= classification of countries into low-, middle- and high-income from the World Bank is used: "*for the current 2014 fiscal year, low-income economies are defined as those with a Gross National Income per capita, calculated using the World Bank Atlas method, of US$1035 or less in 2012; middle-income economies are those with a Gross National Income per capita of more than US$1035 but less than US$12,616; high-income economies are those with a Gross National Income per capita of US$12,616 or more. Lower-middle-income and upper-middle-income economies are separated at a Gross National Income per capita of US$4085*" [2].

Mandarin= Chinese language used in this thesis (see section 3.2.5)

mHealth= mobile health; the term *mHealth* is used throughout this thesis, which stands for the usage of mobile information and communication technologies for health-related purposes. *mHealth* lacks an agreed definition, but several definitions can be found in the literature. In 2004, the first *mHealth* definition was provided by Istepanian *et al.* who defined *mHealth* as "*mobile computing, medical sensor, and communications technologies for health-care*" [3]. More recently in 2011, the World Health Organization Global Observatory defined *mHealth* as: "*medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices*" [4].

List of Tables

List of Figures

List of Photographs

Consent was given by people or caregivers of children who were photographed. The faces of study members in photographs are either not visible or are covered. Photographs 1 and 4 were not part of the studies and show people’s faces. The ownership of each photograph is indicated directly below it.

Acknowledgements

I am indebted to my supervisors, Dr Josip Car and Prof Igor Rudan, for their guidance and support over the course of my PhD. Dr Josip Car fully supported my wish to pursue doctoral research on a topic related to a low- or middle-income country, even when this was difficult to start. Prof Igor Rudan initiated the collaboration with researchers at the Capital Institute of Pediatrics in Beijing in China. My supervisors helped me overcome many PhD-related challenges, which made this PhD a very rich experience.

Much gratitude goes out to my collaborating Chinese colleagues: Yanfeng Zhang, Qiong Wu, Ye Li, Wei Wang, Li Chen and Xiaozhen Du. This thesis would simply not have been possible without their highly efficient and hard work. It was also a pleasure to meet Shuyi Zhang and Tao Li. Even though we were strangers to each other at first, they warmly welcomed me to China as family. It took me a while to get accustomed to China and their friendliness and endless efforts to help me greatly enhanced my visits. Moreover, they showed me China in a way that I could not have imagined. Therefore, in Mandarin, I would like to say: “我 对 你们 的 帮助 表示 由衷 的 感谢" (meaning “I am sincerely grateful for your help”).

The field work in China was funded by the Capital Institute of Pediatrics, which was gratefully received. I am very thankful to the study participants who devoted their efforts and time to the study. Many thanks to the following people for their hard work during the field work: the student interviewers; the survey supervisor Baoxue Li; and Dr Xinglei Sun and colleagues from Zhao County Maternal and Child Health Hospital, Zhao County Health Bureau and Zhaozhou Township Hospital.

This PhD was funded by the Global eHealth Unit and I am very grateful for the contribution this made to my education. I thank Santander for awarding me the “Santander Mobility Award” in 2012 to support one trip to China. I am thankful to all (previous) members of the Global eHealth Unit for their support over the past years, especially to Dr Helen Atherton, Dr Serena Brusamento, Dr Laura Gunn, Dr Kit Huckvale, Dr Cecily Morrison and Nikos Papachristou.

I would like to thank the Department of Primary Care and Public Health at Imperial College London and in particular Prof Azeem Majeed. Over the past years I have met and learned from many brilliant people. I am most grateful to Dr Loretta Platts for proofreading this thesis. Many thanks to Swarna Khare and Lizzie Cecil for help with statistical methods, and Tom Cowling, Farzan Ramzan and Dr Chris Smith for reviewing parts of this work.

I am very thankful to Dr Matthew Harris and Dr Helena Legido-Quigley for critically examining the early and late stage PhD reviews. Also I would like to express my gratitude to the China Health Information consortium and in particular Prof Harry Campbell, Prof Robert Black, Dr Li Liu and Dr Robert Scherpbier for providing very useful advice. Many thanks to Dr Eugene Chang for translations, and Yu Qiu and Dr Agnieszka Ignatowicz for help with the qualitative methods. I am grateful to colleagues, friends and family who read parts of this thesis and provided helpful suggestions. In addition, I acknowledge all co-authors on papers that were published during my PhD.

My initial plans for pursuing a PhD were inspired by Dr Suzanne Holewijn for which I am most grateful. Also I thank Prof Theo Thien and Dr Jaap Deinum for their continuing interest in my studies after my BSc and MSc education at Radboud University in Nijmegen, the Netherlands.

I am very thankful to my friends in the Netherlands for always being there for me. Also many thanks to the friends I made over the past years in London and during my travels for precious moments and help when I needed it most. Since initiating this PhD, I developed a passion for dancing and I am grateful to my dancing friends for many smiles.

This thesis is dedicated to my parents, Marcel and Miriam, my brother Melvin and my sister Merle.

Papers relevant to the content of this thesis

Published

1. **van Velthoven MH**, Li Y, Wang W, Du X, Wu Q, Chen L, Majeed A, Rudan I, Zhang Y, Car J. mHealth Series: mHealth project in Zhao County, rural China - Description of objectives, field site and methods. J Glob Health. 2013;3:020401. Medline:24363919. doi:10.7189/jogh.03.020401
    - Chapter 2, 3, 4, 6 and 8 contain adapted content of this article (Appendix A Copyright permission).

2. **van Velthoven MH**, Li Y, Wang W, Du X, Chen L, Wu Q, Majeed A, Zhang Y, Car J. mHealth Series: Factors influencing sample size calculations for mHealth-based studies - A mixed methods study in rural China. J Glob Health. 2013;3:020404. Medline:24363922. doi:10.7189/jogh.03.020404
    - Chapter 8 and 9 contain adapted content of this article (Appendix A Copyright permission).

3. **van Velthoven MH**, Car J, Zhang Y, Marusic A. mHealth series: New ideas for mHealth data collection implementation in low- and middle-income countries. J Glob Health. 2013;3:020101. Medline:24363911. doi:10.7189/jogh.03.020101
    - Chapter 10 contains adapted content of this editorial (Appendix A Copyright permission).

4. Zhang Y, Chen L, **van Velthoven MH**, Wang W, Liu L, Du X, Wu Q, Li Y, Car J. mHealth Series: Measuring maternal newborn and child health coverage by text messaging - a county-level model for China. J Glob Health. 2013;3:20402. Medline:24363920. doi:10.7189/jogh.03.020402
    - Chapter 1, 10 and 11 contain adapted content of this article (Appendix A Copyright permission).

5. Du X, Wang W, **Velthoven MH**, Chen L, Scherpbier RW, Zhang Y, Wu Q, Li Y, Rao X, Car J. mHealth Series: Text messaging data collection of infant and young child feeding practice in rural China - a feasibility study. J Glob Health. 2013;3:020403. Medline:24363921. doi:10.7189/jogh.03.020403
   - A reference to this article on text messaging collection of 24-hour dietary recall data in rural China is made in Chapter 1, 7, 10 and 11.

6. Li Y, Wang W, **van Velthoven MH**, Chen L, Car J, Rudan I, Zhang Y, Wu Q, Du X, Scherpbier RW. Text messaging data collection for monitoring an infant feeding intervention program in rural China: feasibility study. J Med Internet Res. 2013;15:e269. Medline:24305514. doi:10.2196/jmir.2906
   - A reference to this article on text messaging data collection for monitoring an infant feeding programme in rural China is made in Chapter 1, 4, 5, 6, 7, 10 and 11.

7. Chib A*, **van Velthoven MH***, Car J. mHealth Adoption in Low-Resource Environments: A Review of the Use of Mobile Health care in Developing Countries. J Health Commun. 2014. Medline:24673171. doi:10.1080/10810730.2013.864735
   - A reference to this review of *mHealth* in low- and middle-income countries is made in Chapter 1.

8. **van Velthoven MH**, Majeed A, Car J. Text4baby – national scale up of an mHealth programme. Who benefits? J R Soc Med. 2012;105:452-3. Medline:23257962. doi:10.1258/jrsm.2012.120176
   - A reference to this editorial is made in Chapter 1.

9. **van Velthoven MH**, Brusamento S, Majeed A, Car J. Scope and effectiveness of mobile phone messaging for HIV/AIDS care: a systematic review. Psychol Health Med. 2013;18:182-202. Medline:22788357. doi:10.1080/13548506.2012.701310
   - A reference to this systematic review is made in Chapter 1.

*Shared first authorship.

10. Huckvale K, **van Velthoven MH**, Cash-Gibson L, Felix L, Car J. Self-care using apps for smartphones and other mobile device software: a systematic review of the literature using the example of diabetes mellitus. PROSPERO 2011:CRD42011001429 (protocol)
    - A reference to this protocol for a systematic review is made in Chapter 1.

11. Chen L, Wang W, Du X, Rao X, **van Velthoven MH**, Yang R, Zhang L, Koepsell J, Li Y, Wu Q, Zhang Y. Effectiveness of a smartphone app on improving immunization of children in rural Sichuan Province, China: study protocol for a paired cluster randomized controlled trial. BMC Public Health. 2014;14:262. Medline:24645829. doi:10.1186/1471-2458-14-262
    - A reference to this protocol for a mHealth-based cluster randomised controlled trial is made in Chapter 11.

12. Zhang S, Wu Q, **van Velthoven MH**, Chen L, Car J, Rudan I, Zhang Y, Li Y, Scherpbier RW. Smartphone versus pen-and-paper data collection of infant feeding practices in rural China. J Med Internet Res. 2012;14:e119. Medline:22989894. doi:10.2196/jmir.2183
    - A reference to this article on validation of smartphone-based data collection in face-to-face household surveys in rural China is made in Chapter 1, 2, 3, 4 and 6.

13. Zhang Y, Wu Q, **van Velthoven MH**, Chen L, Car J, Li Y, Wang W, Scherpbier RW. Care-seeking and quality of care for outpatient sick children in rural Hebei, China: a cross-sectional study. Croat Med J. 2013;54:541-9. Medline:24382848. doi:10.3325/cmj.2013.54.541
    - A reference to this article on care-seeking in rural China is made in Chapter 3.

14. Chen L, Wu Q, **van Velthoven MH**, Zhang Y, Zhang S, Li Y, Wang W, Du X, Ting Z. Coverage, quality of and barriers to postnatal care in rural Hebei, China: a mixed method study. BMC Pregnancy Childbirth. 2014;14:31. Medline:24438644. doi:10.1186/1471-2393-14-31
    - A reference to this article on postnatal care in rural China is made in Chapter 2 and 3.

15. Chen L, Dai Y, Zhang Y, Wu Q, Rudan D, Saftic V, **van Velthoven MH**, Su J, Tan Z, Scherpbier RW. A comparison between antenatal care quality in public and private sector in rural Hebei, China. Croat Med J. 2013;54:146-56. Medline:23630142. doi:10.3325/cmj.2013.54.146
    - A reference to this article on quality of care in rural China is made in Chapter 3.

16. Wu Q, **van Velthoven MH**, Chen L, Car J, Rudan D, Saftic V, Zhang Y, Li Y, Scherpbier RW. Improving the intake of nutritious food in children aged 6-23 months in Wuyi County, China: a multi-method approach. Croat Med J. 2013;54:157-70. Medline:23630143. doi:10.3325/cmj.2013.54.157
    - A reference to this aricle on child nutrition in rural China is made in Chapter 3.

17. Wu Q, Scherpbier RW, **van Velthoven MH**, Chen L, Wang W, Li Y, Zhang Y, Car J. Poor infant and young child feeding practices and sources of caregivers' feeding knowledge in rural Hebei Province, China: findings from a cross-sectional survey. Medline: 25079931 [PubMed - in process]. *BMJ Open* 2014;4:e005108 doi:10.1136/bmjopen-2014-005108
    - A reference to this article is made in Chapter 1 and 3 [QW, personal communication].

For other published papers during the PhD see Appendix I Other published papers.

Submitted

18. **van Velthoven MH***, Li Y*, Wang W, Chen L, Du X, Wu Q, Zhang Y, Rudan I, Car J. Prevalence of mobile phones and factors influencing usage by caregivers of young children in daily life and for health care in rural China: a mixed methods study.
    - Chapter 4 and 5 contain adapted content of this article.

19. **van Velthoven MH***, Wang W*, Wu Q, Li Y, Scherpbier RW, Du X, Chen L, Zhang Y, Car J, Rudan I. Comparison of text messaging data collection versus face-to-face interviews for public health surveys: a cluster randomized cross-over study of care-seeking for childhood pneumonia and diarrhoea in rural China.
    - Chapter 6 and 7 contain adapted content of this article.

20. Li Y, Wang W, Wu Q, **van Velthoven MH**, Chen L, Du X, Zhang Y, Rudan I, Car J. Increasing the response rate of text messaging: a delayed randomized controlled trial. Accepted by JAMIA.
    - A reference to this article on a randomised controlled trial evaluating interventions that can improve the response rate of text messaging data collection in rural China is made in Chapter 1, 7, 9 and 11 [YL, personal communication].

*Shared first authorship.

Overview of thesis

This thesis explores the application of mHealth-based collection of information relevant to care-seeking for childhood diarrhoea and pneumonia in rural China and has the following 11 chapters.

Chapter 1

The first chapter provides the background to this thesis. First, the potential that the widespread usage of mobile phones and text messaging offer to increase the quantity and quality of health information in low- and middle-income countries is introduced. Second, filling gaps in information on care-seeking is highlighted as a research priority to reduce the burden of the leading infectious causes of global child mortality: diarrhoea and pneumonia. Third, text messaging is described as an alternative data collection method for the currently used face-to-face household surveys on care-seeking for childhood diarrhoea and pneumonia in China. Fourth, studies on text messaging for health data collection are reviewed and it is shown that none assessed usage for household surveys. Fifth, a lack of evidence and low adoption of mHealth-based interventions is common and challenges and the need for development, evaluation and implementation of these interventions is described.

Chapter 2

The second chapter describes the rationale for the thesis. The study took place in China, because, despite being an upper-middle-income country, China has resource-limited areas in needs of health improvements. Collaborators were found in China who faced challenges in conducting household surveys and were interested in using mobile technology to improve data collection. The aim, objectives and methodological approach is explained. Given the complexity of developing and evaluating mHealth-based interventions, a mixed methods approach was most appropriate. In contrast to previous studies, of which many did not evaluate mobile phone usage, did not make comparisons between data collection methods, used a non-randomised design or included a small number of participants, the research in this thesis made an original contribution by assessing usage of mobile phones, comparing data collection methods using a cluster randomised cross-over design with a large number of participants and evaluating factors influencing participation.

Chapter 3

The third chapter provides an understanding of the Chinese study context. It starts by describing the PhD candidate's background and experiences related to China, because these shaped the research. Then a short introduction to China and *mHealth* in China is given. Lastly, the field site is described: Zhao County, a rural setting in Northern China with high levels of mobile phone usage and literacy.

Chapter 4 and 5

These chapters present a study addressing the first objective of the thesis: assessing the prevalence and factors influencing usage of mobile phones by caregivers. Chapter 4 introduces and describes methods of this study. A quantitative survey and qualitative semi-structured interviews were combined and data were compared and integrated. Chapter 5 presents the results and discussion of this study. Four main themes were found: (i) trends in mobile phone ownership; (ii) usage of mobile phone functions; (iii) factors influencing replying to text messages; and (iv) uses of mobile phones for health care. High mobile phone ownership and usage were confirmed, but text messaging was infrequently used by grandparents. The findings of this study were used to guide the study described in Chapter 6 and 7.

Chapter 6 and 7

These chapters present a study addressing the second objective of the thesis: determining the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia. Chapter 6 introduces and describes the methods of this study. Firstly, interviews and a pilot were conducted to develop and test the text messaging survey. Secondly, a feasibility study using a cluster randomised cross-over design was conducted to compare the novel text messaging survey to the standard face-to-face survey. Chapter 7 presents the results and discussion of this study. Six outcomes were assessed: (i) the response rate; (i) characteristics of responders versus non-responders and completers versus non-completers; (iii) the error rate of the text messaging survey; (iv) data equivalence; (v) the amount of information in responses; and (vi) reasons for differences in responses. The text messaging data were shown to be moderately to substantially equivalent to the face-to-face data. However, challenges with recruiting and following up participants were experienced, which were evaluated in Chapter 8 and 9.

Chapter 8 and 9

These chapters present a study addressing the third objective of the thesis: evaluating factors influencing participation in mHealth-based studies. Chapter 8 introduces and describes the methods of this study. Researchers' observations and structured interviews with caregivers were used. Chapter 9 presents the results and discussion of this study. Several factors influencing recruitment related to organisation, village doctors and caregivers were found, including the availability of lists with names and mobile phone numbers, peoples' understanding of the study, perceived usefulness, incentives, interference with work, trust, and ease of use. Recommendations of ways to improve recruitment and follow-up of caregivers are provided.

Chapter 10

This chapter addresses the final fourth objective. Three ideas where mobile technology could potentially facilitate health data collection are proposed: (i) to conduct and validate household surveys; (ii) to measure the burden of disease; and (iii) to monitor large-scale health programmes.

Chapter 11

The last chapter discusses the thesis' principle findings, strengths and limitations, its recommendations for future research, as well as describing the conclusions from the thesis. This thesis shows the application of text messaging for collection of information relevant to childhood diarrhoea and pneumonia in rural China. It makes a significant contribution to both the scarce evidence-base and methodology for development and evaluation of an mHealth-based intervention. However, since this study took place in a single rural Chinese county which has high levels of both literacy and mobile phone use, the findings may not be generalizable to other contexts. Since this thesis is an example of early stage research, no firm conclusions and recommendations for practice and policy can be made regarding the potential and pitfalls of data collection by text messaging until more research is carried out in this area. This work would be valuable, because mHealth-based data collection could be used to increase the quantity and quality of child health indicators, which can improve implementation of appropriate health interventions and ultimately save children's lives.

1 Background to thesis

Overview of chapter

This chapter provides the background to this thesis on the application of mobile phone text messaging for collection of information relevant to care-seeking for childhood diarrhoea and pneumonia in rural China. First, this chapter introduces the potential that the widespread use of mobile phones and text messaging offer to increase the quantity and quality of health information in low- and middle-income countries. Second, gaps in information on care-seeking for childhood diarrhoea and pneumonia are highlighted as a research priority. Third, mobile phone text messaging is described as a novel method for collection of data on care-seeking for childhood diarrhoea and pneumonia in China. Fourth, a review of studies on text messaging for health data collection is provided. Fifth, challenges and needs for the use of mHealth-based interventions are described.

Photograph 1 Mother using a mobile phone

Photograph courtesy of QW, personal collection

1.1 The potential mobile phones offer to increase the quantity and quality of health information in low- and middle-income countries

Overview of section

The first section of this chapter starts with introducing opportunities that the widespread usage of mobile phones offer for improving health in low- and middle-income countries. Then an overview of *mHealth* is provided. The section concludes by describing the potential of mobile technologies for increasing the quantity and quality of health information.

1.1.1 Opportunities for mobile phones to improve health

Mobile phones and other information and communication technologies have been said to "*surely play a pivotal role in the future of global health*" [5]. This was highlighted by the commitment of the United Nations member states to make use of advancements in information and communication technologies to enhance health care delivery, public health, research and health-related activities in the 58th World Health Assembly in 2005 [6].

Mobile phones are a particularly interesting information and communication technology in low- and middle-income countries; since 2005, more mobile phone users have been located in low- and middle-income counties than high-income countries [7]. By the end of 2014, an estimated 78% of the 6.9 billion mobile phone subscriptions will be in low- and middle-income countries [8]. In contrast to high-income countries, where fixed telephones and computers have been adopted on a large scale, these technologies have not been widely used in low- and middle-income countries where mobile phones have leapfrogged the telephone- and computer-age [9,10].

Globally, adoption of mobile phones has mainly taken place over the past 15 years. In 2000, there were 739 million mobile phone subscriptions worldwide, which was equivalent to 12.1 mobile phone subscriptions per 100 people. In 2002, the number of mobile phone subscriptions overtook the number of landline telephones (18.4 versus 17.2 subscriptions per 100 people respectively) [11]. By the end of 2014, the number of mobile phone subscriptions will approach the number of people in the world (96 subscriptions per 100 people) [8].

These numbers overestimate the actual number of mobile phone users, because an estimated 10% of subscriptions are inactive and people use an average of 1.85 Subscriber Identity Modules (SIM) cards each. Thus, only around 45% of the world's subscriptions are unique users of mobile phones [12]. However, access to mobile phones is higher when mobile phones are shared between people, which can be common in resource-limited settings [13].

The growth in mobile telephone use has been enabled by a good mobile phone distribution system, high network coverage, falling prices of handsets and airtime and usage of prepaid cards [13-15]. People lacking domestic electricity supplies can charge mobile phone batteries in generators that are available in local markets and shops [15]. Moreover, mobile phones have a high social value in various settings [16,17]. Therefore, mobile phones possibly play an even more significant role in societies of low- and middle-income countries compared with high-income countries [10,14].

The functionality of mobile phones has increased enormously since introduction of the first mobile phone to the public in the United States in the early 1980s: the *Motorola DynaTAC 8000x* (*DynaTAC* stands for "Dynamic Adaptive Total Area Coverage"). This phone was barely mobile due to its large size and heavy battery that allowed for only about 20 minutes of talk time. Its high price (US$3995) restricted use to those with significant financial resources [18]. Since, huge advancements in technology have taken place, including decreased weight, increased talk time and the introduction of new functions, such as messaging and applications (apps) [17]. Now mobile phones can broadly be categorised into simple mobile phones and smartphones. Smartphones are mobile phones with advanced computing functions that have Internet access. After the introduction of the *iPhone*® in 2007, smartphones and apps have become very popular and are increasingly used in low- and middle-income countries [19].

At the moment, calling and text messaging are the main functions of the mobile phones used in low- and middle-income countries. These functions are relatively easy to learn by practicing or learning from others. People often continue to use their mobile phone for receiving phone calls and text messages even when their mobile phone is out of credit.

Globally, the number of text messages sent tripled from approximately 1.8 trillion in 2007 to 6.1 trillion (around 200.000 text messages every second) in 2010 [20]. It has been forecasted that an estimated 9.4 trillion text messages will be sent in 2016 [21].

Mobile phones have become part of daily life and many people carry them at all times. Therefore, they provide an opportunity to reach people who were previously hard to reach via traditional modes of communication. This is particularly relevant to people who do not have access to high quality health care in low- and middle-income countries [16,22-24]. Health systems in those settings face a disproportionally high burden of disease whilst having structural problems including limited funds, poor health care infrastructure and information systems and a huge shortage of health workers [5]. Mobile phones can improve communication and delivery of information over vast distances between health care providers, patients and healthy individuals [25]. They can provide access to remote health care facilities and facilitate training for health workers and consultations among health workers. Also mobile phones allow for remote monitoring and surveillance to improve health information systems. This has the potential to lead to an overall increase in the efficiency and effectiveness of under-resourced health infrastructures and ultimately translate into benefits for populations [26,27].

1.1.2 Scope of *mHealth*

mHealth can be interpreted in different ways. Firstly, there are “natural” uses of mobile devices for health-related purposes. For example people can use mobile phones to contact their doctor. Secondly, there are formal mHealth-based initiatives, either building on mobile services or on the broader usage of information and communication technologies in health care [23]. In the latter view, *mHealth* is a branch of the usage of wired information and communication technology in health care, known as *eHealth* [28]. *mHealth* and *eHealth* build on the principles of medical or health informatics (field of information science focussing on analysing and disseminating medical data through computers with over 320,000 publications in *Medline* alone [29]) including *telemedicine* and *telehealth* (delivery of health services and clinical support, including consultation and diagnostics, at a distance via remote information and communication technology to improve health outcomes) [28,30].

mHealth encompasses many different mobile devices including mobile phones, smartphones, personal digital assistants (also known as PDAs), and ultra-portable computers such as tablets, monitoring devices, portable media players and handheld video-game consoles. The different functions of these devices can be used for delivering interventions, including voice (calling and voice messages), text messaging (also known as “short messaging service” or SMS), multimedia messaging (or MMS), photo, videos, multimedia playback, apps, add-ons (for example a gluco-meter to measure blood glucose), automated sensing and the Internet. These different functions can make use of networks such as telecommunication (second, third and fourth generation mobile telephony systems), Global Package Radio Service (also known as GPRS), Bluetooth, Global Positioning System (also known as GPS) and Wi-Fi. Communication taking place can be one-way (communications in one direction), two-way (interactive communication) and multi-way (one-to-many, many-to-one and many-to-many communication using social media) [4,31].

Black *et al.* described three main overlapping functions of *eHealth* [32], which when adapted to *mHealth* can be described as the following: (i) to facilitate communication between healthy individuals, patients and health providers; (ii) to support health workers in their clinical decision making; and (iii) to collect, store and transmit data in health information systems.

Previous reviews on mHealth-based interventions identified 5 [33], 6 [4,34], 9 [35] or 12 [36] functions of mHealth-based interventions in low- and middle-income countries. When combining these functions within the three main functions, the scope of mHealth-based interventions can be described as follows.

Firstly, *mHealth* can be used to facilitate communication between healthy individuals, patients and health providers [37], including communicating test results [38], appointment reminders [39,40], medication reminders (for example for antiretroviral therapy [41], tuberculosis treatment [42]), behaviour change for health promotion and disease prevention [37,43-46] (such as nutrition, exercise [47], tobacco usage [48], alcohol usage, sexual health [49], maternal health [25,50], mental health, malaria and diarrhoea [46]) and management of long-term conditions [37,51,52] (such as diabetes [53], asthma [54], chronic obstructive pulmonary conditions, Alzheimer [52], depression, hearing loss, low vision, osteoarthritis, migraine [55] and HIV/AIDS [56]).

Secondly, *mHealth* can be used to support health workers through point-of care diagnostics, education and training, communication between health workers, planning and scheduling work, human resource management and electronic decision support [26,31,36,57-60].

Thirdly, *mHealth* can be used to collect, store and transmit data in health information systems through household surveys, surveillance (tracking diseases and emergencies), electronic health records, financial transactions and incentives and supply chain management [26,31,33,36,60].

1.1.3 mHealth-based data collection

Mobile phones can play a particularly interesting role in improving data collection in health information systems [26,31,61]. The function of those systems is to produce, analyse and disseminate sound data. Timely available, relevant and sound data are crucial to evaluate health, monitor trends, assess coverage and effectiveness of interventions, inform evidence-based health policy and set priorities [62-64]. Inaccurate data can lead to misleading, biased and potentially harmful decisions [65]. While accurate health information is critical for proper functioning health systems, health information systems in many low- and middle-income countries are weak and do not allow for regular monitoring [62,66].

This causes restrictions for many countries in measuring progress towards national and international health goals and designing and implementing appropriate health interventions [62]. Inadequacies in health information systems are caused by problems on both the demand and supply sides, including a lack of capacity, responsibility and resources. Solutions to these problems must be comprehensive and include sustained information system development [62]. Strengthening health information systems requires production of data from a number of sources: census (population characteristics), vital events (births, deaths, causes of deaths etc.), monitoring, public health surveillance, resource tracking, facility-based service statistics and household surveys [64]. Household surveys are the main mode for data collection of indicators on health and progress towards health goals in low- and middle-income countries [62,67].

The quality of data is dependent on its data collection. Data collection aims to produce data that are accurate, complete, comparable between different places where data is collected, efficient for data recording and processing and suitable for analysis [62]. Data collection in household surveys takes place by interviewers visiting households, administering the questionnaire and recording the responses. Paper-based data collection methods have been the standard method for data collection and involves collection of paper forms and transfer to computer software, which is done twice (double-data entry) to avoid human errors [68].

Over the past 25 years, electronic data collection methods have been developed to avoid procedures that can introduce errors. These methods include computer-assisted personal interviewing applications on mobile devices, such as personal digital assistants and more recently smartphones [67,69-72]. Data can then be transferred to a central database from which it can be analysed. Electronic data collection has been facilitated by open-source tools. These tools have a website and an app that can be downloaded for free on different mobile devices and used for creation of questionnaires [26,33]. Some popular mobile phone software for data collection include Epicollect [73], Magpi (previously named Episurveyor) [74] and Opendatakit [75].

Electronic data collection has been preferred over paper-based data collection, because it can have a similar or higher quality of data, similar or lower costs, reduce item errors, and decrease time of interviews, data handling and data transfer [70-72,76]. Another advantage of electronic data collection is the possibility to use measures that can detect data fabrication [69]. Electronic data collection has shown to be acceptable and feasible for participants and interviewers [69-71].

Still with these advancements, interviewer-administered electronic household surveys face several challenges including limited resources and the need to visit field sites. In high-income countries, household survey data collection often takes place through self-administered questionnaires using post, phones (interactive voice response calls) and computers (online, email). However, these methods have not been feasible in low- and middle-income countries where none of these technologies have been widely used till recently.

Now that mobile phones are widely used, even in resource-limited settings, they provide opportunities to collect data at an individual level and overcome challenges of interviewer-administered surveys (explained later in section 1.3). However, this is an under-researched field, particularly in low- and middle-income countries [33,61] (shown later in section 1.4). Therefore, mHealth-based data collection was the focus of this thesis. Further information on challenges and needs for *mHealth* is provided in section 1.5. First, in the next section (section 1.2), a specific research priority where mHealth-based data collection can play a role is introduced.

Structured summary of section

The first section of this chapter introduced the use of mobile phones for increasing the quantity and quality of health information in low- and middle-income countries. In sum:

1. Mobile phones have become widely adopted and text messaging is a widely used communication method even in low-resource settings. Therefore, mobile phones offer the opportunity to reach people who were previously hard to reach via traditional communication modes. Mobile phones can improve the communication, delivery and collection of health information over vast distances;
2. *mHealth* can be used to facilitate communication between healthy individuals, patients and health providers, to support health workers in their clinical decision making and to collect, store and transmit data in health information systems;
3. Mobile phones can play a particularly important role for data collection at an individual level, whereby they can enhance health information that can be used to measure progress towards health goals.

1.2 Gaps in information on care-seeking for childhood diarrhoea and pneumonia in low- and middle-income countries

Overview of section

After describing the potential of mobile phones for health in low- and middle-income countries, this section introduces a specific area for mHealth-based data collection. A brief overview of progress in child health is given. Childhood diarrhoea and pneumonia are introduced as the main infectious causes of death in children under five years. It is explained that improving knowledge about care-seeking is a research priority for reducing the burden of these illnesses.

1.2.1 Progress in child health in low- and middle-income countries

In 1990, approximately 12.6 million children younger than five died, a number which has decreased to 6.6 million in 2012 [77]. Over recent decades, huge efforts to reduce poverty and improve child health have taken place, particularly in low- and middle-income countries. Around the mid-20th century, a number of United Nations agencies and programmes were established, including the World Bank (1944), United Nations Children's Fund (1946) and World Health Organization (1948) [5]. The World Health Organization defined health as "*a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity*" [78]. Later in 1978, the Declaration of Alma Ata stated that the achievement of optimal health as a "*most important world-wide social goal*" and highlighted the importance of primary health care [79]. These efforts increased after the year 2000 when the World Health Report was released, which focussed on improving health systems (defined as "*all the activities whose primary purpose is to promote, restore or maintain health*") [80]. Moreover, the Millennium Development declaration was adopted in 2000 by leaders of United Nations member states to reduce extreme poverty [81]. Targets of the declaration, known as the eight Millennium Development Goals (MDGs), were set out in 2001 and were agreed to be achieved by 2015. The MDGs have specific targets and indicators in a very broad range of development issues including poverty, education, gender, health, the environment and international relations. Three goals are explicitly related to health: (i) MDG 4 (reduction of child mortality); (ii) MDG 5 (reduction of maternal mortality); and (iii) MDG 6 (combatting HIV/AIDS, malaria and other diseases) [82].

However, the MDGs have received criticism: interactions between different MDGs are not clear, they are too narrow, lack key development needs and equity issues are not well addressed [83]. For maternal and child health, some of these issues have been addressed by launch of the Countdown to 2015 for Maternal, Newborn and Child Survival by the Bellagio Study Group on Child Survival in 2003 [84] and Commission on Information and Accountability for Women's and Children's Health by the United Nations Secretary-General in 2010. The initiatives focus on a selection of indicators for MDGs 4 and 5 and aim to address the interrelatedness of these MDGs [85].

While these global efforts, alongside economic and social development, have contributed to significant progress in achieving MDG 4, most countries will not reach MDG4 and many children die unnecessarily. MDG 4 aims to reduce child mortality by two thirds between 1990 and 2015, but a reduction from 12.6 million to a maximum of 4 million child deaths will most likely not be achieved by 2015 [86]. Childhood diarrhoea and pneumonia are the leading infectious causes of death in children under five years old and caused almost a third of the 6.6 million child deaths in 2012 [77].

1.2.2 A brief introduction to childhood diarrhoea and pneumonia

Diarrhoea

Diarrhoea is defined by the World Health Organization as "*the passage of three or more loose or liquid stools per day (or more frequent passage than is normal for the individual)*". Diarrhoea is not the frequent passing of formed stools or the passing of loose stools by breastfed infants [87]. Diarrhoea is commonly a symptom of an infection in the intestinal tract caused by different viruses, bacteria and parasites. These infections spread through contaminated water or food, or from one person to another person.

Risk factors for diarrhoea include Vitamin A deficiency and inadequate water and sanitation, including poor water quality and hand washing. Diarrhoea can often be prevented through drinking safe water, improved hygiene, vaccination (rotavirus and measles), adequate nutrition, breastfeeding and micronutrient supplementation (Vitamin A and zinc) [88].

Care for diarrhoea does not always have to be sought at a health facility and non-severe diarrhoea can be treated at home with oral rehydration therapy (Oral Rehydration Salts (ORS, a mixture of clean water, sugar and salt), recommended homemade fluids, breast milk, or increased fluids, along with continued feeding), nutrient-rich food and zinc [89,90]. Most deaths from diarrhoea are caused by dehydration, which occurs when a large amount of water and electrolytes (sodium, potassium and bicarbonate) leave the body through liquid stools. Consultation with a health worker is needed in cases of dehydration, diarrhoea with blood in stools (dysentery) and persistent diarrhoea [87].

Pneumonia

Pneumonia is a severe form of an acute lower respiratory infection affecting the lungs which causes the alveoli (small sacs in the lungs that normally fill up with air when breathing) to fill up with fluid and pus, which limits oxygen intake [91]. Pneumonia is caused by various bacteria, viruses and fungi and the most common pathogens are the respiratory syncytial virus followed by influenza virus (flu) [92]. Pneumonia can spread by inhaling pathogens and through airborne droplets from coughing or sneezing [91].

The main risk factors for childhood pneumonia are malnutrition, low birth weight, non-exclusive breastfeeding in the first four months, solid fuel usage and overcrowding [92]. Diarrhoea may also be a risk factor for pneumonia [93]. Key prevention strategies for pneumonia include vaccination (measles, Streptococcus pneumonia, influenza virus and influenza type b), adequate nutrition for mothers and children, micronutrient supplementation (Vitamin A and zinc), reducing indoor pollution and promoting basic hygiene practices [89].

The symptoms of pneumonia are a cough and fast or difficult breathing due to a problem in the chest, which are common in children. Cases with these symptoms are labelled “suspected pneumonia” (children with reported respiratory signs and symptoms that are recognised), because many children with these symptoms do not have “true pneumonia” (children with true disease), but a mild infection [94].

Caregivers with children who present with pneumonia-related symptoms should seek clinical assessment by a health worker. The Integrated Management of Childhood Illness handbook, issued by the World Health Organization, trains health workers to screen children and treat those with pneumonia. The following signs are used to assess the severity in children with pneumonia: fast breathing (non-severe pneumonia), lower chest wall indrawing (severe pneumonia) and danger signs, such as central cyanosis, difficulty breastfeeding or drinking, vomiting, convulsions, lethargy, unconsciousness or head nodding (very severe pneumonia). Oral antibiotics can be given in the community in many cases of non-severe pneumonia. Hospitalisation is recommended for infants younger than two months and in cases of severe pneumonia. Oxygen treatment is recommended for very severe pneumonia [87].

1.2.3 Reducing the burden of childhood diarrhoea and pneumonia

In 2011, pneumonia was responsible for an estimated 1.3 million deaths in children under five and diarrhoea caused 0.8 million child deaths. The majority of these deaths, 72% of deaths from diarrhoea and 81% of deaths from pneumonia, occurred in children younger than two years. Almost three-quarters of these deaths occurred in 15 high-burden countries [95].

There were an estimated 1.7 billion diarrhoea episodes and 120 million pneumonia episodes in children younger than five in 2011. An estimated 2% of diarrhoea episodes (36 million episodes) and 12% of pneumonia episodes (14 million episodes) progressed to severe disease. The case-fatality ratio of severe diarrhoea was 2% and this ratio of severe pneumonia was 9% [95].

The median incidence (the occurrence of new disease cases) of pneumonia was estimated to be 0.29 episodes per child per year in 2000 (though this largely ranged from 0.21 to 0.71) [96] and fell by nearly 25% to 0.22 in 2010 (ranging from 0.11-0.51) [92]. The median incidence of diarrhoea incidence was 2.9 episodes per child per year in 2010, a figure which had not decreased since the year 2000 despite improvements in water, sanitation and hygiene [97].

A single episode of diarrhoea has no long-term consequences, but children in resource-limited settings often experience several diarrhoea episodes a year, which can lead to nutritional deficits and stunting [98]. For severe pneumonia, the most common long-term effect is a reduction in lung volume [99].

Moreover, childhood pneumonia and diarrhoea place a huge burden on children and their families. Health services face large burdens too, as a significant proportion of all child out-patient attendances, in-patient admissions and medication prescriptions are caused by these illnesses [100].

Millions of child deaths from pneumonia and diarrhoea could be prevented through coverage of simple and affordable interventions [86]. Pneumonia and diarrhoea share risk factors (undernutrition, zinc deficiency and suboptimal breastfeeding [95]) and the same prevention strategies (adequate nutrition for mothers and children, breastfeeding promotion and support, micronutrient supplementation etc.) and treatment interventions (improved care-seeking behaviour, improved case management in the community and health facility) can be used for both illnesses and be delivered through the Integrated Management of Childhood Illness approach. Therefore, in 2012 the Global Action plan for Pneumonia and Diarrhoea was issued by United Nation Children's Fund, World Health Organization, and United States Agency for International Development to integrate efforts to reduce deaths from diarrhoea and pneumonia [89]. In 2013, series of papers in *The Lancet* [95,101-103] and the *Journal of Global Health* [92,93,104-106] were published on this topic.

The Lancet Diarrhoea and Pneumonia Interventions Study Group estimated that 95% of diarrhoea and 67% of pneumonia deaths in children under five years could be prevented at a cost of US$6.7 billion by 2025 if coverage of key interventions were scaled-up to at least 80% and immunizations to at least 90% [102]. At least a third of severe episodes of pneumonia and two-thirds of deaths can be prevented by vaccination for Streptococcus pneumonia, influenza virus and *H. influenza* type b. Almost a third of episodes of severe diarrhoea can be prevented by vaccination for rotavirus and cholera [95]. Furthermore, interventions that can make a large impact on reducing the burden of childhood diarrhoea and pneumonia include breastfeeding, ORS and community case management [102].

Nevertheless, usage of existing interventions is not optimal as health systems do not deliver interventions to those in the greatest need and on sufficient scale. A problem for scale-up of childhood diarrhoea and pneumonia interventions is the lack of attention to implementation challenges. Research on developing new interventions has received greater attention than research on health system issues [107]. To increase scale up and coverage of cost-effective interventions, more investment in health systems research has been set as one of the five main steps to planning and management of pneumonia and diarrhoea programmes. Understanding care-seeking behaviours of caregivers is an important health system challenge that has not been addressed adequately [103].

1.2.4 Care-seeking for childhood diarrhoea and pneumonia as research priority

To provide effective health care, clinics, workers and treatment should not only be available, accessible and of good quality, but illness must first be recognised and care be sought by a caregiver of a child. A caregiver is the individual who seeks care for a child, often a family member, such as a mother or grandmother. Care-seeking is any care sought for a child perceived by the caregiver to be ill. The type of care sought can be categorised according to facility type (primary or secondary facility or pharmacy), health care provider (medically trained and unqualified providers), home care or no care [108].

A United Nations Children's Fund report provided estimates on care-seeking by caregivers when their children experienced diarrhoea and pneumonia symptoms. Care-seeking for suspected pneumonia (cough with fast or difficult breathing due to a chest-related problem) slightly increased from an average of 54% to 60% in low- and middle-income countries between 2000 and 2010. While care-seeking for children in rural areas improved from 50% in 2000 to 56% in 2010, care is still more frequently sought for children with pneumonia signs in urban areas (65% in 2010). Only an estimated 39% of children with signs of diarrhoea received oral rehydration therapy and less than a third received recommended homemade fluids, increased fluids and continued feeding. Only a third of children received ORS, but this was also caused by the limited availability of ORS in low- and middle-income countries [89].

There are many factors that influence caregivers' decisions to seek care. Mothers' perceptions of illness severity, abilities to recognise danger signs and cultural beliefs about causes of illness affect their care-seeking behaviour [109,110]. Only 43% of caregivers who had a child with fast or difficult breathing (key symptoms of pneumonia) saw these as signs to seek immediate care for the child [89]. Caregivers are less likely to seek care for diarrhoea when signs are less severe and children are young [111]. Some caregivers see antibiotics as stronger treatment than ORS for diarrhoea, which can lead to inappropriate usage of antibiotics [106]. Care has been reported to be more frequently sought for male children (particularly in South-Asia [112,113]), unconscious children [112] and when a previous child had died [114]. Also, caregivers may not seek care when they perceive the quality of the health facility to be poor [115].

Practical reasons for not seeking care include not having someone to care for family members in case of an emergency [110] and time away from the household and childcare responsibilities [115]. Travelling to health facilities can be a major issue in resource-limited settings. The lack of transport or roads, cost for transport, security concerns for reaching the facility [115] and a longer distance to the main town [110] delay care-seeking. These barriers may be unequally affecting populations and are linked to people's socio-economic position; for example distance and costs are greater barriers for poorer people [114]. Socio-economic factors that have been negatively associated with care-seeking include younger maternal age [116], lower educational level [116,117], lower occupational status [116] and being poorer [112].

A clear understanding of the factors that influence care-seeking is essential for developing interventions that raise awareness about illnesses, as is consistent with the Integrated Management of Childhood Illness handbook for improving care-seeking [87]. For example, for diarrhoea this information can be used to best position ORS and zinc [118]. Yet, there is a lack of understanding how these barriers affect care-seeking in different contexts and for specific illnesses.

The United Nations Children's Fund report based many of its estimates on a subset of 63 countries with available data that covered around 70% of children under five years in low- and middle-income countries and at least 50% of children under five years in each region of the world. However, comparable data were not available in China and data coverage was insufficient to calculate a number of regional averages [89].

Systematic reviews on care-seeking for illness in neonates and children in low- and middle-income countries highlighted the lack of available evidence. They found a limited number of studies, providing estimates with broad ranges, and which were located in only certain regions in the world [108,115]. The scarcity of information regarding access was the most important lesson learnt from one review [115]. It was concluded that representative data from different regions of the world are needed. Improving knowledge of factors affecting utilization of health care, barriers that prevent children being taken to a health facility and mechanisms to improve care-seeking were recommended [108,115].

These issues have not been given a high funding priority by international agencies [119]. For example, indicators on care-seeking for pneumonia, oral rehydration therapy and ORS have only been included in the Countdown to 2015 for Maternal, Newborn and Child Survival, and not in the MDGs and Commission on Information and Accountability for Women's and Children's Health [85].

Recently, care-seeking has been prioritised for research to reduce mortality from pneumonia and diarrhoea within a relatively short time frame. Studying the main barriers to seeking care and access to care for children younger than five in different settings in low- and middle-income countries was given the highest priority for pneumonia research [119] and the third priority for diarrhoea research [118]. Also high priority was given to studying barriers against using oral rehydration therapy for diarrhoea [118,120].

However, while recently more attention has been given to improving the understanding of care-seeking practices, current data collection methods are a major constraint for retrieval of appropriate information. Therefore, current and alternative methods to collect information related to care-seeking for childhood diarrhoea and pneumonia are described in the next section (section 1.3).

Structured summary of section

This section described that filling the gaps in information on childhood diarrhoea and pneumonia is a research priority. In sum:

1. While advancements in child health have been achieved in low- and middle-income countries over the past decades, still many children die unnecessarily and childhood diarrhoea and pneumonia remain the two main infectious causes of death in children under five years;
2. Diarrhoea is an infection in the intestinal tract, pneumonia is a form of an acute respiratory infection affecting the lungs, and these two illnesses share risk factors and prevention and treatment strategies;
3. Many child deaths from diarrhoea and pneumonia can be prevented when simple and effective interventions are available, but scaling-up these interventions faces implementation issues;
4. There are large gaps in current knowledge about care-seeking for childhood diarrhoea and pneumonia. Increasing the quantity and quality of the information on care-seeking is an important research priority, because an improved understanding of care-seeking could be used to guide implementation of appropriate health interventions.

1.3 Text messaging as a novel method for household survey data collection on care-seeking for childhood diarrhoea and pneumonia in China

Overview of section

The third section brings together the previous two sections by introducing text messaging as an mHealth-based method for collection of information on care-seeking for childhood diarrhoea and pneumonia. An overview of current face-to-face household survey data collection is given. It is described how novel mHealth-based self-administered data collection could overcome limitations of the currently used interviewer-administered surveys. Furthermore, it is explained that text messaging may be a suitable method to collect information in China, where the study of this thesis took place. The reasons for choosing China are described in Chapter 2 and the study context is further described in detail in Chapter 3.

1.3.1 Current household survey data collection

Information on care-seeking for childhood illnesses is obtained through community-based sources including household surveys and health research, such as intervention trials. This information cannot be obtained through health facility-based studies, because those studies have inherent selection bias regarding their population sample and care-seeking behaviours when reporting on care-seeking [108].

Representative cross-sectional (meaning that data are collected at one particular point in time) household surveys take place to collect information on demographic and health-related indicators, including knowledge, health practices and access, availability and coverage of interventions. Overall, the aim of obtaining this information is to improve survival and health, which is used to measure outputs of health activities, solve problems and inform effective interventions (World Health Organization Maternal, Newborn and Child Health Household survey, unpublished, 2009).

In household surveys, the aim is to randomly select a sample of children and their caregivers to provide valid information that can be generalised to the entire area in which the survey is conducted. Cluster sampling procedures are used to obtain a representative sample, whereby probability sampling is used (meaning that clusters are selected based on chance). A two-stage procedure is used by which first clusters, a naturally occurring group of people (for example a village), are randomly selected from the population of interest. Then in each cluster, a number of children are randomly selected (World Health Organization Maternal, Newborn and Child Health Household survey, unpublished, 2009).

In the Chinese setting of this thesis, the World Health Organization Maternal, Newborn and Child Health Household survey was used to collect information on care-seeking (unpublished, 2009). This survey has previously been used in Cambodia, Papua New Guinea and Vietnam [121]. In China, national health surveys such as the National Nutritional and Health Survey also collect this information [122]. In other low- and middle-income countries, information on maternal, newborn and child health is collected in international standard programmes such as the Demographic and Health Surveys [123] and the Multiple Indicator Cluster Surveys [124]. Demographic and Health Surveys (also known as “DHS”) is a nationally representative household survey that was introduced by the United States Agency for International Development in 1984. Standard Demographic and Health Surveys are conducted every five years to allow comparisons over time [123]. Multiple Indicator Cluster Surveys (also known as “MICS”) were introduced by the United Nations Children's Fund in 1995 [124].

All these different household surveys have modules with similar questions on childhood diarrhoea and pneumonia. Interviewers ask questions to a participant, listen to the answer the participant gives and, based on this response, select the most appropriate answer option on the questionnaire. The aim of these questions is to assess whether the child had suspected pneumonia and diarrhoea based on signs and symptoms that caregivers can understand.

For diarrhoea, caregivers are asked if their child had liquid stools in the past two weeks. When diarrhoea was present, it is asked whether blood was found in stools. Further questions ask about whether care and treatment was sought (ORS, continued feeding and provision of additional fluids during diarrhoea) and where they were sought.

For pneumonia, caregivers are asked if their child had fever, cough and rapid breathing or difficulty in breathing during the previous two weeks and whether breathing problems were chest-related. When caregivers report symptoms of illness, they are asked whether care was sought outside the home. If care was sought outside the home, the location where care was sought is asked. If no care was sought outside the home, reasons for not seeking care are asked (World Health Organization Maternal, Newborn and Child Health Household survey, unpublished, 2009).

For childhood diarrhoea, the questions about signs of diarrhoea are reasonably accurate [125]. However, for childhood pneumonia, disease signs and symptoms have been known to be poor predictors of actual disease [126]. Therefore, actual cases of pneumonia are not claimed to be measured by these questions. The two-week point prevalence - a measure that is used to assess occurrence of illness in the past two weeks - and antibiotic treatment rates for childhood pneumonia cannot be measured accurately by these surveys. Still, the care-seeking indicators for "suspected pneumonia" are valid, because the signs and symptoms that the caregiver recognised are an appropriate denominator for the proportion of caregivers who sought care (whether or not a child truly had pneumonia) [94].

In the Chinese study context, until recently pen-and-paper based methods were used for these interviewer-administered household surveys. Recently, a study compared pen-and-paper data collection with smartphone-based data collection in this setting. The study showed that smartphone data collection can eliminate data recording and entry errors, whilst having a similar inter-rater reliability and taking an equal amount of time per interview. Therefore, smartphone-based data collection has been used for these surveys in the Chinese context since this study [71].

1.3.2 Challenges of household survey data collection

As described in section 1.2.4, data on care-seeking for childhood diarrhoea and pneumonia are sparse despite that frequent and high-quality data are essential to monitor health and inform health programs. There is a tension between the need for timely data to assist decision-making and the funds and resources that are needed to conduct household surveys frequently [85]. An additional difficulty is the inadequacies of current face-to-face data collection methods. Even when electronic methods are used to avoid recording and entry errors, interviewers still need to visit participants in the field site to carry out the survey. These field visits are a limitation of the current face-to-face data collection method, because they are expensive and cannot always be conducted.

Costs are one of the biggest constraints for designing and implementing household surveys. Costs for field visits include personnel, transport, accommodation, equipment, consumables and other costs. Recruitment and training of interviewers and supervisors is labor-intensive, time-consuming and expensive [127]. Moreover, interviewers can have difficulty accessing households because of poor transportation, caregivers' unavailability and security concerns. There are difficulties in gaining access to particular areas, for example during the wet season when roads are difficult or impossible to pass [110]. Caregivers often work outside home during day time or are too busy to be interviewed. Moreover, some cultural customs prevent interviewers from visiting households. For example, in rural China people believe that it is not good for newborns and mothers to be visited by people within the first months after birth [128].

Further challenges of face-to-face household surveys are as follows. Most household surveys are sample surveys in which representative samples are preselected with each household having a known chance to be selected. In the Chinese study context, a list with names of children is obtained through routine health information systems. As previously mentioned, a common problem is the low quality of health information systems. Therefore, lists of names of participants are often incomplete and inaccurate [4,5].

Achieving a low non-response rate is crucial, as high non-response rates can reduce the representativeness of a sample. While people in rural areas may be more difficult to reach, people living in urban areas may be less likely to participate in household surveys. As a result of multiple revisits to households ("callbacks") and close monitoring of response rates by field staff, non-response in Demographic and Health Surveys and Multiple Indicator Cluster Surveys is well below 10% in most countries [67], but this requires significant efforts. In practice, oversampling of children (for example 30%) is used to compensate for possible refusal and loss to follow-up. Even with the use of over-sampling, still an insufficient number of children may be found. Substitutes (children living nearby and are in the same age group) then have to be used to cover children who cannot be found [129].

It is usually not feasible to conduct household surveys that include very large samples of participants. However, a large sample size is needed for disaggregated analysis by sex, age and socio-economic position [94] and for obtaining adequate denominators to support coverage measurement when the two-week point prevalence of events is very low [130].

Household surveys cannot often be conducted frequently. Regular household surveys carried out according to minimum standards are required to provide frequent data for programme monitoring [85]. These surveys are usually not conducted over a full calendar year, apart from Demographic and Health Surveys in some countries (Senegal and Peru) [131]. Demographic and Health Surveys are usually conducted every five years and the Multiple Indicator Cluster Surveys every three years [67]. However, both diarrhoea and pneumonia have seasonal variance and cross-sectional surveys only ask about care-seeking in the past two weeks [97,132].

Interviewers can introduce bias in household surveys. Both Demographic and Health Surveys and Multiple Indicator Cluster Surveys have minimum requirements for selecting interviewers. This means that interviewers need at least a high school diploma and cannot directly be involved in the management or provision of health services to avoid potential conflict of interest [67]. In addition, all interviewers are trained according to the survey protocol and evaluated before conducting field work. However, interviewer bias cannot be completely avoided, because interviewers can influence interviews and introduce response bias and socially desired answers.

Additionally, concerns have been raised about data quality issues and interviewers fabricating data in low- and middle-income countries [133]. Experiences indicate that interviewers sometimes modify children's age, for example by transferring children to an age group of over five years, to exclude them from the survey sample and thereby reduce their workload [67].

1.3.3 Considering alternative data collection methods

Considering the challenges for current household data collection, there is a need for an alternative cheaper data collection method that can be conducted more easily, more frequently and on a larger scale. This is a crucial step to increase the empirical data that is available in China and other low- and middle-income countries. Various methods can be used to collect data and every method has its advantages and considerations. Besides practical issues, data obtained through a novel method needs to be of equal or higher quality.

Surveys vary in the following: (i) the method of contacting potential participants; (ii) the mode of administering the questionnaire (interviewer-administered or self-administered); and (iii) the medium to deliver the questionnaire (face-to-face, phone, paper, Internet etc.) [134]. Initial contact with participants can be established by a letter, face-to-face contact, an email, or via phone contact. This can be directly followed by administration of the questionnaire [65]. The next sections describe the modes and media of administering questionnaires.

Modes and media of administration

In contrast to low- and middle-income countries where face-to-face surveys are the standard survey method, telephone surveys have frequently been conducted in high-income countries [61]. An advantage of telephone surveys is that they do not require field visits. Nevertheless, these surveys still require a significant amount of resources and time, because interviewers have to be trained, conduct the interviews and several call attempts may have to be made when participants are not home at the time of a call [135]. Similar to face-to-face surveys, telephone surveys are influenced by interviewers. An additional limitation of telephone surveys is the lack of visual cues [136]. Also this method may be inconvenient for participants, because they have to make time to receive phone calls at certain times [137].

Self-administered surveys have been used in a number of research areas such as asthma, smoking cessation and pain research [70]. The questions that are used in household surveys can be adapted from an interviewer-administered format to a self-administered format [61,138]. Thereby, self-administered household surveys could overcome some of the challenges that interviewer-administered household surveys face. A questionnaire can be sent to participants who complete the questions at a time more convenient to themselves. Also self-administered surveys could reduce the number of field visits and do not require interviewers, which could result in a significant reduction in costs and resources. These savings could be used to conduct surveys more frequently on a larger scale.

The different media for self-administered surveys include: post; the Internet; apps; interactive voice response calls (voice messages); and text messages. Postal surveys, in which participants are asked to complete a questionnaire delivered to their homes by post and return the questionnaire by post, have been the traditional method for self-administered surveys in high-income countries [136]. While this method offers some advantages, it is slow, requires data double data entry, has the risk of letters getting lost and still requires a moderate amount of resources. Moreover, postal surveys are not feasible in many low- and middle-income countries where many people do not have access to a post box.

Data quality and mode of administration

Lee *et al.* provided a comprehensive review of data quality with the following measures: accessibility; appropriate amount; believability; completeness; concise representation; consistent representation; ease of operation; free of error; interpretability; objectivity; relevancy; reputation; security; timeliness; and understandability [139]. Relevant to surveys, the main indicators identified by De Leeuw and van der Zouwen (indicator i-v) and Bowling (indicator vi) are: (i) accuracy of the response; (ii) absence of social desirability bias (the proportion of socially desirable answers to a question); (iii) data equivalence (similarity of the responses); (iv) amount of information; (v) item response (the proportion of responses for each question) [136]; and (vi) completion rate (number of completed interviews divided by the total number of interviews) [65].

There are different potential biases that influence data quality which can occur by mode of questionnaire administration, including face-to-face and telephone for interviewer-administered questionnaires and electronic (Internet, email, phone) for self-administered questionnaires. Effects that bias responses are larger between different modes of administration than the medium to deliver the questionnaire Bias can be caused by non-measurement and measurement errors [65].

Non-measurement errors occur when no measurements can be made on some of the target population and encompass non-coverage and non-response errors. Non-coverage errors occur when participants have no chance of being selected for the survey and are related to the survey design and sampling. Non-response errors occur when participants do not participate or partially participate and comprises the item response rate and completion rate [129].

The coverage rate is influenced by the availability of up-to-date information about the target population. Face-to-face surveys generally have more complete population coverage for sampling than electronic self-administered surveys, because electronic surveys rely on access to a device [65].

The response rate is influenced by people's unavailability or unwillingness to participate, researchers' inability to reach participants and communication barriers. Interviewer-administered surveys require field visits and reaching people face-to-face, which may be difficult. However, self-administered surveys often have greater non-response, because participants need to be able to use the electronic self-administered survey method. Also literacy is required to complete a self-administered survey that is based on written texts [65].

In the current household surveys, often a response rate of at least 90% is achieved [67]. However, in the Chinese study setting, a response rate of 70% is not unusual [138]. A response rate of around 60% may be realistic for self-administered surveys, depending on the context [140]. The item-response rate and completion rate of self-administered surveys are generally lower than the response rate for interviewer-administered surveys, because self-administered surveys depend on participants' initiative. Interviewers can motivate participants in interviewer-administered surveys [65]. However, when questions are answered in self-administered surveys, the responses tend to be of higher quality [141].

Measurement error can be defined as "*the difference between the value of a characteristic provided by the respondent and the true (but unknown) value of that characteristic*" [141]. Measurement errors are related to the participant, interviewer, questionnaire and data collection process [65,141].

The mode of a questionnaire influences the cognitive burden for participants to answer a question. Cognitive demands for participants include understanding the question, recalling the requested information from memory, evaluating the link between the retrieved information and the question and communicating the response. Interviewers can explain questions that are unclear to participants, motivate participants to answer questions and help them recall information in interviewer-administered surveys. There is generally no direct option for feedback on questions in self-administered surveys. Hence, interviewer-administered surveys have the least cognitive burden of participants and reduce recall bias [65].

In self-administered surveys, answer options are usually provided and the participant has to make the decision about the most appropriate answer. These surveys are influenced by bias if participants misread or misinterpret questions and instructions. The way the questions are worded and the way the questionnaire is formatted can affect responses to questions. Therefore, self-completion surveys, perhaps even more than interviewer-administered data collection, require excellent questionnaire design and formatting and clearly written questions [141].

Interviewers can introduce bias to surveys as their performance may vary from interview to interview. Moreover, participants may be less willing to disclose information to an interviewer, especially when there are other people present during the interview. Interviewers have shown to influence the response participants give and particularly for sensitive questions, for example about income. Also participants may be more likely to say "yes" in interviewer-administered surveys. Self-administered surveys are not influenced by variance between interviewers and have a lower risk of "yes" responses and socially desirable answers [65,136].

Text messaging data collection

The previously described increase in use of information and communication technologies has provided new opportunities for self-administered data collection. In high-income countries, email and online self-administered surveys have been used [142] and more recently, the widespread use of smartphones has facilitated data collection via apps [143,144]. However, these methods are currently not feasible in many low- and middle-income countries where computers and smartphones are not ubiquitous. Self-administered surveys in the form of interactive voice response calls have been used in these countries. In contexts with low literacy rates, voice messages are preferable over text messages [145]. However, voice messages are less private and it takes considerable training and time to complete an interactive voice response survey [146]. Moreover, voice messages depend on spoken language, which may vary more between settings than written texts [145]. Also, developing voice messages requires significantly more resources and time compared to developing text messages, because the length of the message, speed of delivery and tone of the voice have to be taken into consideration to achieve acceptability and comprehension of participants [145]. Therefore, in settings where literacy is high, text messages are a more practical approach that is easier to scale-up compared to voice messages.

The following paragraphs explain how text messaging data collection could overcome the challenges of the current face-to-face data collection method, describe some considerations for text messaging data collection and how this method could be used in the Chinese setting of this research.

Advantages

Field visits would not have to be conducted for text messaging surveys, because text messages can be sent from a central location at low cost. Thereby, resource-constraints could be overcome by dramatically reducing costs of personnel, transport, equipment, consumables and other costs. These resources could be invested either in increasing the coverage of surveys or used as an incentive for participants. When mobile phone numbers are obtained, text messaging surveys could overcome problems of accessing households. This could potentially lead to an increased representativeness of hard-to-reach populations.

Text messages can be sent across mobile phone operating platforms, including both simple mobile phones and smartphones. Thereby, text messages could be sent to as many caregivers as possible to increase the sample size. Also surveys could be conducted more frequently, for example every three months, to assess care-seeking for childhood illnesses in various seasons. Data could be collected in real-time as text messaging takes place instantly. Moreover, text messaging surveys are not influenced by bias caused by interviewers and participants can respond at a time and place of their convenience [147].

Considerations

The first step in recruiting participants for a text messaging survey is collection of names and mobile phone numbers. While obtaining lists of names is a challenge for all types of surveys, text messaging data collection faces an additional challenge because mobile phone numbers have to be obtained. Lists of mobile phone numbers may not be available, accurate, or complete in many low- and middle-income countries [61]. In addition, text messaging surveys are dependent on coverage of mobile phone networks, access to mobile phones, practices of shared mobile phones, payment for mobile phone usage, usage of text messaging and illiteracy [61]. Moreover, response rates for self-administered surveys are often lower than for interviewer-administered surveys. All these factors can introduce non-measurement bias to surveys. Therefore, the coverage rate, response rate, item-response rate, completion rate and influencing factors need to be assessed for text messaging surveys.

In addition, measurement bias could be considerable for text messaging data collection. Therefore, text messaging surveys have to be validated before they are used to measure child health indicators. As previously described, accuracy of current indicators measured by face-to-face surveys is insufficient for some of the pneumonia and diarrhoea-related indicators [12]. This problem would also occur in a text messaging survey, or even be worsened because caregivers may not understand the survey questions adequately. Text messaging surveys have limitations related to the length of message and lack of communication between interviewers and caregivers.

Moreover, answers to the survey questions are recorded by trained interviewers in face-to-face surveys, whereas participants enter answers themselves in text messaging surveys, which may be less standardised than in face-to-face surveys [147]. Therefore, the text message questionnaires need to be carefully developed so that they are understandable to participants and minimise measurement bias. Also measurement errors should be studied by comparing different modes of data collection [141].

Text messaging data collection in China

In the context of the study setting for this thesis: the rural Zhao County in China, text messaging was found to be the most appropriate alternative data collection method for household surveys. Zhao County has good coverage of mobile phone networks and almost all households have at least one mobile phone [QW, personal communication]. Moreover, illiteracy is low in Zhao County and was 3.76% for mothers in 2010 (data provided by the Zhao County Statistics Bureau, unpublished). An additional important consideration for the study context was that there are many different spoken languages and dialects in China, but only one widely used written text in mainland China: simple Chinese characters (later described in section 3.2.6). Therefore, questionnaires based on written language were preferable over voice-based data collection, because this may facilitate scale-up of data collection.

A preliminary study in the Zhao County showed that text messaging data collection for monitoring an infant feeding intervention and obtaining feeding knowledge was feasible and acceptable to caregivers of young children. Data collected via text messaging had reasonable agreement compared with data collected via a face-to-face survey. The costs of the text messaging survey were much lower compared with the face-to-face survey. However, the text messaging survey had much lower response rates compared with the face-to-face survey. The response rate for the first question was 38.4% for the text messaging versus 68.6% for the face-to-face method. The completion rate (seven questions) was 27.9% for the text messaging versus 67.4% for the face-to-face survey. The main reasons for not replying were that caregivers did not receive text messages, were too busy to reply, or that they did not see text messages in time [138].

Structured summary of section

This section introduced text messaging as a novel way to collect data on care-seeking for childhood diarrhoea and pneumonia in China. In sum:

1. Currently, information on care-seeking for childhood diarrhoea and pneumonia is collected through interviewer-administered face-to-face household surveys;
2. Face-to-face household surveys require a significant amount of resources and are costly. Also data collection faces several challenges related to non-coverage, non-response, sample size, frequency and interviewer bias;
3. Self-administered text messaging surveys could overcome some issues of face-to-face household surveys by collecting data in real-time, on a large-scale and in a convenient and cost-effective way, but both modes of data collection have their advantages and disadvantages that need to be considered;
4. In the context of this study in China with high literacy and mobile phone usage, text messaging may be an appropriate choice for collecting information on care-seeking for childhood diarrhoea and pneumonia. However, a novel text messaging survey requires assessment of measurement and non-measurement errors.

1.4 A review of mHealth-based data collection using text messaging

Overview of section

Following a description of the potential of text messaging for collection of information on care-seeking for childhood diarrhoea and pneumonia in China, this section reviews the evidence on mHealth-based data collection using text messaging. The studies that were found and their outcomes are described. The section concludes by considering gaps in the literature.

1.4.1 Scope of review

The aim of this review was to present the evidence for usage of text messaging for health data collection. Preliminary searches found no studies on text messaging data collection for household surveys in low- and middle-income countries. Therefore, the review included all studies in which text messaging was used to collect information from healthy individuals and patients in all settings. Studies reporting on the following relevant outcomes were included: the response rate; timeliness; data equivalence; feasibility and acceptability to participants; and researchers and costs.

This review excluded studies where health workers were using mobile phones to collect information [148-157]. For example, practitioners undertook influenza surveillance via text messaging, which was compared with epidemiological and clinical data [148]. In addition, a study reporting on analysis methods of repeated text messaging data collection was excluded, because no information on outcomes was reported [158]. Studies that were published after the searches of this review were excluded. This included the previously described text messaging study in Zhao County [138] and studies that were conducted after the study in this thesis and are described later in the thesis [159][YL, personal communication].

This review was not systematic and only undertaken by one reviewer for the English literature (the PhD candidate) and one Chinese reviewer for the Chinese literature (QW). The studies were drawn from extensive previous searches (including >33,000 citations) [53,56,60] covering the *mHealth* literature between 2000 and 2011. An updated search was also conducted to cover the literature up to September 2012.

Relevant search terms ((*phon*, mobil* OR mHealth OR "m health" OR m-health OR eHealth OR telemedicine [MeSH]) AND (data OR information OR collect* OR gather* OR obtain* OR monitor* OR data collection [MeSH])*) were used. Both English language databases (The Cochrane Central Register of Controlled Trials, PubMed, EMBASE, World Health Organization Global Health Library regional index, PsycINFO, Web of Science, MobileActive and Royal Tropical Institute "KIT" Information Portal mHealth in Low-Resource Settings) and Chinese databases (Wanfang Data and China National Knowledge Infrastructure) were searched [71].

1.4.2 Description of studies

A total of 19 studies were found in English literature databases (represented by 21 articles [160-180]: one article [162] had an additional comment paper [163] and one study was described in paper on comparison of methods [178] and feasibility of methods [179]). No studies were found in the Chinese literature. Table 1 presents descriptive information of these studies. The first study was published in 2004 [180]. Most studies took place in high-income countries: Denmark [165,170,174,180]; Australia [161,171,178]; Sweden [166,172,177]; United States [162,167,168]; United Kingdom [164,176]; and Switzerland [175]. Only two studies took place in low-income countries, Uganda [169] and Tanzania [160], and one in a middle-income country, Malaysia [173].

Data were collected mostly for pain [161,166,170,172,174] and alcohol usage [162,175] and for a variety of other purposes: family planning [160]; sexual health [171]; infant feeding [164]; tracking hunger [168]; injuries [165]; irritable bowel syndrome [173]; asthma [180]; antiretroviral therapy adherence [169]; influenza vaccination [177]; day-case analgesia experiences [176]; satisfaction of primary care consultation [178]; and simulated disasters [167]. Data collection took place over different lengths of time varying from two days [176] to 53 weeks [170]. Sample sizes varied from 12 in the feasibility study published in 2004 [180] to 2870 in a pilot study published in 2012 [160]. Ten studies compared text messaging with other methods of data collection [162,164,169-172,175-178], but only four of these studies used a randomised design [162,169,171,178], of which only one took place in a low-income country (including 19 participants) [169]. Half of the comparison studies compared different data collection methods within groups [162,164,170,172,175] and only one of those studies was randomised (including 45 participants) [162].

Table 1 Descriptive information of text messaging data collection studies

First author year	Health purpose	Location	Data collection comparison	Study design	Participants
L'Engle 2012 [160]	Collect family planning information	Tanzania	No method comparison	Data collected during a 10-month pilot of the *Mobile for Reproductive Health programme*	2870 unique users of the programme, 56% male, 60% were aged 29 years or younger
Macedo 2012 [161]	Monitor patients with low back pain	Australia	No method comparison	Observational study nested within a randomised controlled trial over 12 months	105 trial participants, 41% male, aged 18-24 years
Suffolleto 2012 [162] Comment paper [163]	Collect alcohol drinking data	United States	Within group: text messaging versus 28 day calendar-based recall method	-Randomised controlled trial with 3 groups: (i) intervention group with text message feedback; (ii) assessment group with no feedback; and (iii) control group (no alcohol-related text messages) -Data collection over 12 weeks	45 young adults identified as hazardous drinkers and owning mobile phone, 36% male, average of 21 years
Whitford 2012 [164]	Monitor infant feeding	Scotland, United Kingdom	Within group: Text message versus text message, versus telephone call within 24 hours, versus same data collected from other sources and versus related measures	Data collection during a cohort study over 16 weeks	355 women from a cohort of recently delivered women, median age 29 years
Moller 2012 [165]	Assess injury incidence in elite handball players	Denmark	No method comparison	Prospective cohort study over 31 weeks	342 elite handball players, 37% male, 38% aged younger than 16 years

Axen 2012 [166]	Monitor low back pain	Sweden	No method comparison	Prospective observational study over 6 months	262 patients with nonspecific low back pain, 52% male, median age 44 years
Magee 2011 [167]	Collect data during simulated disaster events	United States	No method comparison	Pilot project over 6 months	63 students, 25% male, median age 25 years
Schembre 2011 [168]	Track hunger ratings	Hawaii, United States	No method comparison	Feasibility study over 7 days	Convenience sample of 15 males (n=2) and females (n=13), age 21 years
Haberer 2010 [169]	Collect antiretroviral therapy adherence data	Uganda	Between groups: -text messaging group -interactive voice response group	-Randomised study -Data collection over 3-4 weeks followed by qualitative interviews	19 trial participants (caregivers of human immunodeficiency virus-infected children), 10% male, median age 34 years
Johansen 2010 [170]	Monitor patients with low back pain	Denmark	Within group test-retest: text messaging versus retrospective telephone interview (recall past week, month and year)	Data collection over 53 weeks	25 patients with low back pain, mean age 41 years
Lim 2010 [171]	Collect sexual behaviour information	Australia	Between groups: -text messaging group -online diary group -paper diary group	Randomised controlled trial over 3 months	72 participants, 24 in each group, 28% male, median age 21 years
Alfven 2010 [172]	Monitor children with recurrent pain	Sweden	Within group test-retest: -first verbal data collection in presence of physician -second text messaging	-Test retest procedure with 3 day interval to measure reliability -Response rate over 7 days -Assessment of validity of scale	-Response rate: 15 children with recurrent pain, mean age 12 years -Validity: 37 children, 16 boys, median age 13 years -Reliability: 20 children, 11 boys, median age of 12 years
Kew 2010 [173]	Collect Irritable Bowel Syndrome symptom data	Malaysia	No method comparison	Cross sectional study conducted during a double blind randomised controlled trial, 10 weeks	38 undergraduates with Irritable Bowel Syndrome in a private medical university, 20 males, mean age 22

Kongsted 2009 [174]	Monitor patients with low back pain	Denmark	No method comparison	Longitudinal pilot study over 18 weeks	110 patients with low back pain, 50% male, mean age 43 years
Kuntsche 2009 [175]	Assess alcohol usage	Switzerland	Within group: Internet versus text messaging	Baseline Internet survey and text messaging data collection over 4 weekends	55 French speaking individuals who answered all questions in the Internet survey and participated in the text messaging survey for at least one entire weekend, 33% male, mean age 23 years
Roberts 2009 [176]	Audit day-case analgesia experiences	United Kingdom	Between groups: -first audit postal survey -second audit text messaging survey	Feasibility study, up to 2 days post-procedure	Patients who had undergone day-case surgical procedures: -62 in postal group -25 text messaging group
Bexelius 2009 [177]	Influenza vaccination data collection	Sweden	Between groups: -text messaging survey group -telephone interview group	Feasibility study over approximately one week	-154 participants in text messaging group, 54% male, 60% aged 0-39 years -1009 in telephone group -Random sample of 4550 individuals aged 0–100 years, divided into two groups (2400 text messaging, 2150 telephone) was used
Haller 2009 [178] + Haller 2006 [179]	Assess satisfaction with primary care consultation	Australia	Between groups: -text messaging group -card enquiry group No method comparison	1:1 randomised controlled trial Feasibility study	402 consecutive patients: -193 in text message group -209 in card enquiry group 110 consecutive patients, 35% male, age 21 years
Anhøj 2004 [180]	Monitor patients with asthma	Denmark	No method comparison	Feasibility study over 2 months followed by focus group	12 participants, 6 males, median age 39 years, convenience sample of self-selected participants from a website

1.4.3 Outcomes of studies

Table 2 presents findings on the first three selected outcomes: (i) response rate; (ii) timeliness; and (iii) data equivalence.

Response rate

Apart from one study [170], all studies assessed outcomes related to the response rate. The response rate was reported in different ways, including the item response rate, completion rate, reasons for dropping out and characteristics of participants who responded compared with those who did not respond. The completion rate varied from 15% [177] to 100% [173]. The study with a 15% response took place in a real-life setting. Mobile phone numbers were extracted from telephone directories and for 1055 mobile phone numbers found, only 154 people responded to all three questions [177]. The study in which a 100% response rate was achieved included 38 motived students who answered nine questions. Of 342 responses only 33% were received without reminder; 60% were received a day later after a single reminder; 6% 2-3 days later after 2-3 reminders; and the final two non-responders were tracked down and met face-to-face [173].

One study comparing the completion rate between modes reported a not significantly difference between text messaging (80%) and paper card (86%) data collection on satisfaction with primary care consultation [178]. A study on day-case analgesia experiences reported that the completion rate was 69% postal group and 40% text messaging group, but the response rate in the text messaging group increased to 70% after a reminder was sent [176]. Text message diaries on sexual behaviour had a higher proportion of incompletion compared with paper and online diaries [171].

Timeliness

Some studies reported on timeliness [162,167,168,171]. Text messaging diaries on sexual behaviour were less likely to be submitted late than online diaries (P<0.001) [171]. Studies reported that a high proportion of responses were received relatively quickly: in one study 93% of responses were received within 30 minutes [168], in another study, 70% responded to text messages within 15 minutes and 83% within 60 minutes [172].

Data equivalence

Eight out of the 10 studies that compared text messaging with other forms of data collection assessed data equivalence [162,164,170-172,175,177,178]. Different procedures were used to assess data agreement: kappa was used for categorical (binary) variables [164,171,172]; the Kendall coefficient [171], proportion of agreement and Bland-Altman average difference [162,170], Pearson correlations [162,175] and logistic regression models [177,178] were used for numerical data.

Data equivalence was high when comparing text messaging to: telephone interviews on influenza vaccination [177]; telephone interviews and health visitor interviews on infant feeding [164]; telephone interviews for 1-week and 1-month recall of low back pain [170]; an Internet survey and paper survey on sexual behaviour [171]; verbal assessement of pain in presence of physician [172]; a baseline Internet survey on usual quantity of drinks [175]; and paper cards on satisfaction of primary care consultation [178]. Data equivalence was low for 1-year recall of low back pain by telephone interviews [170], and for a baseline Internet survey about the number of drinks [175] compared with data collected via text messaging.

Table 2 Response rate, timeliness and data equivalence outcomes from text messaging data collection studies

Paper (first author, year)	Response rate	Timeliness	Data equivalence
L'Engle 2013 [160]	-Of 2870 people, 35% (n=995) reported gender, 32% (n=927) age, 29% (n=824) where they learned about the programme, 18% (n=509) an open-ended response -Response rates to the open-ended question were similar across gender, age and promotion point categories -67% of participants answered three or four questions and 33% answered only one or two questions	-	-
Macedo [161]	-Response rates for text messaging alone ranged from 55-74% -Text messaging supplemented with phone interviews ranged from 92-99% - Participants completed a median number of 9 out of 12 assessments via text messaging (interquartile range, 5–11) -No significant effect for any of the following predictors on response rate: age; sex; education level; pain levels at baseline; or pain improvement after 2 months' treatment	-	-
Suffolleto 2012 [162] Baird 2012 (comment paper) [163]	-93% of participants in the assessment and intervention groups replied to the weekly text message drinking questions at least once -73% of participants in the assessment group and 80% in the intervention group completed all 12 weeks of queries	40% of replies were sent within 1 minute in the assessment group compared with 65% in the intervention group	-Agreement between text message and calendar: correlation 0.87 to 0.99 for maximum drinks and 0.73 to 0.97 for days drinking per week -No differences in the proportion of subjects that would be categorised as either heavy drinkers or abstinent
Whitford 2012 [164]	-80% response rate (2372/2952 text messages) -93% participant response rate (329/355 women)	-	-Reliability: kappa was 1.0 for a factual question and kappa was 0.80 for a numerical question -Validity: kappa was 0.92 for text messaging data compared to a phone call within 24 hours and kappa was 0.85 for text messaging data compared with data from a health visitor -Correlation validity was as expected for text responses compared to other demographic and clinical measures
Moller 2012 [165]	Weekly response rate ranged from 85% to 90% over 31 weeks	-	-

Axen 2012 [166]	Mean response rate for the text messages was 83% over 6 months, 90% in first week and 79% in last week -93% participant response rate (244/262 participants)	-	-
Magee 2011 [167]	-Overall response rate of 77% (range 70-86%) -94% of participants responded -Significantly more likely to respond were: participants aged 24-29 (compared to those aged 18-23 years); graduates (compared to undergraduates); and participants with unlimited text message plans (compared to those without)	Median time to receive responses was 13.5 minutes and 80% of participants responded within 90 minutes	-
Schembre 2011 [168]	-Response rate was 75% (12/16 responses), 2 participants had <10 responses -Minor variations by observation day or day of the week	93% of the ratings were received within 30 minutes	-
Haberer 2010 [169]	Text messaging weekly response rate 24% (0–33%) over 3-4 weeks		-
Johansen 2010 [170]	-	-	Test-retest reliability between text message and telephone interview: high proportion of agreement and small Bland-Altman average difference for the 1-week and 1-month recall, but very low proportion of agreement and high Bland-Altman average difference for 1-year recall
Lim 2010 [171]	-Proportion of incomplete diaries: 4% of text messaging diaries; 3% of paper diaries; and 1% of online diaries (P=0.001) -90% (65/72) participants completed the end point: 23/24 from the text messaging group; 22/24 from the online group; and 20/24 from the paper group	Text messaging diaries were less likely to be submitted late than online diaries (P< 0.001)	-Kendall coefficients for numerical data: almost perfect agreement for one question; substantial agreement for three questions; and moderate agreement for one question (the diary collection mode did not affect the correlation) -Kappa for binary categorical variables had substantial agreement on risk classification (kappa=0.74)
Alfven 2010 [172]	All children gave response to all three variables or to none	70% of responses to text messages were received within 15 and 83% within 60 minutes	-Construct validity between 2 scales measuring the same entity was 0.77 -Reliability test-retest: kappa for verbal scale was 0.73 and kappa for Visual Analogue Scale was 0.50
Kew 2010 [173]	-Response rate of 100% during 10 weeks -33% were received on the following Monday without a reminder, 60% were received a day later after a single reminder, 6% 2-3 days later after 2-3 reminders and 2 non-responders were tracked down and met face-to-face	-	-

Kongsted [174]	-101/110 patients responded to the first text message -Follow-up rate declined as the study period went on with 86% in week 6, 78% in week 12 and 70% in week 18 -Drop-outs were more likely to be men, have presented to the chiropractor with acute low back pain and have leg pain in addition to low back pain	-	
Kuntsche 2009 [175]	Most participants (84%) answered all text message questions or left only one question unanswered	-	-Positive Bivariate Pearson correlation for usual quantity of alcohol between baseline Internet data and text messaging data -Not always positive correlation for number of drinks indicated in the text messaging survey over the eight days of the survey
Roberts 2009 [176]	Completion rate was 69% (43/62) in the postal group and 40% (10/25) in the text messaging group which increased to 70% (a further 10) after sending a reminder	-	-
Bexelius 2009 [177]	-40% (344 out of 868) responded to the first question -15% (154 out of 1055 who had a listed mobile phone number) gave answers to all questions -Text messaging gave 14 times higher nonparticipation rate compared with the telephone interview (odds ratio 14), partly explained by low extraction of mobile phone numbers from the telephone directory (44%)	-	No significant difference in data collected via text messaging and telephone interviews
Haller 2009 [178]	Response rate not significantly different between text message (80%) and card (86%)	-	Reported satisfaction not significantly different between text message (93%) and card (88%) when adjusted for clustering
Haller 2006 [179]	-	-	-
Anhøj 2004 [180]	-Half the participants replied to >2/3 of the requested data -Median response rate was 69% -Steady response rate, no signs of decreasing usage over time -Out of a total of 727 study days, there were 423 days (58%) where participants replied to all questions, 31 days (4%) where they replied to some questions and 273 days (38%) where they did not reply at all	-	-

Table 3 presents findings on the second set of three outcomes: (i) feasibility and acceptability to participants; (ii) feasibility and acceptability to researchers; and (iii) costs.

Feasibility and acceptability to participants

Studies required participants to own and be able to use their mobile phones. Some studies reported some information on participants' mobile phone ownership and usage, or on people who had to be excluded because they did not use a mobile phone [161,162,169,178-180]. The study in Uganda found that only 19 out of 121 (16%) participants used a functioning mobile phone and could be included in the study [169]. A study in Australia found that only 12 out of 38 (32%) of people older than 60 years owned and used a mobile phone for text messaging [161].

Overall, text messaging data collection was acceptable to participants [164,166,169,170,179,180] and easy to use [172,173]. However, barriers to using text messaging included ease of use, readability, end user needs (tailoring), privacy, too costly to send text messages, no time to respond to text messages [166] and uncertainty [171] or poor understanding [169] of how to respond. A suggestion for improvement was to have a simpler diary with only one text message [180].

Feasibility and acceptability to researchers

Perceptions of researchers were less frequently reported than perceptions of participants. Text messaging was found to be easy and functional for the collection of large amounts of data [164]. Reported problems were system or researcher errors with sending and receiving text messages [164], inadequate mobile network service [168,179] and inability to send text messages near medical equipment [179].

Costs

Four studies reported very limited information on costs [169,170,172,179] and none of the studies undertook a cost-effectiveness evaluation. While a study published in 2006 reported that sending a text message was more expensive than printing materials [179], later studies reported low costs of sending text messages [169,170,172].

Table 3 Feasibility and acceptability to participants and researchers and cost outcomes from text messaging data collection studies

First author year	Feasibility and acceptability to participants	Feasibility and acceptability to researchers	Costs
L'Engle 2013 [160]	Adolescents and young adults were the heaviest users of the programme among those reporting their age	-	-
Macedo 2012 [161]	-Of 133 participants of a larger trial, 105 (61%) had a mobile phone and 97 (56%) knew how to use text messages and were included -12 out of 38 (32%) people older than 60 years owned and used a mobile phone for text messaging	-	-
Suffolleto 2012 [162] Comment [163]	One participant was excluded because of not owning a mobile phone	-	-
Whitford 2012 [164]	The text messaging survey was found to be convenient and acceptable	-Text messaging was a functional and easy method of gathering a large volume of data -Text messages were sent as scheduled to 92% of participants; however, because of system or researcher errors, 6% were sent the wrong number of texts, 2% had other problems	-
Moller 2012 [165]	-	-	-
Axen 2012 [166]	-Text messaging method was found to be user friendly -Various reasons for drop-out: no explanation (5); impossible to reach by telephone and mail (7); two had neck pain as their primary complaint (2); thought it was silly to answer "0" all the time (1); found the text messages too costly (1); did not have the time to answer (1); or could not remember the degree of bothersomeness (1)	-	-
Magee 2011 [167]	-73% agreed or strongly agreed that they were happy to participate -82% said they would do the study again -10% agreed that the study was a waste of time 71% recommended the study to their friends -47% agreed that they should be compensated for their participation	-	-

Schembre 2011 [168]	-	Of 168 text messages, 3% were undelivered because of mobile service interruptions	-
Haberer 2010 [169]	-31 out of 121 participants of a larger trial owned a mobile phone, 10 either no longer had their own phones or had non-functional phones at the time the study began, one participant had a landline telephone -Poor understanding how to respond to the interactive voice call and text messaging prompts -Lack of understanding during training sessions -Despite problems, technologies were acceptable	-	-Initial set up costs US $1,900 for interactive voice call programming, US$1,000 for text messaging programming and US$300 to establish both systems with local mobile phone network -Ongoing costs US$113 for airtime (US$0.23 per minute and US$0.05 per text message) during the 4-week period
Johansen 2010 [170]	All 25 contactable participants found that a third text message question would have been acceptable	-	-Total costs for text messaging was €9530 (€8700 system lease + €830 for sending text messages) -Text messaging was considerably less costly than a paper-based survey, beyond a threshold number of questionnaires
Lim 2010 [171]	-All but one participant (online group) completed at least one diary -51% preferred online, 38% preferred text messaging and 8% preferred paper -Similar proportions of participants within the text messaging group (70%) and online group (73%) preferred their assigned method -Text messaging participants were more uncertain about how to complete the diary than those in the online group (*P*=0.047)	-	-
Alfven 2010 [172]	-All children had a mobile phone of their own -Children found it easy to describe in figures on text messages their pain intensity, pain duration and pain-related disability	-	Once programmes are built, the costs are low because of use of participants' mobile phones and low costs of text messages
Kew 2010 [173]	-Participants were given the choice between email and text messaging and all chose text messaging -No one reported difficulty using the simple codes to submit symptom reports	-	-

Kongsted [174]	-	No manual entry of data meant fewer human resources and avoiding potential errors	-
Kuntsche 2009 [175]	-	-	-
Roberts 2009 [176]	-	-	-
Bexelius 2009 [177]	-	-	-
Haller 2009 [178]	-Out of 450 young people 409 (91%) had a mobile phone, 7 (1.6%) had to be excluded because they did not want to provide their mobile phone number for research purposes -Several participants sent support and best wishes messages for the trial together with their texted response, none sent negative or unpleasant messages, no comments were found on any of the response cards	-	-
Haller 2006 [179]	-91% (96/110) agreed to participate -91% (87/96) had a mobile phone and 85/87 agreed to provide a phone number for research -No one expressed concern about paying for text message replies	-Could not send text messages near medical equipment because of safety concerns -Inadequate mobile network coverage in the rural practice led to delays in sending messages	Cost of sending a text message (approximately US$0.25) slightly exceeded the usual cost of printed material
Anhøj 2004 [180]	-Participants were enthusiastic about the text message diary; it became an integrated part of everyday life -Participants wished for a simpler diary with only one text message to respond to and a system with a Web interface for system customization and graphical display of diary data history -The self-reported prior experience with text messages was moderate for the majority of the participants; one participant had never used text messaging prior to this study, five were medium users receiving and sending 1 to 3 messages daily, three were heavy users receiving and sending more than 4 messages daily -None of the participants had used a questionnaire based on text messaging prior to the study - For one participant, not having used text messaging before the study was not an obstacle to participation	-	-

1.4.4 Conclusions

Overall, this review showed promising usage of text messaging for health data collection, but the current evidence base is limited. This was particularly the case for low- and middle-income countries, from which only three studies were found. Data were collected for a variety of health-related purposes, but no studies used text messaging for collecting data in household surveys.

Many studies did not compare text messaging data collection to standard data collection methods. Those studies that made comparisons between data collection methods mostly only used small samples or had a non-randomised study design. Some studies included atypical populations which made it hard to generalise their findings.

Outcomes were not consistently reported across studies. Most studies assessed outcomes related to the response rate, which varied hugely depending on the study context. Reminders seemed a useful approach to increase the response rate. Data agreement was often high when comparing text messaging to other forms of data collection.

Some studies reported on those participants that had to be excluded because they did not use a mobile phone and mobile phone ownership and usage of participants. A number of studies showed that text messaging data collection was acceptable to participants, but some barriers to its usage were reported. Text messaging seemed easy and practical for researchers, though some challenges were described. Few studies reported on costs and no studies reported on cost-effectiveness.

Structured summary of section

This section reviewed the literature on mHealth-based data collection using text messaging. In sum:

1. The review included all studies in which text messaging was used to collect information from healthy individuals and patients in all settings. Studies were identified from comprehensive searches of the *mHealth* literature;
2. Nineteen studies were found, of which only three took place in low- or middle-income countries, and none evaluated text messaging for household survey data collection. Many studies did not make comparisons between data collection methods, used a non-randomised design, included a small number of participants or took place in an ideal setting;
3. The results of studies showed variable response rates, some benefits for increased timeliness of data collection, high data agreement when comparing text messaging to other data collection methods, overall acceptability to participants and researchers and little information on costs;
4. Evidence is limited, both in quantity and quality, for the use of text messaging for health data collection, particularly in resource-limited settings.

1.5 Challenges and needs for *mHealth*

Overview of section

After reviewing the evidence on the usage of text messaging for health data collection, this section explains that lack of sound evidence is a common problem in the *mHealth* research field. First, lack of evidence is described as an important reason for low adoption of *mHealth*. Second, gaps in the evidence for *mHealth* are illustrated. Third, some of the requirements for development, evaluation and implementation of *mHealth* are provided.

1.5.1 Low adoption

There is on-going discussion of how innovation can be used to improve health systems around the world [181]. Health systems are notorious for slow and unsuccessful adoption of innovation in information and communication technologies. Lessons learnt from the fields of *telemedicine* and *eHealth* can be applied to *mHealth* [182,183]. However, mobile phones have some distinct differences from the use of web and computer interaction in health care that may facilitate their adoption. Mobile phones are used on a much larger scale compared with other technologies in low- and middle-income countries. Mobile phones are integrated into daily life. In addition, when people own a mobile phone, they often carry their phones with them and leave them on even at night.

Furthermore, a significant part of the innovation that makes use of mobile devices is taking place in low and middle-income countries. This so called “frugal” or “reverse” innovation means that technologies are designed for the needs of low- and middle-income countries, and sometimes are even transferred to high-income countries [181]. For example, the world-leading mobile banking system, named *M-PESA*, was founded by mobile telecom operator Safaricom in Kenya in 2007. It has now been adopted by more than two-thirds of the Kenyan adult population. In 2013, there were 203 million registered mobile money accounts worldwide and almost half of these users were in Sub-Saharan Africa [184]. This has enabled people who never had a bank account before to use banking services [185].

The lack of evidence of the effectiveness of mHealth-based interventions is seen as the most important barrier to their adoption [4,23,33-35,60,186-192]. Additional barriers to *mHealth* implementation include technical, logistical, economic, social and clinical barriers [187]. Technical problems include issues with mobile networks [33], power cuts [33], data transfer and mobile Internet capabilities [35,193,194]. A lack of financial capacity both for people and health care systems limits integration of mHealth-based interventions into the existing health care system [25,33,35,194]. Also, insufficient operational compatibility and standards [33,35], policies to guide practice [33,35] and legal frameworks to protect patient confidentiality [25,33,35,194] have been reported, which result in issues with storage, coordination, aggregation, sharing of data [33] and health information security [33].

Currently very few mHealth-based interventions have been used on a large scale [4,60] despite various actors having expressed enthusiasm for *mHealth*, large investments being made by several international organisations [4,33,195-197] and the industry pushing for scale-up [186]. In 2011, a World Health Organization survey showed that while more than 80% of 114 countries included in the survey reported having at least one mHealth-based programme, approximately two-thirds of these programmes were still at the pilot stage [4]. Many mHealth-based programmes in low- and middle-income countries have been initiated by non-governmental organisations and social entrepreneurships. However, without integration into the health system, they have often been unsustainable [33].

Implementation and scale up of mHealth-based interventions requires sufficient evidence [186,189]. While there is potential for innovation to make health care more efficient, affordable, accessible, patient-centred and safe, evidence for these hypothesised benefits is greatly needed, because innovation can also make health care more time-consuming, costly, unequal, technology-centred and risky. Despite large investments in *eHealth*, there has been quite limited evidence that can show the benefits of technologies and clarity about risks and cost-effectiveness is lacking [32]. A similar situation exists for *mHealth*. Health systems are under high pressure with limited budgets and have to deal with multiple competing health challenges. Without knowledge of the benefits of *mHealth*, policy makers will neither be aware of its importance, nor make *mHealth* part of policy. When sufficient evidence is generated and barriers are resolved, *mHealth* can make a better case for being adopted compared with other competing interventions [4].

1.5.2 Gaps in evidence

No mHealth-based intervention is currently meeting the standards that are required for scale-up. These standards state that evidence for each mHealth-based intervention would have to consist of at least: (i) two high efficacy trials under ideal conditions; (ii) two high quality effectiveness trials in real-life conditions; (iii) dissemination research that confirmed that the intervention can be delivered according to the model that is being tested; and (iv) information about the intervention's costs (as described by Tomlinson *et al.* [186] and adapted by previously reported standards [198,199]).

In the broader context of *mHealth*, a small number of interventions have shown relatively strong evidence, such as text messaging for improving adherence to antiretroviral medication in resource-limited settings [41,193,200] and for increasing smoking cessation in a high-resource setting [37]. Additionally, appointment reminders via text messaging have provided moderate evidence indicating increasing attendance to health care [39,40]. However, evidence for (cost-)effectiveness of these interventions in all settings is unknown. For most other interventions, the evidence is based on a small number of studies that often took place in high-income settings, and used insufficiently rigorous study designs. The following paragraphs illustrate the emerging evidence for *mHealth*.

Mobile phones were already mentioned to have potential to improve the delivery of health care in the 1990s [182]. In 2001, a case of successful usage of text messaging in health care was reported [201]. In 2005, the first systematic review on uses and benefits for text messaging in health care showed that most of the included papers were non-clinical research studies or grey literature reports. Some benefits for the delivery of health were found, but mainly in high-income countries [202]. In 2006, the first review on the usage of mobile phones as a health intervention in low- and middle-income countries was published. Apart from some work in South Africa, there were almost no *mHealth* efforts in low- and middle-income countries. In high income countries, apart from studies on diabetes, health outcomes were rarely assessed at that time [16].

Later reviews undertaken in 2008 concluded that evidence for benefits of *mHealth* was emerging [35,203,204]. However, this was still mainly in high-income settings as out of 30 trials only one took place in a middle-income country (China) [204]. A few years later, *mHealth* reviews on maternal health concluded that while there were potential benefits, there was a need for robust evidence on constraints and impact in low- and middle-income countries [25,50]. Recent rigorous *mHealth* systematic reviews reported that evidence was needed in all settings. Though the number of studies in low- and middle-income countries increased, the number was still relatively small compared to high-income countries [37,58].

The largest number of studies with the most rigorous designs compared to other research areas were found for using mobile devices for data collection in low- and middle-income countries [76]. While a number of these studies showed benefits, no measures that could show impact on health outcomes and programmes after data collection. Also, additional evidence for the usage of *mHealth* in health information systems in low- and middle-income countries is limited [33,60].

Moreover, technology introduction and health care process improvements have been emphasised in the current evidence base, while making the link between theory and effectiveness, behaviour change or health outcomes, has been less explicit [60]. While using a mobile phone for messaging or calling is a straightforward communicative action, its usage in health care involves interaction with the health system, as well as the wider social, legal, political and economic context. This means that mHealth-based interventions are complex interventions, because they consists of both the technology itself and the processes surrounding it [205-207]. Similar to *eHealth*, not enough is known about the social, organisational and cultural elements of successful implementation and adoption of *mHealth* [60,208].

1.5.3 Development, evaluation and implementation requirements

mHealth is a fast-evolving and new research field that has had a relatively short time to develop since the wide adoption of mobile devices over the past 15 years. Previous experiences with use of information and communication technologies in health have not always been used to inform *mHealth* efforts. *mHealth* discussions have been focussed on the technology and neglected the health-related problems [183]. Monitoring and evaluation of *mHealth* has often taken place insufficiently. In 2011, only 12% of surveyed countries by the World Health Organization reported evaluation of *mHealth* initiatives, which were more frequent in high-income countries (23%) than in middle-income (14%) or low-income countries (7%) [4]. Thus, while there have been a large number of *mHealth* projects in a wide range of areas, many have been small-scale pilots that ended without follow-up [34].

Moreover, establishment of rigorous evaluation methods for *mHealth* has been slow. A frequently mentioned barrier for measuring impact of *mHealth* is the methodological challenge for evaluation of mHealth-based interventions [60,209,210]. Generation of evidence for complex interventions requires a significant amount of resources, which may be more difficult to generate in low- and middle-income countries [210]. However, without knowing how and why mHealth-based interventions work, large investments could be wasted on ineffective, repetitive projects that may even do harm [183,189,190].

Some advancements have been found in the *mHealth* literature between 2002 and 2012: (i) evaluation moved from assessment of technology towards assessment of its impact on health outcomes; (ii) the number of published studies per year increased; (iii) the development of interventions has become more accurately described and based on past evidence or theory; and (iv) sample sizes increased [211]. Still, much improvement is needed. A review found more than 50 mHealth-based studies in low- and middle-income countries, but these studies were not delivering the results that were needed to show impact [60]. Efforts have attempted to address these problems with evaluation of *mHealth*, including The mHealth Evidence Workshop of the United States National Institute of Health mHealth Training Institute [190] and The Bellagio eHealth Evaluation Group [212].

Not only more studies, but more importantly, studies of higher quality are needed [212]. *mHealth* efforts need to aim at establishing technological, theoretical and measurement principles. All aspects of mHealth-based interventions need consideration, including inputs, mechanism, output, outcomes and impact, to produce a comprehensive evidence base for how mobile devices can improve health care in low- and middle-income countries [60,183].

The Medical Research Council provided recommendations on development, evaluation and implementation of complex interventions. This process includes different phases of development, pilot and feasibility testing, evaluation and implementation that can take place concurrently and be used to inform each other [205-207]. In the following paragraphs, some of the needs for these phases that can be used for evaluation of mHealth-based interventions, as complex interventions, are described.

mHealth-based interventions require a clear definition and understanding of the problem and its context before addressing technology-related issues [183]. For development of an mHealth-based intervention, the existing evidence needs to be reviewed. High quality systematic reviews are the gold standard. If no review exists, the literature needs to be reviewed and updated when development starts.

Behavioural interventions based on theory or conceptual models have been suggested to increase the likelihood of successful interventions [44,186,204,205,213]. Theory can be defined as "*a set of well-developed concepts related through statements of relationship, which together constitute an integrated framework that can be used to explain or predict phenomena*" [214]. Theories can be tested and differ in this way from models, which main function is to describe and specify relations and processes [215]. Even simple interventions that seem straightforward, such as reminders, need to be guided by theory, because innovative modes of delivery alone can be insufficient to change behaviours [213]. However, specific theories for mHealth-based interventions need to be developed as *mHealth* is interactive and adaptive [213]. Various theories and models have been used for *eHealth* interventions and are relevant to *mHealth* [187,213]. Factors that may constrain people's behaviour, such as usage of mobile phones, needs to be assessed [216].

Both processes and outcomes of the intervention need to be estimated [205]. Principles should be established to identify strategies that can deliver optimal mHealth-based interventions. This can contribute to resources, tool-kits and a framework that can explain how and why certain interventions work or fail needs [186].

Pilot testing needs to take place to assess efficacy of interventions. Feasibility needs to be assessed as acceptability, recruitment and follow-up could be different in real-life compared to pilot settings. The results of these studies need to be fed back into development of interventions to realise their full potential [205]. Also mHealth-based interventions should be made interoperable with existing information and communication technologies in health care and adopt similar standards [183].

Evaluating an intervention includes estimating effectiveness, measuring outcomes and understanding processes [205]. Evaluation of mHealth-based interventions requires a multidisciplinary approach with a range of experts in technology, epidemiology and social sciences [190]. The capacity and competency of researchers needs to be developed to improve quality of research [190,212]. Appropriate study designs from multiple disciplines need to be considered for the different stages of research [186,190,212,213]. For example statistical methods from engineering and computer sciences can facilitate aggregation and analysis of data and provide insights in the vast amount of data that can be obtained [190]. Cost-effectiveness is an important outcome, particularly to support sustainability of mHealth-based interventions [183].

Implementation of mHealth-based interventions encompasses dissemination, monitoring and follow-up [205]. Considering the needs of people rather than the needs of policy makers and doctors is essential for succesful implementation [25,188,217]. Also alignment with local, regional and national health priorities and planning is required for scalability [192]. Ultimately, governments, policy makers and the industry need to cooperate and set principles, legal and ethical standards, policies for funding and coordinate efforts, to create a sustainable environment for mHealth-based interventions [25,212].

Structured summary of section

This section provided an overview of challenges and needs for *mHealth*. In sum:

1. A lack of evidence is an important factor influencing the current low adoption of *mHealth*;
2. The current evidence base for mHealth-based interventions lacks both information on effectiveness and an understanding of how these interventions work;
3. Development and evaluation of mHealth-based interventions require improvements to establish a meaningful evidence base that can guide implementation.

2 Rationale for thesis

Overview of chapter

Following the background chapter, the current chapter describes the rationale for this thesis, which includes reasons for studying the research topic, choosing the field site in rural China, aims and objectives and methodological approach.

Photograph 2 Chinese lanterns

Photograph from the PhD candidate's personal collection

2.1 mHealth-based data collection of information relevant to care-seeking for childhood diarrhoea and pneumonia as research topic

The reasons for studying the research topic were introduced in Chapter 1 and can be summarised as follows:

1. Mobile phones and text messaging are widely used, even in low- and middle-income countries. This has offered a great opportunity for improving the quality and quantity of health information in settings where health information systems are inadequate;
2. Childhood diarrhoea and pneumonia are the leading infectious causes of deaths in children younger than five years. Information on care-seeking is required to guide implementation of appropriate interventions that can prevent most deaths in young children. However, this information is lacking. Therefore, filling the gaps in information on care-seeking for childhood diarrhoea and pneumonia in resource-limited settings is a research priority;
3. Currently, interviewer-administered face-to-face household surveys are used to collect information on care-seeking for childhood diarrhoea and pneumonia, but they cannot provide the information that is needed. mHealth-based self-administered surveys could overcome limitations of face-to-face surveys. In the Chinese study setting of this thesis, text messaging showed promising usage for collecting information from caregivers on their child's health. Text messaging may be used to collect data in real-time, on a large scale and in a convenient, cost-effective way. However, measurement and non-measurement errors need to be taken into consideration;
4. A review of the literature found some benefits, but a lack of evidence on collection of health information using text messaging. No studies assessed usage of text messaging for household surveys and most studies took place in high-income countries. Also studies had methodological shortcomings;
5. In the broader context of *mHealth*, a lack of sound evidence and methodological issues are common. While *mHealth* has been used for different purposes in a variety of settings, there is currently insufficient evidence to support scale-up. Development and evaluation of mHealth-based interventions requires improvement so that sufficient evidence for implementation can be provided.

2.2 Chinese study site

Overview of section

In the following sections, the rationale for choosing the Chinese field site is described. Also ethical approval is provided. Chapter 3 provides more detailed information on the study context.

2.2.1 Field site

A field site in China was chosen for this PhD, because while China is an upper-middle-income country where rapid development has taken place, it still has resource-limited areas that are in need of health improvements. Moreover, mobile phones are widespread in China (see section 3.2).

Chinese researchers (YZ, WW, YL, XD, QW and LC) who were willing to collaborate were found. The Chinese researchers were experienced in conducting interviewer-administered face-to-face household surveys on child health in rural China. They faced challenges with interviewer-administered surveys (which were explained in section 1.3.2) and were interested in using *mHealth* to improve their current data collection methods.

The collaboration combined expertise in child health in China, global child health (IR, University of Edinburgh) and mHealth (JC and the PhD candidate, Imperial College London). The Chinese researchers are based at the Integrated Early Childhood Development Department of the Capital Institute of Pediatrics in Beijing. The Capital Institute of Pediatrics was the first of its kind specialising in child health in China and was set up in 1958. It now consists of a research institute and an affiliated hospital. The Institute has a strong connection with the World Health Organization, United Nations Children's Fund and Chinese Ministry of Health [218].

Zhao county was selected as a field site for this thesis, because the Chinese collaborators had good experiences with conducting research in this county over the past years and were aware of local customs and dialect (slightly different from Mandarin) [71,219-222]. Zhao County is located 280 kilometres south of Beijing in Hebei Province.

Zhao County had been chosen as field site for previous research for the following reasons: (i) the county had a low quality of care for children and high levels of inappropriate feeding practices; (ii) few maternal and child projects had been implemented in the county over the past 20 years; (iii) the socio-economic development of Zhao County is similar to Hebei Province as a whole, which is similar to the national average; (iv) Zhao County has a relatively small migrating population from rural to urban areas compared to other counties, which allowed studying a stable population (data provided by the Zhao County Statistics Bureau, unpublished, 2010); and (v) the Zhao County Health Bureau and Zhao County Maternal and Child Health Hospital showed strong willingness to support quality improvement and good cooperation in research projects. More information on Zhao County is provided in 3.4, including the specific studies that took place in this setting.

2.2.2 Ethical approval

Ethical approval was obtained from both the Capital Institute of Pediatrics Ethical Committee and the Imperial College Research Ethics Committee (Appendix B Ethical approval). Also verbal permission was obtained from the local health officials at the Zhao County Health Bureau and Zhao County Maternal and Child Health Hospital.

2.3 Aim: to explore the application of mHealth-based collection of information relevant to childhood diarrhoea and pneumonia in rural China

Overview of section

The overall aim of the thesis was to explore the application of mHealth-based collection of information relevant to childhood diarrhoea and pneumonia in rural China. This aim had four thesis objectives: (i) assessing the prevalence and factors influencing the usage of mobile phones by caregivers; (ii) determining the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia; (iii) evaluating factors influencing participation in mHealth-based studies; and (iv) exploring ideas for mHealth-based data collection [223]. Each of these thesis objectives had specific study objectives. The rationale for these objectives is explained below.

2.3.1 Objective 1: assess the prevalence and factors influencing the usage of mobile phones by caregivers

The widespread usage of mobile phones in low- and middle-income countries has created a great opportunity for mHealth-based interventions, but there can be disparities in usage of mobile phones in different settings. An understanding of mobile phone usage by target populations is a precondition for effective mHealth-based interventions. However, there is limited research on usage of mobile phones and usage is context-specific [17,183].

Therefore, the first objective of this thesis was to assess the prevalence and factors influencing the usage of mobile phones by caregivers in Zhao County. This was undertaken by: (i) measuring the prevalence of usage of mobile phones; (ii) exploring factors influencing usage of mobile phones; and (iii) exploring usage of mobile phones for health care. Findings were used to inform the following objectives of this thesis.

2.3.2 Objective 2: determine the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia

A novel mHealth-based data collection method needs to produce data that are equivalent or of higher quality than data collected through the standard method [224]. This requires assessment of validity in terms of measurement and non-measurement errors, because the mode of data collection can have effects on data quality, especially when there are different modes of administration (interviewer-administered versus self-administered) [65].

Therefore, the second objective of this thesis was to determine the validity of a novel text messaging survey on care-seeking for childhood diarrhoea and pneumonia. A selection of the most relevant indicators for surveys described in the background were addressed [65,136], because it was not feasible to assess all measures for data quality [139]. An evaluation of the text messaging method took place by assessing: (i) the response rate; (ii) characteristics of responders versus non-responders and completers versus non-completers; and (iii) the error rate (factors affecting the response rate were addressed in objective 3). In addition, the text messaging survey was compared with the face-to-face survey (reference standard) in terms of: (i) data equivalence; (ii) the amount of information in responses; and (iii) reasons for differences in responses.

2.3.3 Objective 3: evaluate factors influencing participation in mHealth-based studies

There are several steps in the recruitment and follow-up of participants in mHealth-based studies where participants may be lost; from collecting mobile phone numbers to completing data collection. However, there is limited understanding about factors influencing these procedures in mHealth-based studies [186].

Therefore, the third objective of this thesis was to evaluate factors influencing participation in mHealth-based studies by: (i) exploring factors influencing recruitment and follow-up in the cross-over study that was undertaken for objective 2; and (ii) providing recommendations that could improve recruitment and follow-up for future studies.

2.3.4 Objective 4: suggest ideas for mHealth-based data collection

The fourth objective was to suggest ideas for three promising areas of mHealth-based data collection: (i) to conduct and validate household surveys; (ii) to measure the burden of disease; and (iii) to monitor large-scale health programmes.

2.4 Methodological approach

Overview of section

This section describes the methodological approach for objective 1, 2 and 3. Objective 4 did not have specific methods as it was based on ideas and therefore is not described here. Objective 1, 2 and 3 each had a specific study linked to them and the detailed methods for each study are described separately in Chapter 4 (objective 1), Chapter 6 (objective 2) and Chapter 8 (objective 3). These three studies were linked to each other to address the overall aim of the thesis in the following way: the findings of objective 1 were used to inform objective 2 and 3, and objective 3 was used to explain the findings of objective 2. Each of these three studies used a mixed methods approach, whereby quantitative and qualitative approaches were combined. The following sections describe the background of the quantitative, qualitative and mixed methods approaches and what specific approaches were used in this thesis.

2.4.1 Background to methodological approach

Quantitative methods

Quantitative research aims to test a hypothesis and uses a deductive approach whereby the relationship between variables is assessed. Variables are measured and numbered data are analysed using statistical procedures. A researcher uses an objective position whilst conducting quantitative research. The procedures of quantitative research are described in detail, thereby allowing replication of the methods by others. The methods aim for validity and reliability that can allow for meaningful interpretations of data. Generalisation of findings to other settings is important. Quantitative research can broadly be categorised in survey and experimental research [225].

Qualitative methods

The goal of qualitative research is to understand social phenomena. Qualitative research is used for exploration and for providing an understanding of the meaning that people give to social events. Qualitative methods were developed in the social and human sciences and have increasingly become accepted in the medical sciences [226-228]. Qualitative methods use an inductive approach, whereby data collection and analysis is used to develop concepts. The design of qualitative research is emergent, meaning that questions can change as more is learnt about the problem [229]. Qualitative description is important for good quantitative research, especially in areas where little previous research has taken place [226].

The role of the researcher and what is known from the literature plays a different role than in quantitative research. Researchers are the key instrument and often collect data themselves by reading documents, observing behaviour or interviewing participants. Data collection often takes place in natural settings where participants experience the phenomena that are explored. Important for rigour in qualitative research are sharing preconceptions and positions (reflexivity), adequate and sufficiently varied sample (transferability), description of an overall framework (interpretation) and transparent and systematic analysis procedures [230,231].

Mixed methods

Mixed methods make use of perspectives of quantitative and qualitative approaches and purposely integrate or combine data that is obtained through them. Thereby, these approaches can complement each other by making use of the strengths of both and answer questions that are inadequately answered by one approach [232,233].

Many different terms have been used for mixed methods, including *multimethod research [234]*, *qualitative and quantitative methods [230]*, *mixing qualitative and quantitative methods [235]* and *mixed methodology [236]* among other terms, but most recent writings use the term *mixed methods* [237-239].

There is no agreed definition of mixed methods [240], but one provided by Creswell and Plano Clark is *"Mixed methods research is a research design with philosophical assumptions as well as methods of inquiry. As a methodology, it involves philosophical assumptions that guide the direction of the collection and analysis and the mixture of qualitative and quantitative approaches in many phases of the research process. As a method, it focuses on collecting, analysing and mixing both quantitative and qualitative data in a single study or series of studies. Its central premise is that the use of quantitative and qualitative approaches, in combination, provides a better understanding of research problems than either approach alone"* [237].

Philosophical ideas or worldviews remain mostly hidden in research, but they need to be identified as they influence the practice of research [229]. A worldview is "*a basic set of beliefs that guide action*" [241]. This means that a worldview describes the general ideas that a researcher has about the world and the nature of research. There are a variety of different worldviews including post positivism (theory verification, typically seen as a quantitative worldview), constructivism (theory generation, typically seen as a qualitative research approach), participatory (change-oriented and related to political change) and pragmatism (real-world oriented, problem-centered). Mixed methods researchers can use these and other worldviews. The pragmatic worldview is particularly applicable to mixed methods, because this worldview is not devoted to any one system of philosophy and reality. Thereby, it can be used for both quantitative and qualitative research strategies.

Pragmatism has a number of assumptions. Researchers acknowledge that research always occurs in social, political, historical and other contexts. Also researchers do not see the world as an absolute unity and thus do not use just one research approach. Thereby, they are free to choose the most appropriate research methods, techniques and procedures according to what is needed to understand the research problem [229].

The usefulness of mixed methods has increasingly become accepted in health sciences [226-228,230,232,233]. Public health problems are often complex as they result from different causes that require an understanding of the socio-cultural, economic and political context. These problems require research that uses a range of quantitative and qualitative methods [226,242,243]. Mixed methods can also be particularly useful to develop and evaluate complex interventions as they can explore different aspects of the intervention, which may provide greater insight [236].

This has resulted in a growth in mixed methods research in books and journal articles in health sciences and other research disciplines [232]. Mixed methods have been used to study a variety of health-related issues in different low- and middle-income countries [244-246], including China [221,247]. However, the presence of mixed methods research in health sciences is still quite limited [239], which may be caused by the challenges that this approach can bring to research. The researchers involved need to be familiar with both quantitative and qualitative research. Also data collection may be more extensive and data analysis more time-intensive, because both quantitative and qualitative data are used [232].

Several aspects influence the design procedures of a mixed methods study. Firstly, collection of qualitative and quantitative data can take place at the same time (concurrently) or in phases (sequentially). In cases where the data is sequentially collected, either the quantitative or qualitative data collection comes first and is followed by the second approach. The data that is collected through the first approach can be used to guide the second approach [229,232].

Secondly, different weight or priority can be given to quantitative and qualitative procedures in a study. Equal weight can be given or one of the procedures can be given more weight.

Thirdly, *when* and *how* mixing occurs needs to be considered. Mixing can take place during different phases of a study - data collection, analysis, interpretation - or during all phases. Phases can be mixed by integration, whereby different sources of data can be compared at the interpretation phase. Also mixing of data can be connected between different phases to guide further sampling, data collection and analysis. In addition, these phases can be embedded into a larger study with a different function than the primary study to explain results of analysis of the larger study [229,232].

2.4.2 Use of mixed methods in this thesis

A mixed methods approach was considered as most appropriate to address the aim and objectives of this thesis. Text messaging data collection is complex, because it involves several interacting components, including tailoring to the study context, different actors (participants, health workers, researchers, policy makers and industry), behaviours of people and assessment of a range of outcomes. As described in section 1.5.3, the development and evaluation process of complex interventions requires both an understanding of processes and evaluation of outcomes, for which both quantitative and qualitative methods can be needed [206].

Table 4 shows an overview of the thesis objectives, study objectives, approaches and mixing in this thesis. The following sections describe the rationale for these in detail.

Approaches used for objective 1

To assess the prevalence of usage of mobile phones, a quantitative approach was required, because prevalence is a numerical outcome. To explore factors influencing usage of mobile phones, a qualitative approach was used, because there was limited understanding of these factors and this approach is particularly useful to provide understanding in under-explored research areas [226].

A concurrent mixed methods study took place in which quantitative and qualitative data were collected around the same time. Equal weight was given to the data. Mixing occurred by integration; the intent of the study was to compare and integrate quantitative and qualitative data in the phase of interpretation. The results of this study were used to guide the following objectives of the thesis.

The quantitative approach was a survey, which is well-suited for descriptive studies that aim to gather information on phenomena [248]. Surveys were previously described in section 1.3.

Semi-structured interviews were used as qualitative approach. In a semi-structured interview, a researcher talks about a topic with a participant using an interview guide that contains open-ended questions covering areas of research interest. Usually these interviews take place in people's natural settings. The use of open-ended questions ensures that the direction of the interview goes towards the participants' views and not towards perceptions of the researcher [249,250].

Focus groups were considered as an alternative approach. Focus groups are a form of a group interview that usually involves six to ten people with similar backgrounds. Focus groups use communication between people in a group to provide insights. Advantages of focus groups are their cost-effectiveness, improved data quality when participants check and balance each other's ideas and a quick assessment of the diversity of views. Drawbacks of focus groups are the limited number of questions that can be asked, extensive skills required for the moderator (interviewer), confidentiality issues and difficulty with identifying contrasting views from the minority of participants. Focus groups were considered less appropriate, because they require people to openly discuss their views and it was anticipated to be difficult for participants to freely speak about their views in the Chinese study context. It was unknown what views participants had and a group discussion may have inhibited participants to talk when they had contrasting views. Individual interviews were considered as more appropriate, because they made it easier for participants to share their personal views, especially when these were different [250].

Semi-structured interviews were preferred over in-depth interviews. In-depth interviews use an unstructured approach and usually focus on one or two specific topics. Little was known about the research topic and semi-structured interviews allowed for exploration of a range of topics [249,250].

Approaches used for objective 2

To determine the validity of the novel text messaging survey on care-seeking for childhood diarrhoea and pneumonia, the text message survey had to be developed and tested. The current standard face-to-face questionnaire had to be transferred to a text message format. This process required moderate modification of the questionnaire, because the questions had to be worded differently to make them fit into a text message format. This may have changed the meaning of the questions and may have influenced comprehension of the questions by participants. Also, as described in section 1.3.3, there are different cognitive processes involved in interviewer-administered and self-administered surveys. Recommendations have been developed to support measurement equivalence between different modes of data collection by the International Society for Pharmacoeconomics and Outcomes Research. The level of evidence needed for moderate modification includes cognitive interviewing, usability testing (qualitative approach) and equivalence testing (quantitative approach) [224].

A sequential study took place in which first the qualitative and then the quantitative data were collected. Equal weight was given to the data. Mixing occurred by connection; the intent of the study was to first analyse and interpret the qualitative data, which were then used to guide the quantitative study.

The qualitative approach involved cognitive interviewing and usability testing. Cognitive interviewing is a technique that can be used to evaluate potential questions and improve validity of data that is being collected. This allowed for checking caregivers' understanding of the meaning of questions and that meanings were existent across caregivers [141,251]. Usability testing aimed to evaluate whether participants could correctly respond to text messaging questions and took place both during the cognitive interviews and during a pilot [224]. Based on the results, the final questionnaire that was used in the quantitative study was developed.

The quantitative approach encompassed a feasibility study using a cluster randomised cross-over study design to compare the face-to-face survey (reference standard) and text messaging survey.

Clustering meant that interventions were assigned to groups (villages) rather than to individuals (caregivers). This was desirable because contamination bias may have occurred when people shared their experiences within a group and individual randomisation was not possible because of organisational reasons. The cross-over design meant that caregivers either completed the face-to-face survey first and then the text messaging survey (group 1) or the other way around (group 2) [224]. The intervention was assigned based on a random procedure so that bias from assigning certain villages to group 1 or 2 could be prevented. This study was a feasibility study as it was the first to study validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia. It was aimed to test equivalence of each question in a survey separately so that problems for specific questions could be identified.

A test-retest study design was used in the previously conducted study in Zhao County on text messaging data collection in which questions for monitoring an infant feeding intervention and assessing feeding knowledge were used [34]. However, a cross-over design was considered more appropriate than a test-retest design to allow assessment of whether differences were mode related and not influenced by whether caregivers gained experience or lost interest by previously answering the questions. Another design that was considered was a parallel study in which one group completed the face-to-face survey and the other group the text messaging survey. This was not feasible, because a parallel design only allows for comparisons of mean values of the data between groups and no mean values were aimed to be calculated [224].

Only four of the outcomes were part of six indicators for data quality for surveys [65,136]: data equivalence (similarity of the responses); amount of information; item response rate; and completion rate. Two quality indicators could not be assessed: a validity check of the data against the true values; and the absence of social desirability bias (the proportion of socially desirable answers to a question).

Approaches used for objective 3

To explore factors influencing participation in mHealth-based studies, views of different people who were involved in the cross-over study (objective 2) were seen as valuable, because they could explain factors from different points of view [212].

Participants of the cross-over study, researchers and village doctors were considered to be the most relevant actors, because they were directly involved in the cross-over study. A qualitative approach was considered most appropriate to provide in-depth insights into people's views, while a quantitative approach allowed assessment of known factors on a larger sample size. However, views of village doctors were not presented in this thesis, because the decision to conduct interviews with village doctors was made after submitting the protocol for this PhD thesis to the Imperial College Research Ethics Committee. The interviews with village doctors were approved by Capital Institute of Pediatrics Ethical Committee and the methodology and results were reported elsewhere [252].

A concurrent study took place where data collection was embedded in the cross-over study and was used to explain findings from objective 2.

Reported in this thesis are structured interviews that were conducted with participants of the cross-over study. They aimed to explore factors that were thought to influence participation based on the results of objective 1 and to provide more in-depth insights into participants' experiences and explore new factors. Therefore, these interviews contained a mix of both closed questions (quantitative) and open-ended questions (qualitative).

Closed questions were a suitable method to study known factors, because though these questions are often used for descriptive purposes (as was described for the survey of objective 1), they can also be used for exploring aspects of a situation [248]. Open-ended questions were used to study new factors and used similar principles as was described for the semi-structured interviews of objective 1. Other approaches were considered less suitable for the previously explained reasons.

Observations and experiences during field work were used to provide a perspective from researchers. Field work experiences aim to describe the setting, activities, people and meaning of what was observed. Quality can be achieved through prepared observers who make factual and accurate descriptions. Advantages of observations include obtaining an understanding of the context, allowing the observer to be open, seeing things in a different way and learning things that people would not mention in interviews. Therefore, observations were chosen to capture field work experiences [253,254].

Table 4 Objectives and usage of mixed methods in this thesis

	Thesis objectives	Study objectives	Strategies of inquiry	Mixed methods Timing	Mixed methods Mixing
1	Explore the prevalence and factors influencing usage of mobile phones by caregivers	-Measure the prevalence of usage of mobile phones -Explore factors influencing usage of mobile phones -Explore usage of mobile phones for health care	Survey among caregivers Semi-structured interviews with caregivers	Concurrent: Data collection for both approaches around the same time	Integrated: -collection, analysis and interpretation of data for both approaches separately -comparison and integration of results of both approaches
2	Determine the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia	-Develop and test the text messaging survey -Assess the response rate, characteristics of responders versus non-responders and completers versus non-completers and error rate of the text messaging survey -Compare the text messaging survey to the standard face-to-face survey in terms of data equivalence, amount of information and reasons for differences	Usability testing, cognitive interviewing and pilot with caregivers Cluster randomised cross-over study among caregivers	Sequential: First, collection of qualitative data Second, collection of quantitative data	Connected: Collection, analysis and interpretation of qualitative data to inform collection of quantitative data
3	Evaluate factors influencing participation in mHealth-based studies	Explore factors influencing recruitment and follow-up in objective 2 and provide recommendations for improving recruitment and follow-up	Structured interviews with participants of cross-over study Observations of researchers involved in cross-over study	Concurrent: Data collection for both approaches around the same time	Embedded in objective 2: Collection, analysis and interpretation of quantitative and qualitative data separately

Structured summary of chapter

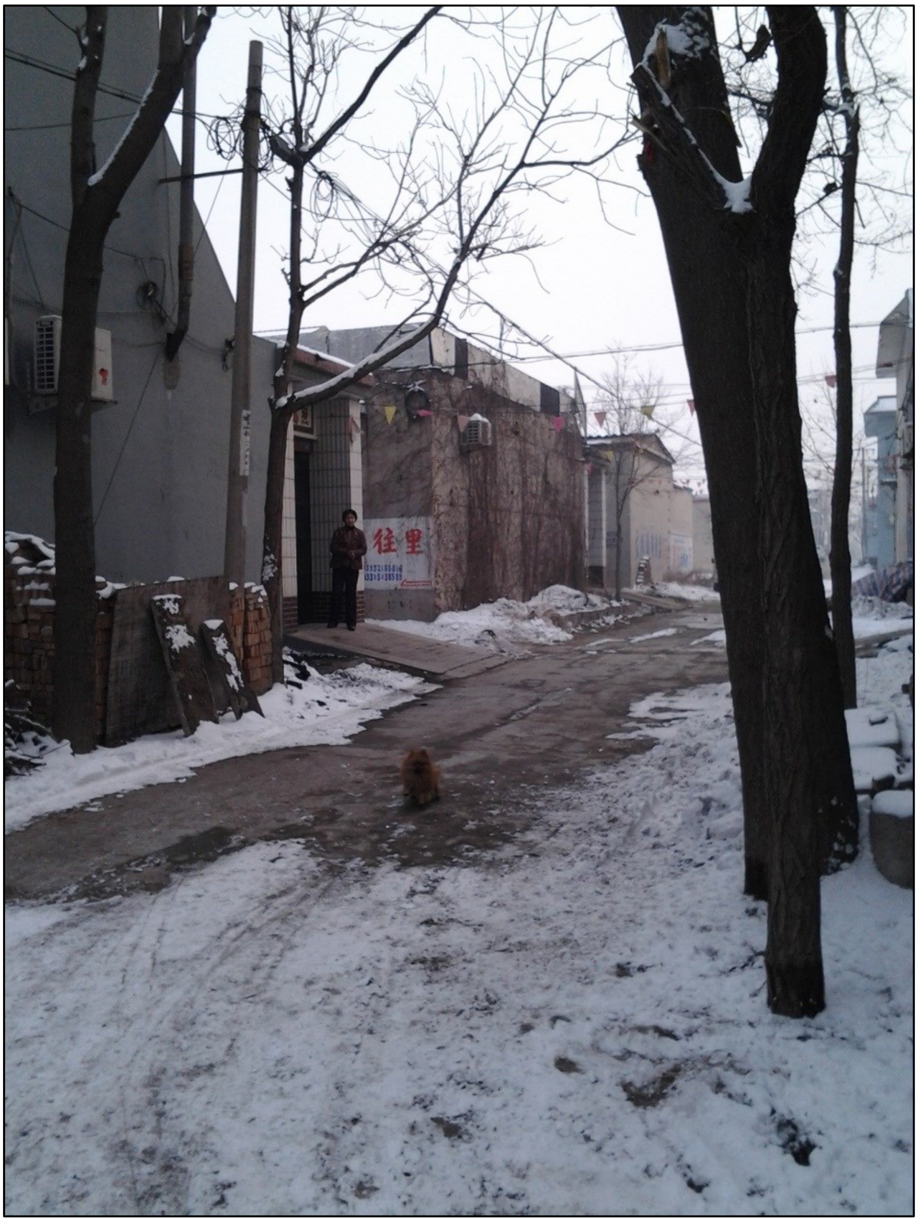
This chapter described the rationale for this thesis. In sum:

1. mHealth-based data collection of information relevant to care-seeking for childhood diarrhoea and pneumonia was chosen as research topic, because mHealth-based data collection, and specifically text messaging, has potential use to fill gaps in information in low- and middle-income countries, but was previously unexplored;
2. A field site in China was chosen for this PhD, because while China is an upper-middle-income country where rapid development has taken place, it still has resource-limited areas that are in need of health improvements. Collaborators in China were found who faced challenges with conducting household surveys on child health and were interested in using *mHealth* to improve data collection;
3. The aim of the thesis was addressed by four main objectives that were linked to each other sequentially;
4. A mixed methods approach, whereby quantitative and qualitative approaches were combined, was considered as most appropriate to address the aim and objectives of this thesis, because of the complexity of developing and evaluating mHealth-based interventions.

3 Study context

Overview of chapter

Following the chapter describing the rationale of this thesis, this chapter provides an understanding of the Chinese context in which the study took place. It starts by describing the PhD candidate's background and experiences related to China. Then a short introduction to China and *mHealth* in China is given. Lastly, the field site, Zhao County, is described [223].



Photograph 3 Street in Zhao County

Photograph from the PhD candidate's personal collection

3.1 The PhD candidate's background and experiences related to China

The researcher's "backpack", including previous experiences, shape and influence research and are therefore need to be clarified [230]. The PhD candidate was born and brought up in the Netherlands and her native language is Dutch. She moved to the United Kingdom in April 2010 and has since acquired professional proficiency in the English language. The PhD candidate did not visit China and had few preconceptions about China before starting her PhD. She did what she could to prepare visits to China by reading literature and watching movies about China and speaking to people who had been in China, though realising that this would not be anything compared to visiting China.

The PhD candidate made five visits to China between February 2012 and April 2013. During the first visit, a week in February 2012, the PhD candidate met the Chinese researchers and discussions about collaborative research were initiated. After this first visit, two Chinese researchers (YZ and QW) visited Imperial College London and the University of Edinburgh for a week in March 2012 to further establish the collaboration. QW stayed for one month in April 2012.

Photograph 4 QW and YZ during a visit to London

Photograph courtesy of Dr Laura Gunn, personal collection

The PhD candidate's second visit to China took place during a week in May 2012. She attended meetings at the United Nations Children's Fund in Beijing and discussed further collaborative research plans with the Chinese researchers and second supervisor (IR).

During the third visit in June and July 2012, the PhD candidate attended a PhD-related course organised by Imperial College's graduate school at Tsinghua University in Beijing. After the course, she taught English to first-year Tsinghua University students during a one-month summer camp at Tsinghua University, from which she gained insights into the perspectives of young students who came from all over China.

During the fourth visit, three weeks in October and November 2012, the PhD candidate presented her PhD-related work at the United Nations Children's Fund in Beijing.

The last visit lasted for three months between January and April 2013, during which the majority of the field work for this thesis took place. The PhD candidate was present during the semi-structured interviews and cognitive interviews in Zhao County and was based in Beijing during the cross-over study (described later in section 2.4.2).

During the PhD candidate's first, fourth and fifth visit to China, she was welcomed and hosted by the Chinese researchers in Beijing. The Chinese researchers helped the PhD candidate to obtain insights into the Chinese study context. In addition to the discussions about planning and organising the research, various aspects of Chinese culture and life were discussed. WW provided accommodation to the PhD candidate during the fourth and fifth visit. The PhD candidate worked at the Capital Institute of Pediatrics in Beijing during her visits, apart from trips to the Zhao County field site.

Photograph 5 Park in Beijing

Photograph from the PhD candidate's personal collection

During the fourth and fifth visit to China, the PhD candidate visited the Zhao County field site three times. During the first visit to Zhao County, the Chinese researchers and the PhD candidate met the local health officials who approved of the study. During the second and third visit, the PhD candidate participated in the interviews that took place for objective 1 and 2 of the thesis.

Initially, a journey from Beijing to Zhao County (280 kilometres) involved a train journey from Beijing to Shijiazhuang City (the Provincial capital of Hebei Province, with an estimated 10 million inhabitants) of approximately two hours, but later this travel time was halved with a newly built high-speed train. Travelling from Shijiazhuang to the main town in Zhao County, named Zhaozhou City, took approximately an hour by car. The visits were essential to gain insight in how people in a rural context in Northern China lived. When the PhD candidate visited Zhao County local people sometimes asked her where she was from, what she was doing and if she could teach them English.

Prior to visiting China, the PhD candidate did not have the opportunity to learn Mandarin because of time constraints. Whilst visiting China, the spoken and written language with the Chinese researchers was English. This was welcomed by the Chinese researchers, because it provided an opportunity for them to improve their English language skills. After the PhD candidate's last visit to China, she acquired beginner-level proficiency in Mandarin and can read and write some Chinese Characters.

Photograph 6 The PhD candidate and a child during field work

Photograph from the PhD candidate's personal collection

3.2 A brief introduction to China

Overview of section

This section provides a brief introduction to China in terms of geography, history, development, population, language and health. These aspects are important to better understand the broader study context. While numerous additional aspects can be described about China in much greater detail, these go beyond the scope of this thesis.

3.2.1 Geography

China is located in Eastern Asia and is one of the biggest countries in the world with a surface of approximately 9.6 million km^2, which is roughly 40 times larger than the surface of the United Kingdom. Despite China's enormous size, the whole of China uses one time zone, China Standard Time, throughout the year (Greenwich Mean Time plus eight hours without summer time). China's capital Beijing is located in the North of China and is surrounded by Hebei Province. The administrative levels are national, provincial, prefectural city, county, township and village. At provincial level, there are 22 provinces, four municipalities (Beijing, Tianjin, Shanghai and Chongqing), five autonomous regions (Uyghur, Inner Mongolia, Tibet, Ningxia Hui and Guanxi Zhuang) two special administrative regions (Hong Kong and Macau) and the claimed Taiwan Province [255].

3.2.2 History

China's history goes back more than 4000 years and is one of the oldest in the world. The Shang Dynasty, circa 1700–1046 before Christ, was the first Chinese state for which clear written records were found. China's first emperor, Qin Shi Huang, ruled from 221-206 before Christ and was followed by many dynasties. The last dynasty, the Manchu Dynasty, ended in 1912 when Sun Yat-Sen founded the Republic of China. In 1949, the Communists under Mao Zedong founded the People's Republic of China. Mao Zedong ruled China until his death in 1976, during which China was largely closed off from the West. In 1978, communist leader Den Xiaoping took over and led China from a centrally planned towards a market economy [256].

3.2.3 Development

After the introduction of a market economy, China's economy grew dramatically with growth rates averaging 10% and the country is now the world's second largest economy after the United States [257]. Still China remains an upper-middle-income country where almost 100 million people lived below the national poverty line at the end of 2012 [258]. However, China has reached most MDG targets and the remaining ones are within reach. Between 1981 and 2008, poverty was reduced from 84% to 13%, meaning that 500 million Chinese people are not considered poor anymore. A huge contributor to this reduction has been China's internal migration – meaning that people move from rural to urban areas – because only a very small percentage of people in urban areas are considered poor [259]. China's internal migration is the largest in history. Although the numbers are not precisely known, there are now at least an estimated 170 million migrants [260]. While 30 years ago 20% of Chinese people lived in urban areas, this is now around 54% and estimated to rise to 70% in 2030 [261]. Migrants generally move out of their hometowns in rural areas to cities in urban areas to find work, such as in factories. This has made a huge contribution to China's export industries; for example, around 50% of the 1.8 billion mobile phones that were distributed around the word were made in Guangdong province in 2011 [262].

3.2.4 Population

There are approximately 1.3 billion Chinese people, which makes one in five people in the world Chinese [263]. The Communist Party still governs China and introduced two major policies to control its population. Firstly, to control internal migration and prevent Chinese people from moving to urban areas, Mao Zedong introduced a household register system - the *Hukou* system - in 1958 [264]. This system divides people into those having either a rural or an urban *Hukou*. The *Hukou* is assigned at birth and does not change automatically when a person migrates within China. Only on rare occasions someone with a rural *Hukou* can obtain an urban *Hukou* when moving to an urban area. The *Hukou* system enlarged inequalities in Chinese society that were already present, because people with an urban *Hukou* receive more benefits than people with a rural *Hukou,* while incomes were already generally higher in urban areas compared to rural areas. Only an estimated 20% of migrants have formal contracts, which allow them to receive health insurance [265].

Secondly, Den Xiaoping introduced the “one-child policy” in 1979. This policy restricts many parents to having only one child and enforces fines when they have more children. This policy has prevented an estimated 400 million births since its introduction. Several reforms have been introduced easing the policy. For example, ethnic minorities are exempted from the policy and parents in rural areas are allowed to have a second child if the first child was a girl. Also parents are allowed to have a second child if they were both an only child. The most recent reform was introduced at the end of 2013, and now parents in both urban and rural areas are allowed to have two children if either one of them is an only child [266].

3.2.5 Language

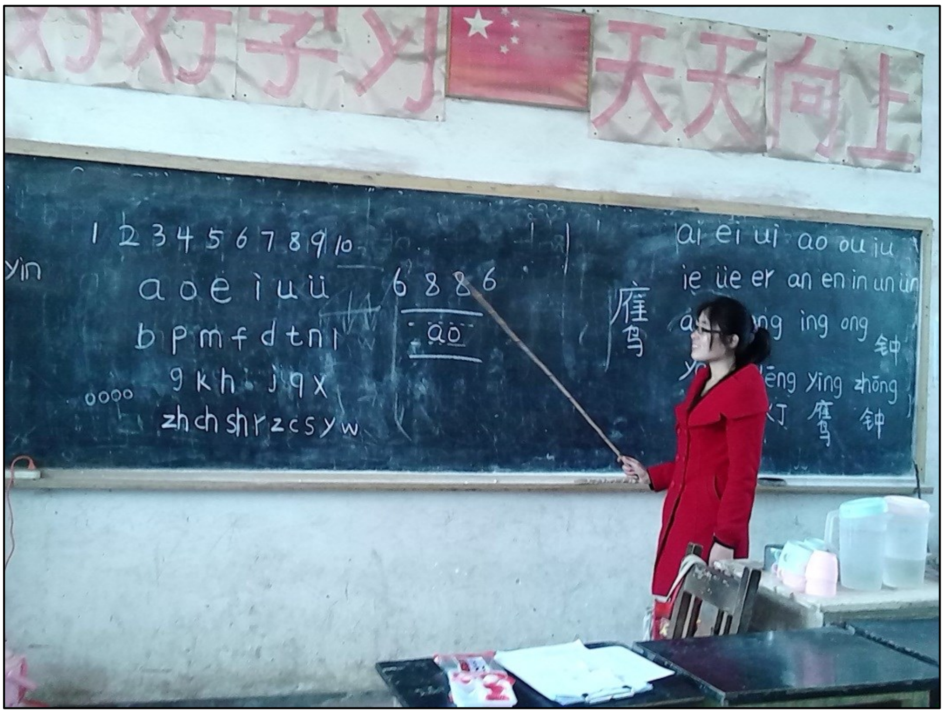
Chinese language is often referred to as Chinese, by which Mandarin is often meant. Chinese is a broad term that includes many different languages and dialects in China, including Mandarin. Mandarin is the People’s Republic of China’s official language and most spoken form of Chinese. This is also known as *Putonghua*, which means “common language”. It is based on the speech of Beijing, but also has incorporated aspects of dialects [267].

There is a huge diversity in languages spoken around China. Firstly, there are a large number of regional dialects. However, Mandarin speakers can generally understand other people despite the heavy regional accents. Those accents can be as different as those in the English language of English and Scottish. Secondly, there are more than 300 million Chinese people who speak Sino-Tibetian languages other than Mandarin, such as Cantonese and Hakka. These languages can be as different as German is from English. Thirdly, even more linguistically different are the minority population languages, more than 50, and many of those are not Sino-Tibetian. Some of these languages are more closely related to languages from other countries such as Turkish and Korean [268].

Chinese words consist usually of one or two vowels, sometimes three, but not more as is common in Western languages. Each vowel has a distinct meaning and the meaning of different vowels is combined in words with two or three vowels. Mandarin has four tones in spoken language and each vowel is given a tone. Depending on the tone, the vowel has a different meaning [267].

The written Chinese language is expressed in Chinese characters. A more simplified version of Chinese characters was adopted in China in the past century. Simple Chinese characters are the same all over mainland China. Hence, while people from different regions of China may not understand each other in spoken language, they will be able to communicate by Chinese characters. Some of these characters stem from written pictures while others are a combination of meanings of different elements of characters [268].

Pinyin is the official phonetic system for transcribing the Chinese pronunciation of Chinese characters into the Latin alphabet (pinyin can be translated as "spelled-out-sounds"). This system was developed in the 1950s based on earlier forms of Romanization [269]. Since, it has been adopted at primary schools and adult education in China. In 1982, the international organisation for standardization adopted pinyin as international standard [270]. Pinyin has facilitated learning Mandarin for both Chinese people and foreigners. Also pinyin made Mandarin more accessible to foreigners, for who it is much easier to read pinyin than Chinese characters. Therefore, pinyin is often used in foreign publications. Another huge advantage of pinyin is its use as an input method for computers, mobile phones and other electronic devices.



Photograph 7 Blackboard with pinyin and Chinese characters in a school

Photograph courtesy of WW, personal collection

3.2.6 Health

Health care system

China's health care system has globally received much interest, which was demonstrated by for example the publication of *The Lancet*'s fourth China-themed issue in 2013 [271]. Changes in China's economy, politics and socio-cultural environment have contributed to an evolution of China's health care system and improved the health of Chinese people [272]. Major advancements were achieved in decreasing rates of most infectious diseases and infant mortality whilst increasing life expectancy in the 30 years after establishment of People's Republic of China in 1949 [273].

China's has a three-tier health care system which was established in the post liberation period between 1949 and 1965 [272]. There is usually a general hospital and a maternal and child health hospital at county-level, one hospital in each township and one clinic in each village. Each village clinic has one or more community-based health workers – known as village doctors – who stem from the barefoot doctor movement during the Cultural Revolution (socio-political movement enforcing communism by eliminating cultural elements and capitalism from China) between 1966 and 1976. After the introduction of market reforms by Den Xiaoping in the early 1980s, many village doctors' clinics turned into private practises (non-government owned and for-profit institutions that provide health services) [273].

Between 1990 and 2000, the negative consequences of economic development on health, including pollution, accidents, injuries, tobacco usage and obesity, were not successfully addressed by policies of the Chinese government [272]. In 2003, the severe respiratory distress syndrome epidemic became an international health problem and revealed the weakened state of China' health care system [273]. Efforts to address this issue were successfully implemented as was shown by an effective response to a major earthquake in Sichuan Province in 2008 [272]. However, China's health care system still faces significant challenges. In 2009, the most recent health care reform was introduced, which aims to achieve universal health coverage by 2020 [274,275].

Health beliefs

The whole of a culture is important to understand health care, because beliefs about health and illness are shaped by culture [276,277]. Intrinsic to health care in China are traditional Chinese Medicine. Although traditional medicines are very commonly used, their effectiveness may not be clear from an evidence-based perspective [278]. There are different beliefs in Traditional Chinese Medicine compared with the Western biomedical system [277]. For example, a very commonly mentioned concept in Chinese medicine is *Shanghuo*. Although this concept varies from person to person and does not have standard signs and symptoms, it can be described as "*a physiological process of uncoordinated responses to stresses and a disorder of homeostasis with physical and mental fatigue syndromes*" [279].

Specifically relevant to child health, an important belief is, *zuoyuezi*, or the *sitting month* in brief (means "sitting the first month after delivery"). This belief restricts women from going out of their home or receiving visits from others in the first month after delivery [128].

Photograph 8 Traditional Chinese medicine in village clinic

Photograph from the PhD candidate's personal collection

Child health

Major advances have been achieved in child health over the past decades in China [280,281]. The under-five mortality rate dropped from 64.6 per 1000 live births in 1990 to 20.6 per 1000 live births in China in 2006. China thereby achieved the fourth MDG nine years ahead of target [282,283]. Improvements in social determinants of health (birth rate, maternal education, percentage of minority counties, crowding, sanitation etc.) made the largest contributions to these reductions, followed by health programmes and interventions, economic determinants, political determinants and health system and policy determinants [281].

The under-five mortality rate was further reduced to 16.4 per 1000 live births in 2010 [280]. China reached a decline of 12% for both diarrhoea and pneumonia per year between 2000 and 2010, which was far above the 4.4% target set by the MDG 4 [95]. In 2010, an estimated 0.3 million children younger than five died in China. Pneumonia was the leading cause of deaths in children aged 0-59 months and accounted for approximately 55,000 deaths (17%) and diarrhoea accounted for approximately 10,000 deaths (3%) [280].

However, there are substantial differences in mortality between different areas in China. The variations in mortality rates between provinces have only decreased from nine-fold differences (ranging from 13.7 to 126.7 per 1000 live births) in 1990 to eight-fold differences (ranging from 4.8 to 38.9 per 1000 live births) in 2006 [281]. Additionally, children under five years of age in rural areas were 2.8 times more likely to die than children in urban areas in 2010 (mortality rates of 20.1 and 7.3 per 1000 live births respectively) [284]. Therefore, further reducing under-five mortality in areas with the highest burden remains one of the biggest challenges for child health services in China. As pneumonia and diarrhoea still make large contributions to these deaths, further reducing pneumonia and diarrhoea-related deaths in young children is a main priority [107,119,284].

There are some specific challenges for child health in China. Firstly, while the one-child policy put a public focus on child health [272], traditionally Chinese people prefer boys over girls and the policy led to many sex-selective abortions and a shortage of girls in China [285]. Mortality among girls is higher than among boys in China, though this situation is slowly normalising [286].

Secondly, China's internal migration has led to an estimated 10-20 million so called "left-behind" children. Migrants usually do not bring their children with them when they move to urban areas, because children with a rural *Hukou* do not receive benefits when they move to urban areas. Paying for education and living costs of children with a rural *Hukou* in urban areas is often too expensive for migrant parents. As a result, many of these children are cared for by family members in rural areas, usually their grandparents and sometimes other relatives such as aunts and uncles. However, evidence has shown that left-behind children receive less care and poorer nutrition compared to children who are cared for by their parents [287].

Photograph 9 Children drinking water at a primary school in Zhao County

Photograph courtesy of WW, personal collection

3.3 *mHealth* in China

Overview of section

This section provides information about mobile phones and *mHealth* in China. Furthermore, a small selection of the most relevant observations the PhD candidate made during visits to China are described, which can be used to inform mHealth-based studies in China.

3.3.1 Usage of mobile phones

In 2014, China ranked first in the world's mobile markets with an estimated 1.2 billion mobile phone subscriptions, which accounts for approximately 92% of the population [288]. China also has the largest smartphone market in the world [289].

In contrast to Western countries where landline telephones were widely used for about a century before mobile phones were introduced, China jumped from having minimal landline telephone coverage to being the world leader in mobile telecommunication in less than two decades. Landline telephones were introduced to China in 1882, but had only a coverage rate of 0.4% (two million users) till the early 1980s. Mobile phones were introduced in China in 1988. China's large economic growth, industrialization, migration and consumerism contributed to a large growth in both landlines and mobile phones. In 1999, there were approximately 109 million landline users and 43 million mobile phone subscriptions in China. In 2003, the number of mobile phone subscriptions took over the number of landline telephones and there were about 269 million mobile phone subscriptions and 263 million landline users. The usage of landline telephones decreased for the first time in 40 years in 2007, with about 2 million fewer users than in 2006 [10].

There are three main state-owned mobile telecom operators in China: China Mobile (around 776 million subscriptions), China Unicom (around 286 million subscriptions) and China Telecom (around 185 million subscriptions). There were an estimated 448 million 3G subscriptions in China in 2014 (China Mobile has around 215 million, China Unicom 129 million and China Telecom 104 million) [288].

Mobile phone text messaging is very popular in China. Sending one text message usually costs ¥0.1 (about £0.01) and receiving a text message is free. One text message can contain around 65 Chinese characters, 140 non-Chinese characters or a reduced number when these characters are mixed. Depending on the mobile phone, some can be used to send and receive longer text messages.

In 2013, an estimated 431 billion text messages were sent in China. However, the usage of text messaging is decreasing because of the wide usage of Internet and instant messaging programmes on mobile phones. There were 500 million Chinese people using Internet on their mobile phone, an increase of 80 million compared to the year before [290]. A widely used Chinese instant messaging programme named *QQ* (*Tencent QQ*) on mobile phones and computers had more than 200 million users at the same time and a total number of more than 800 million users in 2014 [291,292]. The QQ programme is also spreading outside China with its international version [293].

Photograph 10 Advertisements with mobile phone numbers

Photograph from the PhD candidate's personal collection

3.3.2 mHealth-based studies

mHealth has increasingly gained attention in China [194,294]. Mobile phones were used during the severe acute respiratory syndrome outbreak in 2003 [295] and after the Sichuan earthquake in 2008 [156]. China Mobile has invested in several applications including a hospital booking system, remote consultation and diagnosis, health information text messages and drug tracking [194].

The first review on *mHealth* in China [296] found 10 mHealth-based studies in China of which nine were found in Chinese databases and only one in PubMed [294]. The review showed that the Chinese government introduced a large number of text messaging public health education programmes, including programmes for child health. These programmes were hard to track as they were not reported in a dedicated database. Overall, the review concluded that the applicability of *mHealth* to the Chinese health care system has not been assessed, but that there is great potential with widespread technology availability and decreasing costs [296].

Photograph 11 Mother in village clinic using her mobile phone

Photograph from the PhD candidate's personal collection

3.3.3 Further observations that could help the planning and conducting of mHealth-based studies

Mobile phone spam

Mobile phone spam is a common problem in China [297]. The PhD candidate used a China Mobile phone number in China to communicate with the Chinese researchers. The SIM card had no problems with network coverage both in Beijing and in Zhao County. However, while the PhD candidate did not sign up for any mobile service and did not give her phone number to people she did not know, she received several text messages a day and one or two phone calls a week from various organisations. These text messages and calls were mainly advertising.

Censor

The Chinese government enforces strong censorship on its internal media including television, radio, film, theatre, print, text messaging, instant messaging and the Internet. Text messages are automatically screened for key words that are provided by the Chinese police [298]. Internal websites in China such as *Weibo,* a very popular microblogging website with 500 million users and 100 million messages being sent every day, is said to be monitored by an estimated two million people employed by the Chinese government [299]. Moreover, several foreign websites including *Youtube, Dropbox, Facebook* and *Twitter* are blocked in China. This phenomenon is also known as “the great firewall of China”, but has not been officially acknowledged by the Chinese government [300].

Traditional calendars

Particularly in rural areas, Chinese people use traditional calendars, though most Chinese people are familiar with the Western calendar. While the official calendar in China is the Gregorian, also known as Western or solar, traditionally the Chinese calendar, also known as Han or lunisolar, is used. While the Western calendar is fixed and corresponds approximately with the astronomical cycles, the Chinese calendar is tied to the phase of the moon. Therefore, while the Western New Year starts on the first of January each year, the Chinese New Year, also known as Spring Festival, falls on a different day each year, usually between mid-January and February (Western calendar months).

Chinese celebrations

China has a number of public holidays. Some of these are related to the Western calendar such as the Labour Day (1^{st} May) and National Day (October 1^{st}). Others are related to the Chinese calendar including Chinese New Year, Dragon boat festival, also known as Duanwu festival, (5^{th} day of the 5^{th} month) and Mid-Autumn festival (15^{th} day of 8^{th} the month). The most important Chinese celebration is Chinese New Year. Chinese people will travel back to their home towns to be with their family and this causes the largest seasonal internal migration in the world each year.

Photograph 12 Traditional decoration for the Chinese New Year

Photograph from the PhD candidate's personal collection

Air quality

Poor air quality is a major issue in China. When the PhD candidate visited China for the fifth time in January 2013, Beijing had one of the worst levels of air quality in years [301]. The Air Quality Index is used as an indicator by the American Environmental Protection Agency ranging from 0-500. Levels lower than 50 are "good" and pose little or no risk, levels higher than 100 are "unhealthy" for sensitive groups, and between 300 and 500 are "hazardous" for the entire population. While this scale ends at 500, Beijing reached levels of above 700 in January 2013.

Moreover, air pollution consists of different air pollutants and one of the most hazardous is "particulate matter 2.5", because it is so small that it can go deep into the lungs and some even into the bloodstream. The World Health Organization regards air with more than 25 micrograms of "particulate matter 2.5" per cubic metre based on 24-hour concentrations as unacceptable [302]. Measurements from the American embassy in Beijing showed levels of "particulate matter 2.5" of 886 micrograms per cubic metre in January 2013 [301,303].

Photograph 13 Day with low air quality

Photograph from the PhD candidate's personal collection

3.4 Zhao County, Hebei Province, China

Overview of section

This section illustrates the specific context of the study - Zhao County - in relation to its geography, population, information and communication technologies, health care and previous health research.

3.4.1 Geography

Zhao County is located in Hebei Province, which is situated in the northern part of the North China Plain with an area of 190,000 km^2 (for comparison, the size of the United Kingdom is 245,000 km^2), bordering the capital Beijing.

Shijiazhuang City administers Zhao County, which is one of the 114 counties in Hebei Province. Zhao County covers an area of 675 km^2 and is located 40 km south of Shijiazhuang City [304]. Zhao County has the following 16 townships: Hancun; Yanghu; Beizhongma; Beiwangli; Xinzhaidia; Gedatou; Daifuzhuang; Zhaozhou; Fanzhuang; Nanbaishe; Daian; Qiandazhang; Gaocun; Xiezhuang; Wangxizhang; and Shahedian (Figure 1). Those 16 townships have 281 villages, ranging between 7 and 46 villages per township [305].

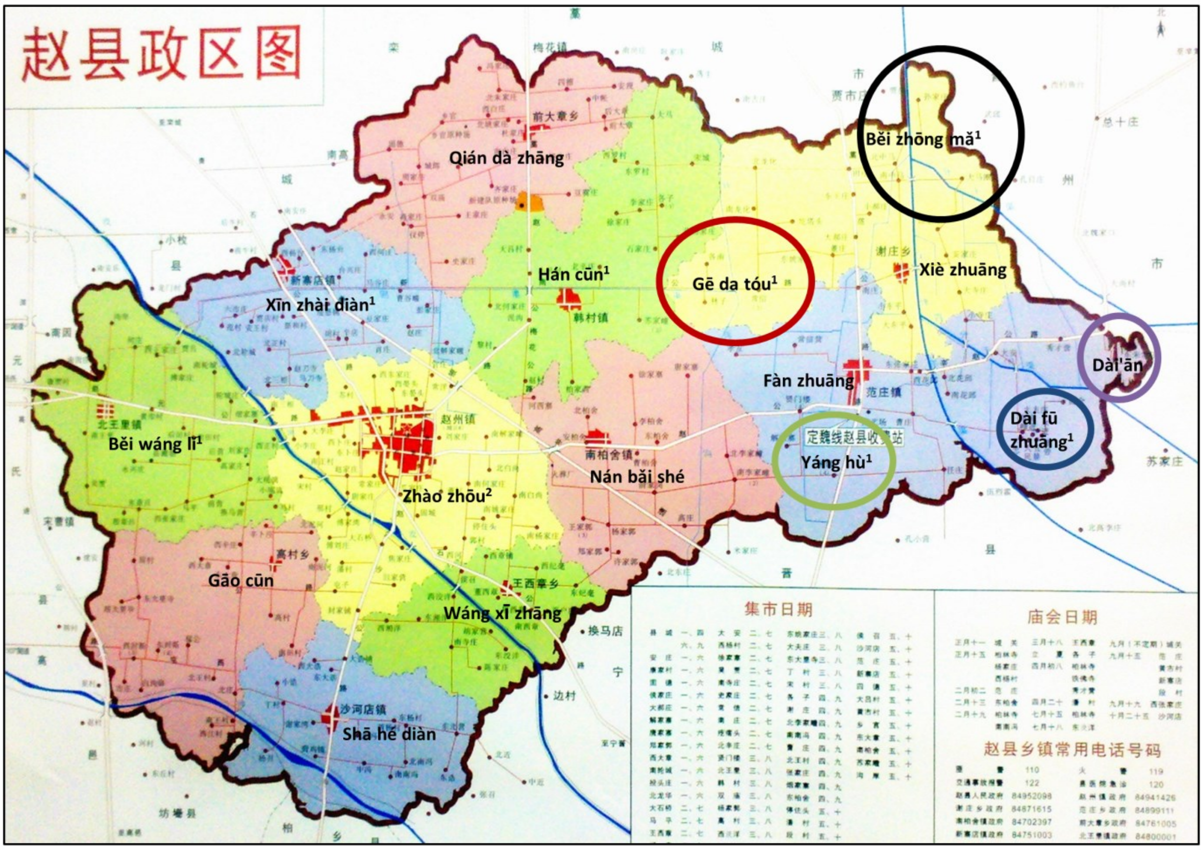


Figure 1 Map of Zhao County ***(赵县)***

The map (edited) shows 11 coloured areas. For the nine townships on the left side of the map, these nine areas correspond with the nine townships: Běi wáng lǐ 北王里 (green left upper area), Gāo cūn 高村 (red left middle area), Shā hé diàn 沙河店 (blue left lower area), Xīn zhài diàn 新寨店 (blue middle upper area), Zhào zhōu 赵州 (yellow central area), Wáng xī zhāng 王西章 (green middle lower area), Qián dà zhāng 前大章 (red left upper area), Hán cūn 韩村 (green right upper area), Nán bǎi shé 南柏舍 (red right lower area).

However, the two areas on the right side of the map correspond with seven townships: the two township areas (Xiè zhuāng 谢庄 (yellow right upper area) and Fàn zhuāng 范庄 (blue right lower area)) and five townships that are marked with circles. The five circles correspond to the areas of the five townships and the names of the townships are written in the middle of the circles.

Superscripts above the townships indicate when they are covered in the survey (1) or in the remaining study (2). Townships included in the survey were: Hán cūn 韩村 (green right upper area), Yáng hù 杨户 (around the green circle), Běi zhōng mǎ 北中马 (around the black circle), Běi wáng lǐ 北王里 (green left upper area), Xīn zhài diàn 新寨店 (blue middle upper area), Gē da tóu 圪瘩头 (around the red circle), Dàj fū zhuāng 大夫庄 (around the blue circle). The township for the remaining study was: Zhào zhōu 赵州 (yellow central area).

Figure courtesy of Shuyi Zhang, personal collection.

There are a number of famous historical sites in Zhao County. Bailin (Cypress Grove) Temple is a Buddhist temple built during the Eastern Han Dynasty (25 -220 years Anno Domini). Zhaozhou "Arch" (Anji) Bridge is one of the worlds' oldest stone bridges (built 595-605 years Anno Domini) [305,306].

Photograph 14 Bailin (Cypress Grove) Temple

Photograph 15 Zhaozhou "Arch" (Anji) Bridge

Photographs from the PhD candidate's personal collection

3.4.2 Population

Hebei Province has a total population of 70.3 million, of which the rural population accounts for 56.3%. Zhao County has both semi-urban and rural areas with an estimated total population of 571,000, of which 518,000 people (90.7%) had a rural *Hukou* in 2010. The female illiteracy rate was 3.76% in 2010. The main ethnic group is Han (99.9%). All households have access to tap water (data from the Zhao County Statistics Bureau, unpublished, 2010).

Photograph 16 Street in rural Zhao County

Photograph from the PhD candidate's personal collection

Houses in rural Zhao County are often traditional, single family homes with a small courtyard closed by a wall. In winter, heating is rarely used and temperatures in home reach values just above zero. Therefore, most people wear coats in their homes when it is cold.

Photograph 17 Child in house in Zhao County

Photograph from the PhD candidate's personal collection

The annual per capita net income of rural residents in Zhao County was ¥6464 (about £646), which was higher than the average for residents of Hebei Province which was ¥5958 (about £599) in 2010 (close to the national average of ¥5919 (about £592)) [1,307]. Many people in Zhao County work in agriculture, including *Xuehua* "snowflake" pears, wheat and corn.

Photograph 18 Corn

Photograph 19 Factories where agriculture products are processed

Photograph from the PhD candidate's personal collection

3.4.3 Information and communication technologies

While a relatively low proportion of households in rural areas have a functioning landline telephone, mobile phones are widely used both in urban and rural areas in Zhao County. Simple mobile phones could be bought for as little as ¥139 (about £14), while smartphones started with prices around ¥1199 (about £120) (the PhD candidate, observation). A survey among 1601 caregivers of young children in Zhao County showed that 99.4 % of households had at least one mobile phone. Moreover, 61.2% of the households owned computers, with 54.8% having access to Internet [QW, personal communication].

Photograph 20 Mobile phone shop in street in Zhaozhou City

Photograph from the PhD candidate's personal collection

3.4.4 Health care

Zhao County has four hospitals at county level: (i) a public general hospital; (ii) a public maternal and child health hospital; (iii) a public traditional Chinese medicine hospital; and (iv) a private general hospital. Each of the 16 townships has a public township hospital and all the 281 villages have a village clinic.

The government set that the basic public health services for maternal and child health care should mainly be provided at township level in Zhao County. Health workers in township hospitals are the main provider of antenatal and postnatal care and vaccinations [220]. Almost all women deliver in the township or county hospital and health workers record names of caregivers and their children after birth [147].

Village clinics are often privately-owned by village doctors who receive small subsidies from the government for providing public health services. Village doctors live in the communities they serve and have a good relationship with villagers. Village doctors provide primary health care at village level and are trained and supervised by staff at township and county-level. Education and training of village doctors varies, but usually they have at least primary school or junior high school and short basic medical training [273,308].

Photograph 21 Village clinic in Zhao County

Photograph from the PhD candidate's personal collection

3.4.5 Previous maternal, newborn and child health research

A number of studies on maternal, newborn and child health were undertaken in the study context and are reported in the following paragraphs.

A household survey was conducted in August 2010 on antenatal care among 1079 women with children younger than two years in Zhao County and Luannan County in Hebei Province. The results showed that almost all women (98%) received antenatal care services at least once, 80% at least four times and 54% at least five times. About half of the women (46%) visited antenatal care facility within their first trimester. Both health workers in public and private sectors did not provide all 16 standardised services, but considerably more women in public sector received antenatal care procedures. Most women received antenatal care in county or higher-level hospitals (75%) and very few in township hospitals (8%). Significantly fewer women were weighed and tested for HIV/AIDS in township than in county or higher-level hospitals [220].

A mixed methods study, including a household survey and semi-structured interviews, reported on postnatal care. The household survey was conducted in August 2011 on postnatal care among 1442 mothers of children younger than two years in Zhao County. The results showed that only 8% of women received a timely postnatal home visit within one week after delivery and 24% of women received postnatal care within 42 days after delivery. Among women who received postnatal care, 37% received counselling or guidance on infant feeding and 32% on cord care. Only 24% of women reported that the service provider checked jaundice of their newborns and 18% were consulted on danger signs and thermal care of their newborns. Of 991 mothers who did not seek postnatal care within 42 days after birth, 65% of them said that they did not knew about postnatal care and 24% of them thought it was unnecessary.

Semi-structured interviews were conducted among 24 township maternal and child health care workers. Qualitative findings revealed that health care workers' ability to reach out to women at home was restricted by staff shortages and inconvenient transportation. In addition, health care workers said that in-service training was inadequate and more training on postnatal care, hands-on practice and supervision were needed [221].

Two surveys combined in one paper reported on child health. The first survey, a household survey, was conducted in August 2011 among 1601 caregivers of children younger than two years in Zhao County. The results showed that the prevalences of fever, cough and diarrhoea in children were 16.8%, 9.2% and 15.6%, respectively. Caregivers of children with those signs and symptoms primarily sought care in village clinics and township hospitals. Only approximately 40% of children with suspected pneumonia received antibiotics. Very few children with diarrhoea received ORS (1.2%) and zinc (4.4%).

The second survey was a health facility survey assessing case management of 348 children and was conducted in July 2011. The results indicated that very few sick children were fully assessed, and only 43.8% were correctly classified by health workers when compared to the gold standard. Use of antibiotics for sick children was high and not according to guidelines [222].

Other data from the household survey conducted in August 2011 among 1601 caregivers of children younger than two years in Zhao County showed that almost all women (99.5%) delivered their child in a hospital and that almost all children (99.8%) were ever immunised. Early initiation of breastfeeding was only 22.4%, exclusive breastfeeding for six months was less than 10% and continued breastfeeding up to the age of two was only 38.2%. In addition, only 32.5% of children were given iron-rich food. The main sources of infant feeding information were family members, neighbours, friends and popular media. Only around 20% of the information came from health facilities and nearly none came from the communities [QW, personal communication].

Furthermore, a mixed methods study (including a 24-hour dietary recall survey, local food market survey, and development of a key local food list, food combinations, and recipes) took place in Wuyi County in Hebei Province. This study found that dietary diversity was poor; approximately 10% of children consumed meat and only 2% consumed vitamin A-rich vegetables. The main reason for not giving meat was the mothers' belief that their children could not chew and digest meat [219].

Structured summary of chapter

This chapter described the context of the study in this thesis. In sum:

1. The PhD candidate did not visit China and had few preconceptions about China before starting her PhD. She actively engaged with the study context and participated in the field work;
2. China is located in Eastern Asia and is one of the biggest and most populous countries in the world. While major advances have been achieved in child health over the past decades in China, there are substantial differences in mortality between different areas in China and further reducing pneumonia and diarrhoea-related deaths in young children in these areas is a main priority;
3. Mobile phones and text messaging are widely used in China and *mHealth* has been used on a limited scale;
4. The studies described in this thesis took place in Zhao County, which is a rural setting in Northern China with high usage of mobile phones and low levels of illiteracy.

4 Prevalence and factors influencing usage of mobile phones by caregivers: study methods

Overview of chapter

Following a description of the study context, this chapter introduces a study linked to the first objective of this thesis and describes the methods of this study.

4.1 Introduction

An understanding of usage of mobile phones is a precondition for effective usage of *mHealth*. Despite that mobile phones are globally widely used, there may be differences in access and usage in different settings. While mobile phone usage is important to consider for mHealth-based studies, this has been under-researched [17,183]. In Kenya, where most mHealth-based trials in low- and-middle income countries have taken place [193,200,309-311], only two recent quantitative studies assessed usage of mobile phones [312,313]. In China, only one mixed methods study explored usage of mobile phones among pulmonary tuberculosis patients in Chongqing Province in Western China [314].

Knowledge of factors influencing mobile phone usage are needed to optimise experiences of users of mHealth-based interventions [23,33,46,56]. In addition, exploring the natural role of mobile phones in health care can facilitate integration of mHealth-based interventions in the health system and optimise health benefits [23]. Although people in different settings may use their mobile phones in similar ways, this is highly context-specific and therefore requires research in different settings [17,33]. In the context of this study, previous observations in Zhao County showed that mobile phones and text messaging were commonly used (section 3.4.3). However, information on how exactly caregiver used their mobile phones in their daily lives and for health care was unknown.

4.2 Objectives

This study assessed the following: (i) prevalence of mobile phones; (ii) factors influencing usage of mobile phones; and (iii) usage of mobile phones for health care.

4.3 Methods

Overview of section

This section starts with the methodological orientation and theory of the study. This is followed by a description of the study setting and sample, recruitment, interviewers, questionnaires, data collection, participants and data management and analysis. In these sections, survey methods are described before the semi-structured interview methods. The survey is reported according to the "*strengthening the report of observational studies in epidemiology*" checklist where applicable [315]. The semi-structured interviews are reported according to the "*consolidated criteria for reporting of qualitative research"* checklist [316].

4.3.1 Methodological orientation and theory

A mixed methods approach was used, whereby a quantitative survey and qualitative semi-structured interviews were combined in one study and data collection took place around the same time. The survey assessed prevalence of usage of mobile phones, both in daily life and for health care. Semi-structured interviews explored factors influencing usage of mobile phones and how mobile phones were used for health care. The quantitative and qualitative data obtained from these strategies were compared and integrated. Thereby, the data could be used in a complementary way and guide the following parts of the thesis.

There was only limited previous literature reporting on mobile phone usage [17,183]. A useful method for investigating an under-researched area is grounded theory, which can be described as "*theory that was derived from data, systematically gathered and analysed through the research process*" [214]. Grounded theory was developed by Glaser and Strauss in the 1960s and has been used in health research [233]. This approach requires researchers to have no or few preconceived ideas and seeks to give meaning to social interactions and experiences. Hence, grounded theory was considered the most appropriate approach for the semi-structured interviews. However, grounded theory requires a significant amount of resources and time [215] and a thorough analysis was not feasible in this study.

To overcome this challenge, a thematic analysis approach was chosen. Thematic analysis is another commonly used approach and somewhat similar to grounded theory. Thematic analysis is increasingly used as a "light" version of grounded theory, because it requires fewer resources while still some principles of grounded theory can be used. Similar to grounded theory, thematic analysis is also especially useful for under-researched areas. Thematic analysis is "*a method for identifying, analysing and reporting patterns (themes) within data*". A benefit of thematic analysis is its flexibility and independence of theory and worldview. While it is a useful method for providing an overall description of data, a limitation of the method is that some complexity and depth are lost. For that reason, it was aimed to provide a rich thematic description of the entire data set that reflected the most important findings and it was anticipated that thorough insights in specific issues could not be obtained [317].

4.3.2 Study setting and sample

Both the survey and the semi-structured interviews took place in Zhao County in winter 2013 (see section 3.4). The weather conditions included low temperatures, snow and poor air quality.

Photograph 22 Zhao County in winter

Photograph from the PhD candidate's personal collection

Survey

The survey was part of a randomised controlled trial aiming to assess the effectiveness of infant feeding information sent via *QQ* in reducing anaemia prevalence (trial registered at the China Ethics Committee for Registering Clinical Trials, registration number ChiECRCT-2012033). The trial took place in village clinics in seven townships in Zhao County (Hancun, Yanghu, Beizhongma, Beiwangli, Xinzhaidian, Gedatou and Daifuzhuang). These townships cover mainly rural areas of Zhao County, and have 107 villages with an estimated total population of 206,600, under-five population of 12,700 and 3600 children aged 6-23 months [304]. The seven townships were chosen for the trial, because no studies that could have introduced bias in the trial had taken place in these townships. The other nine townships in Zhao County were ineligible as other studies had taken place: in seven townships (Zhaozhou, Fanzhuang, Nanbaishe, Daian, Qiandazhang, Gaocun and Xiezhuang) a study evaluating Integrated Management of Childhood Illness had taken place and in two townships (Wangxizhang and Shahedian) an mHealth-based study had taken place [WW, personal communication].

The survey sample was part of the sample of the randomised controlled trial, which included caregivers (mother, fathers, grandmothers, grandfathers and others) of children aged between six months and two years. The caregivers in the survey sample were not selected based on their mobile phone usage. Caregivers were excluded if they had a child of a different age, if they were not willing to participate, or if they were unable to read or understand the informed consent materials.

There was no specific sample size calculation for the survey, because the survey was part of the randomised controlled trial. The sample size calculation for this trial was based on the following assumptions. The main outcome of the trial was anaemia prevalence and a sample of 816 was required for sufficient power of the analysis. A sample size of 408 children aged 6-23 months from 51 villages in the intervention and 408 in the control group from 51 villages (816 children in total) was sufficient to show a between-group difference for all key indicators with intraclass correlation coefficient for anaemia of 0.0686, 90% power and a 5% significance level [WW, personal communication].

The anaemia prevalence was estimated to be 61.4% and it was aimed to detect a difference of 10% in prevalence reduction between the intervention and control group. Based on the national trends in anaemia prevalence (anaemia prevalence declines when children grow up), it was estimated that the anaemia prevalence decreased from 61.4% to 47.4% in the control group and from 61.4 to 37.4% in the intervention group [WW, personal communication].

Caregivers in the trial had to use *QQ* and it was estimated that 50% of caregivers used this programme. Therefore, at least 1632 caregivers had to be asked to participate and fill in the survey, so that 816 caregivers who used *QQ* could be included in the trial. Based on previous experiences, it was estimated that 2400 caregivers out of 3600 children on the list of names (70%) could participate and complete the survey [WW, personal communication].

Semi-structured interviews

The semi-structured interviews took place in one township in Zhao County: Zhaozhou Township (a township that was not included in the survey). Zhaozhou Township has the largest population (estimated total population of 109,200) of townships in Zhao County and has both semi-urban (downtown/centre) and rural areas. Caregivers were recruited in Zhaozhou city, which represents a semi-urban area in Zhaozhou Township, and in a village in a rural area of Zhaozhou Township [304]. Semi-structured interviews took place in homes and village clinics.

Participants were eligible if they were a caregiver of young child and used a mobile phone. Caregivers who did not use a mobile phone were excluded, because these caregivers could not provide insights into the research questions related to factors influencing mobile phone usage. The sample was purposefully selected based on characteristics that were considered to be relevant: type of caregiver, age, urban or rural residence, education and type of mobile phone (simple mobile phone or smartphone).

The sample size for the semi-structured interviews had to be large enough to cover the diverse views of caregivers and to reach saturation of themes. Saturation is reached when no new themes emerge from the interviews [214]; between 12 and 60 interviews is generally enough [318] and saturation is commonly reached within 20 interviews [230]. Therefore, it was planned to interview between 15 and 20 caregivers. Additional interviews were planned to be held if saturation on the objective of the interviews was not reached within these interviews.

4.3.3 Recruitment

Survey

Recruitment of caregivers took place by asking them from "door-to-door" on the day and invite willing caregivers to come to the village clinic, where recruitment took place. A doctor from Zhao County Maternal and Child Health Hospital was the main local contact during the field work. The county hospital doctor had good connections with local people at different levels of the health care system and was experienced with assisting in health research. He obtained a list with names of children for immunization in each village in the seven townships from the township hospital doctors. Village doctors were asked to help with recruiting caregivers in the village clinics, because many caregivers were familiar with their village doctor and more likely to participate when they were asked by their village doctor.

Before the study started, village doctors were contacted on three occasions. Firstly, the township hospital doctors informed all village doctors about the study and asked them to participate.

Secondly, two days before the study started the township hospital doctors asked the village doctors: when it was convenient to visit their villages; to check the township hospital list with names of children; and to inform caregivers of children when they should come to the village clinic. The township hospital doctors informed the county hospital doctor during these steps.

Thirdly, half an hour before the interviewers arrived in the village, a township hospital doctor or the county hospital doctor asked the village doctor to start gathering caregivers.

It was expected that village doctors were familiar with all young children in their village, because they reported newborns to the township hospital each month. Therefore, they were expected to be able to recruit a significant number of caregivers from their own records.

However, it was anticipated that not all village doctors were willing to help, but that they did not tell this to the township hospital doctor, the county hospital doctor or to the researchers in advance. It was expected that less willing or busy village doctors would make fewer efforts to find caregivers of children on lists of names. Therefore, village doctors were given a small financial incentive, ¥50 (about £5) per village, for their efforts to increase their willingness to participate.

A number of recruitment strategies were used to encourage caregivers to come to the village clinic: (i) using loudspeakers in the villages; (ii) making phone calls to caregivers; (iii) visiting caregivers in their homes; (iv) asking caregivers to ask their neighbours; (v) asking people on the street; (vi) and going to places where many people could be found, such as a market or wedding.

When available, loudspeakers in the villages were used and village doctors were asked to make the following announcement: *"We are from the Capital Institute of Pediatrics and Zhao County Maternal and Child Health Hospital, if you are a parent of a child aged over six months and younger than two years, you can take the child to the village clinic, it is best if the mother comes, we will do a survey and then get a free test for anaemia, you can wait to get the result"*.

For some of the villages, the county hospital doctor obtained a list of phone numbers from the local immunization service centre, which was used to call caregivers. For other villages, the county hospital doctor was unable to obtain this list as these villages belonged to an immunization service centre that was unwilling to provide the phone numbers.

When caregivers arrived in the village clinic, interviewers informed eligible caregivers about the study procedures, asked them to read the information sheet and gave them the opportunity to ask questions. The interviewers told caregivers that the study results were not used to assess the health of their child and that they should contact a health worker if they had any concerns about the health of their child.

Additionally, interviewers told caregivers that they could decide to withdraw from the study at any moment and that this did not influence the health care they received. Interviewers asked caregivers who were willing to participate if they understood what participation in the study included and to sign the informed consent form.

Caregivers were given a towel (worth ¥5 (about £0.50)) for their time to complete the face-to-face survey, which was also done in previous studies in Zhao County [71,138].

Semi-structured interviews

The county hospital doctor asked the village doctors when it was convenient to visit their villages two days before the study started and arranged a time for recruitment. When the interviewer YL and the PhD candidate arrived in the village clinic, the county hospital doctor and YL asked village doctors to find caregivers who were willing to participate. YL did not know the caregivers prior to the interviews. YL approached the caregivers and asked them face-to-face if they were interested in participation. An approach similar to the surveys for was used obtaining informed consent and YL explained caregivers the aim of the interviews. YL introduced the PhD candidate to the caregivers and explained the purpose of the PhD candidate's presence. A snowballing method was used; caregivers were asked if they knew any other caregivers who were willing to participate. Caregivers were given a towel (worth ¥5 (about £0.50)) for their time.

4.3.4 Interviewers

Survey

The interviewers were trained medical students from local universities. They were guided by three survey supervisors (WW, YL and Baoxue Li), who were all experienced in supervising surveys in Zhao County. The survey was carried out by three teams of interviewers: two large groups of 10 interviewers and one smaller group of 7 interviewers (27 interviewers and 3 supervisors in total). The supervisors trained the students on survey techniques prior to study commencement. The training included the following: (i) introduction to the survey aims; (ii) obtaining informed consent; (iii) usage of a smartphone for recording the answers; (iv) a detailed explanation of every survey question; and (v) interview practice.

The students practised with a student partner in pairs through role play and discussed their experiences with the entire group. The supervisors carefully monitored the students, gave constructive comments and validated how students asked the questions.

The supervisors assessed the students at the end of the training. In this test, two supervisors role played: one took the role of an interviewer and another took the role of a caregiver. The supervisors were experienced in role-play and thus their recorded answers were used as gold standard. All students were asked to record what the supervisor answered. The recorded data of all the students were compared to the gold standard. There were a total of 347 questions in the survey instrument and the overall agreement for all questions for all the students was more than 97%.

Semi-structured interviews

YL conducted the semi-structured interviews with caregivers in Mandarin. The PhD candidate was present during the interviews to help YL and to record any non-verbal communication and observations. The use of an interpreter was not feasible as there was no person in the research team who was a native speaker both in Mandarin and English. However, the use of an interpreter was less desirable as this could have influenced the flow of the interview.

The experiences and knowledge of YL and the PhD candidate complemented each other (for experiences of the PhD candidate see section 3.1). YL is a female native Chinese MSc student with a BSc in medical sciences and who grew up in Beijing. YL was very familiar with the study context as she was involved in several studies that took place in Zhao County and led research on text messaging data collection in this setting [138]. YL had little experience with qualitative research, but the PhD candidate was trained in qualitative methods and had previously conducted semi-structured interviews. Therefore, the PhD candidate trained YL in qualitative research methodology, which included an explanation of qualitative methods and interview techniques (e.g. how to ask open-ended questions) and practice with team members and caregivers in Zhao County.

YL helped the PhD candidate to understand the local context in Zhao County. There was an obvious risk that the PhD candidate misunderstood Mandarin expressions or non-verbal actions. Therefore, YL and the PhD candidate worked closely together and had thorough discussions throughout data collection and analysis to ensure that the PhD candidate correctly understood the meaning of what the participants said.

4.3.5 Questionnaires

The questionnaires for the survey and semi-structured interviews were developed at the same time and the questions were partly matched so that the results from the semi-structured interviews could provide more in-depth insights in the survey results. Factors influencing usage of mobile phones known from the literature and factors based on experiences were used to develop these questionnaires including the following: costs; ability to use the mobile phone; changing mobile phones and SIM cards; place where mobile phone was kept; network problems; sharing or borrowing mobile phones; and lost or stolen mobile phones [23,33,46,56].

Survey

The survey consisted of four modules: (i) identification; (ii) mobile phone; (iii) *QQ;* and (iv) household (Appendix C Questionnaires). Demographic questions from the identification and household modules were selected from the World Health Organization Maternal, Newborn and Child Health Household survey (unpublished, 2009). These questions were adapted from these modules to the local context in Zhao County and had been used in previous research [71]. The questionnaire for the randomised controlled trial included additional questions relevant to the trial for the identification, *QQ* and household modules, and for four other additional modules.

For the mobile phone part of the survey, the PhD candidate developed the mobile phone usage-related questions in collaboration with three Chinese researchers (YZ, YL and WW) and an *mHealth* expert (JC). Then YL and WW translated the mobile phone-related questions independently from English into Mandarin. WW and YL compared the translations and disagreements were discussed with YZ. Then, a bilingual translator (Dr Eugene Chang) second-checked whether the meaning of the translated questions was comparable between Mandarin and English.

The mobile phone usage-related questions were pilot tested with caregivers in Zhaozhou Township and minor changes were made in the questions to ensure that the questions were understandable and appropriate.

Semi-structured interviews

The interview guide was developed in a similar way as the mobile phone usage-related questions in the survey. In addition, a Chinese sociologist (Yu Qiu) and sociologist (Dr Agnieszka Ignatowicz) were asked for advice about the semi-structured interviews. Probing questions (asking open-ended questions; questions starting with how, why, what etc.) were used to follow-up on the questions in the guide, because an in-depth understanding of topics usually comes from probing [319]. It was expected that caregivers may have felt uncomfortable to talk about problems with their mobile phone. Therefore, tactical questions were asked in the semi-structured interviews to encourage caregivers to talk about problems with their mobile phone (Appendix C Questionnaires).

Specific research questions were not defined at the start of the interviews, but initial broad research questions were formed. The initial questions were aiming to better understand how caregivers use their mobile phones and what caregivers' experiences were when using a mobile phone for seeking health care. Halfway through the interviews YL and the PhD candidate felt that saturation was reached on the first question, which was then redefined into "which factors influence whether caregivers respond to text messages" (Appendix C Questionnaires).

The questions were pilot tested with caregivers in Zhaozhou Township. It was then decided to not specifically ask about text messaging data collection. It was felt that answers to questions about future scenarios would be biased by socially desirable responses. Therefore, only information about caregivers' experiences with using their mobile phone was requested. However, during the formal interviews, some caregivers asked the interviewers about the text message data collection study. It was decided to present these findings, though they were not based on caregivers' experiences. These findings need to be interpreted with some caution, because they may be influenced by socially desirability bias.

4.3.6 Data collection

Survey

Interviewers used a smartphone to record answers of caregivers in the village clinic with reasonable privacy, which was validated in Zhao County [71].

Semi-structured interviews

The semi-structured interviews were carried out at a neutral and private location that was comfortable for caregivers. This was often the caregivers' home, or if that was not possible, a quiet room in the village clinic. Caregivers were asked if they could be interviewed alone and to ask their family members and other people not to disturb the interview. This was achieved in most interviews, but some interviews were briefly interrupted by other people, who were then asked to leave the room.

When the participant gave permission, the interview was recorded with a digital recorder, notes were taken to record non-verbal communication and photographs were taken of the caregiver and child (with face not identifiable and with their verbal and with written permission). The interviews took between 15 and 60 minutes.

YL summarised her understanding of what the caregiver said twice during the interview to verify her understanding of the caregiver's views. Because of this procedure, transcripts were not sent to caregivers for validation.

YL translated parts of the interview content several times during the interview to allow the PhD candidate to ask additional questions. The researchers reflected after each interview and at the end of each field work day and recorded their ideas. They aimed to also gain insights from dissonant cases; people who were unusual in some way.

4.3.7 Participants

Survey

Of the estimated 3600 children aged between six months and two years on the list of names, a total of 1892 caregivers were interviewed and 1854 caregivers were included. The remaining 1708 caregivers of children (3600 children on the list of names minus 1892 caregivers recruited) could not be recruited, because they were not present in the village, the list of names was incorrect, or they did not meet the inclusion criteria. The following caregivers were excluded: 14 caregivers with children who were younger than six months or older than 23 months (this was because the list of names could not be validated and there was a small time difference in time between obtaining the list of names and conducting the survey) and 24 records of children who shared a caregiver (caregiver had twins or two children aged 6-23 months and only the youngest child was included).

Table 5 shows that of the 1854 included participants, most were mothers (1548; 83.5%), some were grandparents (260; 14.0%), and only a small proportion were fathers (41; 2.2%) or other caregivers (5; 0.3%). About one third of children (548; 31.5%) were aged 0-11 months and two third (1270; 68.5%) were aged 12-23 months. There were more boys (964; 52.0%) than girls (890; 48.0%). Most children were an only child (946; 51.0%) or had one sibling (833; 44.9%) and had a rural *Hukou* (1841; 99.3%).

Participants were asked who took care of the child the majority of the time and most participants were the main caregiver of the child (1722; 92.9%). Table 6 shows overlap between the surveyed participants and primary caregivers of children.

Table 5 Characteristics of survey participants and children (N=1854)

	n (%)
Gender of the child	
Boy	964 (52.0)
Girl	890 (48.0)
Age of the child	
0-11 months	584 (31.5)
12-23 months	1270 (68.5)
Number of children in the household	
1	946 (51.0)
2	833 (44.9)
3	71 (3.9)
4	2 (0.1)
Do not know	2 (0.1)
Relation of participant to the child	
Mother	1548 (83.5)
Father	41 (2.2)
Grandmother or grandfather	260 (14.0)
Other caregiver*	5 (0.3)
Participant is primary caregiver	
Yes	1722 (92.9)
No	132 (7.1)
Additional other household member taking care of the child†	
Yes	296 (16.1)
No	1537 (83.8)
Do not know	2 (0.1)
***Hukou* child**	
Rural	1841 (99.3)
Urban	13 (0.7)

*Child's sister (1), child's older brother's wife (1), child's father's older sister (3).
†Two mothers discontinued the interview and did not answer this question and there were 17 missing values.

Table 6 Relation to the child versus primary caregiver of the child (N=1854)

Relationship to the child	Primary caregiver Mother	Father	Grandmother or grandfather	Other caregiver	Total
Mother	1538	0	10	0	1548
Father	29	6	6	0	41
Grandmother or grandfather	83	1	176	0	260
Other caregiver	1	0	2	2	5
Total	1651	7	194	2	1854

Table 7 shows that of all 1854 mothers and fathers of children, the median age of mothers was 26.0 years (Q1-Q3; 24.0-29.0) and the median age of fathers was 27.0 years (Q1-Q3; 25.0-30.0). The median education level was junior high school (9 years of education).

The median family net income in the last year was ¥17,250 (about £1725) (Q1-Q3; ¥20,000-30,000) and the median family net expenditure was ¥15,000 (about £1500) (Q1-Q3; ¥10,000-20,000), but these two questions had a very high proportion of missing values (>60%).

Table 7 Characteristics of all mothers and fathers of children (N=1854)

	Median (Q1-Q3)	Do not know answers
Mother's age in years	26.0 (24.0-29.0)	9
Mother's education level*	3 (3-3)	54
Mother's years of education	9.0 (9.0-9.0)	82
Father's age in years	27.0 (25.0-30.0)	12
Father's education level	3 (3-3)	43
Father's years of education	9.0 (9.0-9.0)	102
Family net income in last year (¥)	17,250 (20,000-30,000)	1188
Family living expenses in the last year (¥)	15,000 (10,000-20,000)	1129

*3=Junior high school (9 years of education).

Table 8 shows the median ages of survey participants. The median age of the 176 grandparents who were primary caregivers of the children was 51.0 years (Q1-Q3; 48.0-57.0).

Table 8 Age of survey participants, median (Q1-Q3)

	Mothers (n=1548)*	Fathers (n=41)	Grandparents (n=176)†	Other caregivers (n=5)‡
Age in years	26.0 (24.0-29.0)	28.0 (25.0-31.0)	51.0 (48.0-57.0)	30.0 (19.3-44.5)

*6 "do not know".
†1 "do not know", for grandparents this question was only asked to primary caregivers.
‡1 "do not know".

Table 9 shows education and occupation of survey participants. Only few mothers (7; 0.5%) and no fathers (0; 0.0%) were not educated. Of the 176 grandparents who were primary caregivers of the children, more than a third (64; 36.4%) did not have education.

Table 9 Education and occupation of survey participants, n (%)

	Mothers (n=1548)	Fathers (n=41)	Grand-parents (n=176)*	Other caregivers (n=5)
Education				
No education	7 (0.5)	0 (0.0)	64 (36.4)	0 (0.0)
Completed primary school (6 years of education, children start primary school from the age of six)	92 (5.9)	2 (4.9)	46 (26.1)	1 (20.0)
Completed junior high school (9 years of education)	1198 (77.4)	34 (82.9)	43 (24.4)	1 (20.0)
Completed senior high school (general education school, 12 years of education in total)	127 (8.2)	1 (2.4)	21 (11.9)	1 (20.0)
Completed secondary school (professional education school, 12 years of education in total)	68 (4.4)	2 (4.9)	1 (0.6)	0 (0.0)
Completed college (more than 15 years of education)	40 (2.6)	2 (4.9)	0 (0.0)	1 (20.0)
Completed university or above (more than 16 years of education)	5 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)
Do not know	11 (0.7)	0 (0.0)	1 (0.6)	1 (0.0)
Occupation				
Home	1386 (89.5)	0 (0.0)	158 (89.8)	2 (40.0)
Work	156 (10.1)	41 (100.0)	17 (9.6)	2 (40.0)
Do not know	6 (0.4)	0 (0.0)	1 (0.6)	1 (20.0)

*For grandparents this question was only asked to primary caregivers.

Semi-structured interviews

A total of 17 caregivers were interviewed. Two participants were asked by two doctors from Zhao County Maternal and Child Health Hospital. The remaining 15 caregivers were asked by village doctors in three village clinics in Zhaozhou City and in one village clinic in rural Zhaozhou Township.

A total of 23 caregivers were approached and six caregivers were not able or refused to participate in the interview. In the first village clinic in Zhaozhou City, one mother who was asked to be interviewed was not at home. In the second village clinic in Zhaozhou City, no one refused. In the third village clinic in Zhaozhou City, three participants refused to participate. One mother said that her family did not want the interview to take place in her home. When the opportunity for interview in the clinic was offered, she still did not want to participate. A second mother said that she heard about research last week on television that worried her (e.g. genetically modified rice) and therefore, she did not want to participate in research. A third mother was not at home.

In the village clinic in rural Zhaozhou Township, one mother gave as a reason for refusal that she was busy with her shop and worried about her sick child. One father orally consented, but did not wish to read the informed consent; he said that this was too much effort.

The 17 interviewed caregivers included 13 parents (12 mothers and one father) and four grandparents, (two grandmothers and two grandfathers) (Table 10). Parents were aged between 24 and 33 years and grandparents were aged between 48 and 57 years. Only caregivers who used a mobile phone were interviewed and more than half (10/17) of participants used a smartphone. It was found that there was a difference in views from parents and grandparents. Therefore, the type of caregiver was indicated with the findings in the results section in Chapter 5 where this was appropriate.

Table 10 Characteristics of semi-structured interview participants

Nr	Care giver	Age years	Education level	Occupation	Age child (months)	Gender child	*Hukou*	Nr of children	Type of mobile phone
1	Mother	25	7	Housework	1	Boy	Rural	1	Simple phone
2	Mother	24	3	Housework	10	Girl	Rural	2	Smart phone
3	Grand mother	57	2	Head organisation	28	Girl	Urban	1	Simple phone
4	Grand father	57	3	Construction	25	Girl	Rural	1	Simple phone
5	Mother	27	3	Other	34	Girl	Rural	1	Smart phone
6	Mother	24	3	Housework	18	Girl	Rural	1	Smart phone
7	Mother	30	5	Housework	53	Boy	Rural	2	Smart phone
8	Mother	32	3	Housework	64	Boy	Rural	2	Smart phone
9	Mother	30	7	Technical	25	Boy	Urban	1	Simple phone
10	Mother	28	3	Housework	5	Girl	Unclear	2	Simple phone
11	Mother	24	3	Housework	14	Boy	Rural	1	Smart phone
12	Mother	24	3	Commercial	3	Girl	Rural	1	Simple phone
13	Mother	25	3	Housework	26	Girl	Rural	1	Smart phone
14	Mother	24	5	Housework	21	Boy	Urban	1	Smart phone
15	Father	33	3	Commercial	40	Girl	Rural	2	Smart Phone
16	Grand mother	48	3	Housework	9	Girl	Rural	1	Simple phone
17	Grand father	52	4	Commercial	0	Boy	Rural	1	Smart phone

*Education level:
1=no education;
2=completed primary school (6 years of education);
3=completed junior high school (9 years of education);
4=completed senior high school (general education school, 12 years of education in total);
5=completed secondary school (professional education school, 12 years of education in total);
6=completed college (more than 15 years of education);
7=completed university or above (more than 16 years of education).

4.3.8 Data management and analysis of outcomes

The survey and semi-structured interviews were analysed separately and then the results were compared and integrated. The structure of the themes that were found in the semi-structured interviews was used for reporting; the survey results were added to these themes.

Survey

When interviewers completed the face-to-face questionnaire, data were wirelessly and securely uploaded into an Excel database via an Internet server. Data were also saved on the memory card of the smartphone as an encrypted file. Data could only be decrypted with special software. The supervisors collected the smartphones at the end of each field work day. They returned the smartphones, cleared from the data that were entered during the previous day, to the interviewers in the morning.

Only the supervisors were able to enter the databases and no changes could be made to the databases. Each participant was given an identification number and the databases with participant information linked to the identification numbers could only be accessed by the researchers. Data were anonymised for analysis and reporting.

The PhD candidate used SPSS version 16.0 [320] for the statistical analysis of the quantitative data. She used a simple descriptive analysis to calculate proportions, medians (Q2), 25 (Q1) and 75 (Q3) percentiles for the demographic and mobile phone usage-related indicators (Appendix C Questionnaires). Missing data were not imputed. WW checked the analyses using SAS version 9.2 [321].

Semi-structured interviews

The recorded data and transcripts were kept on a secure computer and anonymised. A local student transcribed the recorded data verbatim in Word 2007. These transcriptions were checked by a second student and second-checked by YL (who conducted the interviews) by listening to the tapes. Then YL translated the interviews into English entirely. WW checked the translations. Where there were discrepancies, WW and YL discussed the meaning of the transcripts. The bilingual translator checked a random selection of 10% of the transcripts to validate the translation.

The transcripts were transferred in computer-aided qualitative data analysis software *MAXQDA 11*, which was used to analyse the data [322]. To maximise rigour, YL and the PhD candidate conducted the analysis independently: YL in Mandarin and the PhD candidate in English. When analysing the data, the influence of YL and the PhD candidate's social positioning was considered; meaning that YL was seen by the interview participants as a young female medical researcher from Beijing and the PhD candidate as a young female foreigner. From the openness of participants and richness of the data, it became clear that participants felt comfortable talking to YL in presence of the PhD candidate.

Thematic analysis was conducted in six steps as described by Braun and Clarke. Firstly, YL and the PhD candidate read through the interviews several times in an active way (searching for meaning) to obtain an overview of the interviews. They kept memos to capture thought processes [317].

Secondly, initial codes were given to findings (units of texts). Coding was undertaken for as many possible findings as possible (including context). Full and equal attention was given to each data item and data which were different were kept from the main story. YL and the PhD candidate compared and discussed their coding in detail after each interview [317]. An inductive or bottom coding method was chosen; the data is then strongly linked to the themes, which is somewhat similar to a grounded theory approach [214].

Thirdly, YL and the PhD candidate searched for themes and sorted codes into potential themes. A theme "*captures something important about the data in relation to the research question, and represents some level of patterned response or meaning within the data set*". Themes were added until no new themes were found. YL and the PhD candidate only looked for semantic (explicit) level themes and did not look beyond what a participant said. They carried out this process independently and discussed and compared their findings [317].

In the fourth step, the themes were reviewed and compared on two levels: of the coded data extracts and in relation to the data set. This was continued until a good idea was found of what the themes were and how they fitted in the data set [317].

In the fifth step, themes were defined and named [317]. YL translated the Mandarin themes into English and the PhD candidate compared these with the English themes and completed a final version of the English themes. To validate the translation of the themes, the bilingual translator translated the final English version of the themes back into Mandarin and YL compared these with the original Mandarin themes [323].

In the sixth step, different themes were related to each other to develop an explanation in relation to the research question. The PhD candidate choose vivid quotes which captured the essence of key points and wrote the “story” (analysis results) [317].

To verify the data, the PhD candidate compared field work memos and observations with the analysed data. Moreover, she discussed the results within the research team to verify the understanding of the interpretation. Both the English translations and the original Mandarin transcripts are provided for the themes and quotes in the results in Chapter 5.

Structured summary of chapter

This chapter introduced and described the methods of a study addressing the first objective of this thesis. In sum:

1. A survey (quantitative) and semi-structured interviews (qualitative) took place concurrently. The survey assessed the prevalence and factors influencing the usage of mobile phones both in daily life and for health care. Semi-structured interviews explored factors influencing usage of mobile phones and how mobile phones were used for health care;
2. The survey included participants of a randomised controlled trial, which was conducted in seven rural townships in Zhao County. The semi-structured interviews included caregivers in Zhaozhou Township (a township that was not included in the survey), which has both semi-urban and rural areas;
3. Caregivers were asked to participate by local doctors and recruited by trained interviewers;
4. Interviewers for the survey were trained local students. YL interviewed semi-structured interview participants in presence of the PhD candidate;
5. The questionnaires for the survey and semi-structured interviews were developed at the same time and the questions were partly matched so that the results from the semi-structured interviews could provide more in-depth insights into the survey results;
6. Data collection for the survey was carried out with a smartphone in the village clinic with reasonable privacy. The semi-structured interviews were carried out at a neutral and private location that was comfortable for caregivers;
7. Of the 1854 included survey participants, most were mothers (1548; 83.5%); the remaining were grandparents (260; 14.0%) and only a small proportion were fathers (41; 2.2%) or other caregivers (5; 0.3%). In semi-structured interviews, 17 caregivers participated: 12 mothers, 1 father, 2 grandmothers and 2 grandfathers;
8. Descriptive analysis was used to analyse the survey results and thematic analysis to analyse the semi-structured interview results. Then these results were compared and integrated.

5 Prevalence and factors influencing usage of mobile phones by caregivers: study results and discussion

Overview of chapter

After introducing and describing the methods of the study linked to the first objective of this thesis in Chapter 4, the current chapter presents the results and discussion of this study.

Photograph 23 Interviewer YL and grandmother during an interview

Photograph from the PhD candidate's personal collection

5.1 Results

Overview of section

The results section is divided into the four main themes that were found: (i) trends in mobile phone ownership; (ii) usage of mobile phone functions; (iii) factors influencing replying to text messages; and (iv) uses of mobile phones for health care (Table 11). Firstly, quantitative data from the survey are presented where data were available. Secondly, qualitative data obtained from the semi-structured interviews are described. By reporting the results in this way, the semi-structured interview results allowed for explanation and clarification of the survey results.

Table 11 Overview of themes related to usage of mobile phones

Themes			Subthemes	
Nr	**Mandarin**	**English**	**Mandarin**	**English**
1	手机所有权的趋势	Trends in mobile phone ownership	手机和智能手机	Mobile phones and smartphones
			使用手机多久了	Duration of mobile phone usage
			用手机的原因	Reasons for using mobile phones
			共用手机	Shared mobile phones
			获得手机方式	Method of mobile phone acquisition
			换手机	Changing mobile phones
2	手机的使用	Usage of mobile phone functions	手机使用中的问题	Problems whilst using mobile phones
			手机话费	Mobile phone bills
			短信	Text messages
			打电话	Phone calls
			发短信和打电话的比较	Comparison between making phone calls and sending text messages
			其他功能	Other functionalities
3	回短信的影响因素	Factors influencing replying to text messages	查看手机	Checking mobile phones
			信任发送者	Trusting the sender
			接到短信时心情	Emotion/feeling when receiving a text message
			回短信的重要性	The importance of replying to text messages
			短信的易用性	Ease of use of text messages
4	手机在卫生保健方面的应用	Uses of mobile phones for health care	给医生打电话	Calling the doctor
			给家人打电话	Calling family
			健康相关短信	Health-related text messages
			上网查询健康相关信息	Browsing the Internet for health-related information
			健康相关应用	Health-related apps

5.1.1 Theme 1: Trends in mobile phone ownership

The first theme had the following six related subthemes: (i) mobile phones and smartphones; (ii) duration of mobile phone usage; (iii) reasons for using mobile phones; (iv) shared mobile phones; (v) method of mobile phone acquisition; and (vi) changing mobile phones and SIM cards.

5.1.1.1 Mobile phones and smartphones

Table 12 shows that out of the 1854 survey participants, a large proportion (1620; 87.4%) used mobile phones. A considerably higher proportion of mothers (1433; 92.6%) and fathers (41; 100.0%) used mobile phones compared to grandparents (142; 54.6%). Table 13 shows that these findings were similar to when survey participants were asked about mobile phone usage of their household members.

Table 12 shows that almost a third of the 1620 mobile phone using participants used a smartphone (487; 30.1%), but they were almost all mothers and fathers (484; 99.4%). However, about 1 in 10 caregivers did not know whether they used a simple mobile phone or smartphone (155; 9.8%).

When the brand of the mobile phone was asked, many participants (639; 39.4%) did not knew the brand of their mobile phone, many mentioned Nokia (429; 26.5%) and the remaining participants (552; 34.1%) mentioned approximately 60 other brands (not shown in table).

All semi-structured interview participants used a mobile phone, because this was one of the selection criteria for participating in the interview. Many had a smartphone (I2, 5-8, 11, 13-15, 17), but this did not mean that caregivers had it for its more advanced functionalities. Not everyone could use the more advanced functions of a smartphone (I7), or was aware of the smartphone operating system (I6). Reasons for buying a smartphone were that many other people had a smartphone or that the smartphone was on sale (I2). The more advanced functions were not always perceived as necessary (I17). A phone that could be used to make phone calls was sufficient (I2).

Grandfather: "It is an information age, and our country has developed very fast. [Everybody] needs a mobile phone, though we don't need a mobile phone with many functions". "信息时代嘛，国内发展也不慢。必须有个手机，但是不需要多夸大"。(I17)

5.1.1.2 Duration of mobile phone usage

Mobile phones were commonly used for approximately 5 to 10 years (I1, 3, 6, 9, 10, 11, 13, 14), and sometimes less than 5 years (I2, 7, 12, 16) or more than 10 years (I4, 14, 15). The longest user of a mobile phone was a grandfather (I4) who received a "*Dageda*"* more than 20 years ago when he went to work in Shijiazhuang (the provincial capital of Hebei Province).

Grandfather: "That was… in (19)80s, yeah, in (19)80s (making noise from his nose.) "那时候是…八几年，恩，八几年那时候。（吸鼻子）" "….At that time it was not bad, to give me a mobile phone, a Dageda (early mobile phone) at that time. "那时候, 不赖的，给一个大哥大，那时候"。 (I4)*

*Early mobile phones were called "*Dageda*". The word "*da*" (大) means "big" and the word "ge" (哥) means "brother". *Dageda* was used as a Mandarin buzzword for company bosses, because these mobile phones were expensive and the people who could afford to buy them were usually bosses of companies. *Dagedas* used analogue signals and could only support voice communication. They were used from 1988 after China's first analogue mobile phone system was put in place [10].

Because the mobile phone has been widely used for a long time, caregivers were generally familiar with their usage (I8).

Mother: "…. Now who is not familiar with mobile phone use"? "现在谁使手机不熟悉啊"？(I8)

Caregivers did not find it difficult to use a mobile phone and only when changing a mobile phone, it took a little while to get used to a new mobile phone (I2). However, a grandmother said that she could not store numbers on her mobile phone, but that her children helped her out (I16).

Grandmother: "My children store them for me". "都是他们给存"。
YL: "Ok. "哦"。
Grandmother: "I'm too old to remember how to use the mobile phone. My brain does not work well". (laughing with sounds) "我不行，上岁数了，这个脑袋真不好使了"。（笑了笑）(I16)

5.1.1.3 Reasons for using mobile phones

Semi-structured interview findings showed that before mobile phones became widespread, landline telephones were used by some in Zhao County. The mobile phone replaced the landline telephone (I3-5, 16). It was more convenient to use a mobile phone, because the landline telephone could not be answered when going out of the home (I3, 16). This was perceived as so convenient that caregivers kept on using the mobile phone. Another reason for start using a mobile phone was because everyone had one (I6, 11-13, 17). Many found it convenient to contact others by a mobile phone (I1-12, 14, 17). Family members, friends and colleagues could easily be contacted with a mobile phone without having to walk somewhere or when being away from home (I2, 7, 14, 17).

Grandfather: "[Everybody] in the family needs to have a mobile phone now". "现在吧家人都有…都得有了"。
YL: "Why? Why does [everybody] need to have a mobile phone now"? "为什么都得有啊"？
Grandfather: "Because it is more convenient to get information by mobile phone and we can find [each other] easily. We had to go to other people's homes before. Now a phone call is sufficient". "就是信息方便呗，找找你吧，一找就到了，当时原先找你吧……还敲你门类或者什么地，现在打个电话就行了"。
YL: "Ok". "恩"。(I17)

A mobile phone facilitated solving common daily life problems, such as informing someone when running late, asking someone to pick up the child from school, or asking for help when a bicycle had a flat tire (I7). A mobile phone was particularly needed during pregnancy, so that someone could be contacted in case something happened (I1). However, there was no need for an expectant mother to use a mobile phone when someone, for example the mother-in-law, kept her company during pregnancy. In those cases the mobile phone became more important after pregnancy when the child was born and the mother was more frequently alone (I2). Starting to work was a reason to use a mobile phone (I5, 11, 13). Caregivers needed their mobile phones for work (I1, 3-5, 7, 9); for example to contact colleagues or customers (I1, 9).

Most caregivers had one mobile phone, but some had two: one for private use and one for work. A mother who was a teacher had two mobile phones. She used the mobile phone that was provided by work to check in and out of the school and to call other teachers (I9). In several interviews was mentioned that schools in Zhao County used a so-called *"Xiao Xun Tong"**, which was a school mobile phone information programme used both by teachers and parents of schoolchildren. Teachers sometimes received text messages with information about meetings and both the private and school mobile phone could be used in the school information programme (I9). Parents needed a mobile phone for this programme to receive information about their children's school arrangements, such as home work (I7).

Mother: "Yes, it is needed for "Xiao Xun Tong", for when your child goes to school. You must use the mobile phone and the text message function". "恩，对，孩子上学不是得用校训通，你必须得用那个……那个手机，必须得用那个短信"。 (I7)*

*Xiao Xun Tong, is an interface/software/service/app provided by a mobile operator in China, which provides communication channels between home and school. It allows: mass texts from a teacher to all class pupils, web interface for classroom notifications to/from teachers from/to parents, classroom administration, grade administration, web-based homework etc [324].

Mobile phones had become part of caregivers' daily lives and they had formed a habit of using them (I10, 13). It would be hard to give up using a mobile phone, though it would be possible to live without it (I1).

5.1.1.4 Shared mobile phones

Table 12 shows that almost all households of survey participants had more than one mobile phone (1806; 97.4%), and very few households had only one mobile phone (22; 1.2%) or no mobile phone (17; 0.9%). Table 13 shows that of caregivers and their household members who used a mobile phone, almost all mothers (1653; 99.2%), fathers (1731; 98.5%), grandmothers (712; 95.8%) and grandfathers (850; 97.0%) owned a personal mobile phone.

In addition, the semi-structured findings showed that it was uncommon to share mobile phones permanently with others. Both caregivers and their family members usually had their own mobile phone. However, the interviews revealed that mobile phones were sometimes shared for a short period of time.

It was commonly the father who used the mother's mobile phone (I1, 2, 7). This was OK when the mobile phone was only used for a brief period of time, for example when the father wanted to play games on the mother's smartphone, because he only had a simple phone (I7). However, it was not OK when the father took the mother's mobile phone for a longer time, because then arrangements had to be made that allowed the mother to stay connected. One creative solution was that the mother and the mother-in-law shared the mother-in-law's mobile phone, which could hold two SIM cards at the same time. This way both the mother and mother-in-law could use their own mobile number. However, it was found inconvenient to communicate this way. Therefore, the father was urged to buy a new mobile phone for himself (I2).

5.1.1.5 Method of mobile phone acquisition

Table 12 shows that survey participants bought mobile phones most frequently in a county level shop (926; 57.2%) or in the local village (269; 16.6%). A small proportion of participants (39; 2.4%) obtained the mobile phone in another way: receiving a new phone from a shop (15; 0.9%); receiving an old phone from another person (12; 0.7%); buying a mobile phone somewhere outside Zhao County (10; 0.6%) or sharing a mobile phone with others (2; 0.2%) (see also previous subtheme Shared mobile phones).

These survey findings were consistent with the semi-structured interview findings. Mobile phones were usually bought in local shops. When a mobile phone was required for work, it was usually provided by the employer (I1, 4, 9). Mobile phones were also received as a gift from a relative. These gift mobile phones were either new (I6, 8, 14) and sometimes given for a special event such as a birthday (I6), or old and given when a relative bought a new mobile phone (I9, 16). Old mobile phones did not always function well, but this was not a problem when it was usable (I9).

Mother: "I think it was from a relative. The former mobile phone was broken. I could not use it and someone said he/she had an old one, so I used it. It is ok as long as it can make phone calls, because I do not use other functions". "亲戚的吧，我上边那个手机是坏了，不能用了，然后别人说有一个旧的我就用了只要能打电话就行了，因为不用其他功能"。(I9)

5.1.1.6 Changing mobile phones and SIM cards

Table 12 shows that most survey participants (1347; 83.2%) did not change their mobile phone number in the past year, and a relatively low proportion had changed it once (193; 11.9%).

Similar to these survey findings, also semi-structured interview findings showed that caregivers did not change their mobile phone very often. It was common to change the mobile phone approximately every two years. One grandmother still used her first mobile phone obtained over five years ago (I3). The mobile phone was changed when there were problems, or when it was disliked (I10).

Mother: "It was just, I used it for a very long time, I didn't like it any more". "就是时间长了不喜欢了"。 (I10)

Sometimes when the mobile phone was changed, also the SIM card was changed, because it was convenient to buy both at the same time (I4). A high charge by the mobile telecom operator was a reason for changing SIM cards (I9). The need to stay in touch was a reason for not changing the SIM card often. A mother said that when she was younger, it was more common for her to change her mobile phone number. When credit was below zero, it saved her money to buy a new SIM card instead of buying new credit, because then she did not have to pay for the amount of credit that she was in debt. This could easily be done, because no identification card was required to register the SIM card. However, when having a family, it was more important to stay in touch. Therefore, now she had a family, she disliked changing her mobile phone number as relatives and friends could then not be contacted until she gave them her new mobile number (I2).

Mother: "It's not exactly for the reason that I registered it with my own ID card. It's that now you are…because after having a baby now, most of time, such as communicating with friends，you should keep the same mobile phone number. You can't change it very often. If you change it very often, you waste your time informing others that you changed your number, and it's not easy for them to contact you, right". "也不是说因为说用自己的身份证。是因为你现在不是，因为你现在生了小孩以后很多时候，你那个朋友联系啦嘞，固定了，你不能成天换号啊，成天换号你光去通知人啊， 人家跟你联系也不是很好联系，是吧"。(I2)

Table 12 Mobile phone ownership of survey participants (N=1854)

	All		**Mothers**		**Fathers**		**Grand parents**		**Other caregivers**	
	n (%)	**N**	**n (%)**	**N**	**n (%)**	**N**	**n (%)**	**N**	**n (%)**	**N**
Using mobile phone										
Yes	1620 (87.4)	1854	1433 (92.6)	1548	41 (100.0)	41	142 (54.6)	260	4 (80.0)	5
No	234 (12.6)		115 (7.4)		0 (0.0)		118 (45.4)		1 (20.0)	
Type of phone										
Smartphone	487 (30.1)	1620	470 (32.8)	1433	14 (34.1)	41	2 (1.4)	142	1 (25.0)	4
Simple phone	978 (60.4)		844 (58.9)		23 (56.1)		109 (76.8)		2 (50.0)	
Unknown	155 (9.6)		119 (8.3)		4 (9.8)		31 (21.8)		1 (25.0)	
Number of mobile phones in household*										
>1	1806 (97.4)	1853	-	-	-	-	-	-	-	-
1	22 (1.2)		-	-	-	-	-	-	-	-
0	17 (0.9)		-	-	-	-	-	-	-	-
Do not know	8 (0.5)		-	-	-	-	-	-	-	-
Place where mobile phone was bought*										
County	926 (57.2)	1619	832 (58.1)	1432	23 (56.1)	41	68 (47.9)	142	3 (75.0)	4
Village	269 (16.6)		246 (17.2)		5 (12.2)		18 (12.7)		0 (0.0)	
Town	158 (9.8)		136 (9.5)		7 (17.1)		15 (10.6)		0 (0.0)	
City	147 (9.1)		131 (9.1)		5 (12.2)		10 (7.0)		1 (25.0)	
Other[†]	39 (2.4)		33 (2.3)		0 (0.0)		6 (4.2)		0 (0.0)	
Do not know	80 (4.9)		54 (3.8)		1 (2.4)		25 (17.6)		0 (0.0)	

Number of times mobile phone number was changed in last year*										
Never	1347 (83.2)	1619	1179 (82.3)	1432	38 (92.7)	41	128 (90.1)	142	2 (50.0)	4
Once	193 (11.9)		179 (12.5)		2 (4.9)		10 (7.0)		2 (50.0)	
Twice	49 (3.0)		47 (3.3)		1 (2.4)		1 (0.7)		0 (0.0)	
Three times	13 (0.8)		13 (0.9)		0 (0.0)		0 (0.0)		0 (0.0)	
Four times or more	8 (0.5)		7 (0.5)		0 (0.0)		1 (0.7)		0 (0.0)	
Unknown	9 (0.6)		7 (0.5)		0 (0.0)		2 (1.5)		0 (0.0)	

*One mother discontinued the interview and did not answer this question.

†Other ways to obtain a mobile phone were as follows: mobile phone was given by a shop when connecting to the Internet for their own computer or when they changing the mobile phone card (15); old mobile phone was received from another person (12); mobile phone was bought somewhere outside Zhao County (10); mobile phone was shared with others (2).

Table 13 Survey participants' and household members' mobile phone usage (N=1854)

	Mothers		**Fathers**		**Grand mothers**		**Grand Fathers**		**Other caregivers**	
	n (%)	**N***	**n (%)**	**N†**	**n (%)**	**N†**	**n (%)**	**N†**	**n (%)**	**N**
Using mobile phone										
Yes	1666 (89.9)	1853	1758 (94.9)	1853	743 (40.1)	1853	876 (47.3)	1852	123 (41.6)	296
No	178 (9.6)		79 (4.3)		1082 (58.4)		949 (51.2)		163 (55.1)	
Do not know	9 (0.5)		15 (0.8)		27 (1.5)		27 (1.5)		10 (3.3)	
Owners of mobile phone										
Mothers	1653 (99.2)	1666	25 (1.4)	1758	7 (1.0)	743	1 (0.1)	876	1 (0.8)	123
Fathers	11 (0.7)		1731 (98.5)		10 (1.3)		13 (1.5)		1 (0.8)	
Grand mothers	0 (0.0)		0 (0.0)		712 (95.8)		12 (1.4)		1 (0.8)	
Grand fathers	0 (0.0)		0 (0.0)		13 (1.7)		850 (97.0)		6 (4.9)	
Other caregivers	2 (0.1)		2 (0.1)		1 (0.2)		0 (0.0)		113 (91.9)	
Other person	0 (0.0)		0 (0.0)		0 (0.0)		0 (0.0)		1 (0.8)	
Able to make phone call										
Yes	1645 (98.8)	1666	1734 (98.6)	1758	718 (96.6)	743	857 (97.8)	876	121 (98.4)	123
No	18 (1.1)		22 (1.3)		23 (3.1)		14 (1.6)		2 (1.6)	
Do not know	2 (0.1)		2 (0.1)		2 (0.3)		5 (0.6)			
Able to send text message										
Yes	1505 (90.4)	1666	1624 (92.4)	1758	171 (23.0)	743	264 (30.1)	876	96 (78.0)	123
No	157 (9.4)		130 (7.4)		568 (76.4)		601 (68.6)		27 (22.0)	
Do not know	3 (0.2)		4 (0.2)		4 (0.6)		11 (1.3)		0 (0.00)	

*One mother discontinued the interview and did not answer this question.
†Two mothers discontinued the interview and did not answer these questions.

5.1.2 Theme 2: Usage of mobile phone functions

The second theme, usage of mobile phone functions, had the following six subthemes: (i) problems whilst using mobile phones; (ii) mobile phone bills; (iii) text messages; (iv) phone calls; (v) comparison between making phone calls and sending text messaging; and (vi) other functionalities.

5.1.2.1 Problems whilst using mobile phones

Table 14 shows that nearly all of 1619 survey participants (one mother did not answer this question) who used a mobile phone said that it functioned for calling and text messaging (1600; 98.8%).

In the semi-structured interview it was found that while some caregivers had no problems with their mobile phones (I3, 7), problems that limited calling and text messaging with a mobile phone were quite common (I4). The following sections describe the following problems that occurred whilst using mobile phones: (i) non functioning mobile phone; (ii) phone running out of credit; (iii) empty battery; (iv) lost mobile phone; and (v) radiation.

Not functioning mobile phone

Sometimes mobile phones did not function because of accidents such as dropping the mobile phone in water (I5, 8). In other cases, mobile phones did not work well without a clearly identifiable reason (I4, 6, 7, 9). It was thought that mobile network problems caused the mobile phone to dysfunction, but it was not always known for sure whether this was a mobile phone or network problem (I9). When possible, caregivers solved mobile phone problems themselves (I4).

Grandfather: "I was listening and listening like that till I couldn't hear it. I couldn't make phone calls and I couldn't receive phone calls. I took the battery out and it was ok". "这么听着 听着听不到了再打也打不出去了， 接也接不着了。把电池摘了就行了"。(I4)

When caregivers could not solve problems themselves, they would take their mobile phone to a repair shop or buy a new mobile phone (I4, 8).

Running out of credit

It occasionally happened that there was no mobile phone credit left on the mobile phone. Depending mobile telecom operator policies and user age and credit, some could still use the mobile phone when there was minus ¥2 (about £0.20) or more credit in debt. Still, caregivers had to be careful with recharging credit before their mobile phone credit ran out, because otherwise they were unable to use their mobile phone. Some paid much attention to recharging credit on time, because the mobile phone had to be used for work (I3). When having a family, it was important to stay in touch and arrangements were sometimes made to recharge credit for the whole family (I2).

Mother: "Eh..now it's nearly never happens. Because I started using it after having my baby, I mean, for example, if there is not enough mobile phone credit, I will recharge it, and I will also recharge her father's and her grandmother's mobile phone. I will recharge them together, recharge them all. Whenever one mobile phone has not enough credit, only if there is one person, for example, he/she receives a text message to inform him/her, then he/she will recharge every one's mobile phone credit, in case someone else has not enough mobile phone credit. I mean, now it's not likely to not have enough mobile phone credit". "嗯。。。欠费的现在基本上不遇到了，因为我基本上现在生完小孩以后开始使哈，就是比如说话费里头没多少钱啦，我都去交啦，包括我的，他爸爸的，他奶奶的，一起交，都得交上了。甭管谁欠费，有一个人的手机，比如说...那个短信不是过来哈说余额不足，然后去交话费的时候就是几个人的都交上，每个人都交点，然后省的万一谁欠费了，是怕内个，现在不会说出现说欠费的情况了"。 (I2)

Text message reminders were received when mobile phone credit was low (I2, 3, 7, 9). Credit could be bought in the mobile telecom operator service centre (I1, 2), but being able to buy credit online was found convenient (I1, 9).

Battery runs out

Sometimes the mobile phone ran out of battery (I1, 3), but usually mobile phones were charged before this occurred (later described as subtheme Mobile phone switched on under Theme 3: Factors influencing replying to text messages).

Losing mobile phone

Sometimes a mobile phone was lost and then a new mobile phone was bought (I4, I9). In these cases, money had to be paid if someone wanted to keep the original mobile phone number, which was infrequently done. Therefore, it was more common to change the mobile phone number when a mobile phone was lost (I4).

Radiation from mobile phone

Radiation from mobile phones, computers and televisions was perceived as harmful and spontaneously mentioned by a number of caregivers (I1, 2, 7, 8, 12, 13). This information was obtained from relatives, friends, books, newspapers, magazines and television (I1, 7, 8, 12, 13).

Mother: "Television says that radiation is not good, so I am afraid of it". "他说不好咧，怕呗" (I13)。

Radiation was thought to be particularly harmful to infants, young children and pregnant women (I1, 2, 12). An observed effect of radiation was that a child got fever when using the computer or when playing with the mobile phone (I13). The harmful effects of radiation were not always very clear to caregivers, but it was thought that exposure to radiation could lead to malformation during child development (I1).

Mother: "For me, I feel it's less bad for adults, mainly because just take it into consideration that…that children's immune systems are weak, and if there is some radiation, you see, in the book, like in the book I read when I was pregnant, maybe it will cause the… radiation caused by using mobile phone, if there is radiation, right, the pregnant woman, it is likely to lead to malformation of the child, malformation."" 对我的话感觉大人吧还好一点这倒无所谓，主要是考虑到小孩毕竟他…免疫都低吧，然后有辐射的话，你像那个书上，那个孕期时侯看的那个书似的，容易可能是会造成就是（听不清）那个…用手机辐射，如果说辐射哈，大人的情况下，容易造成小孩畸形啊，发育畸形。*" (I1)*

Despite the perceived harmful effects of mobile phone radiation, still mobile phones were used. The radiation was not so bad, because preventive measures could be taken that limited the harmful effects of radiation (I1).

Mother: "I just feel that I can live with the radiation, because the radiation is something that you can try to keep away. Yes, just that, when you are careful the radiation will not do big harm to the body. You can just be careful to avoid those occasions, using a mobile phone when the radiation is strong. It's OK if you are careful, the radiation, actually, is not a big harm...though I pay attention to radiation, but I don't think it's a big problem". "就是感觉......就是这个辐射就是还可以接受的的情况，因为这个辐射毕竟...就是说，他就是你可以避免或者就是可以减...减少对，对，就是那个，平时注意的话，他这个辐射对身体，比如说，没有太大危害，就是说，你平时注意不要...就是说这种情况下，容易辐射比较高的情况下使用，就是，都可以。所以说你平时注意就行了，他这个辐射其实没有太...虽然说就是重视辐射，但是没有把它想象的太严重"。 *(I1)*

When having a child, it was more important to pay attention to radiation and the mobile phone was often kept away from the child (I13). Other preventive measures included not using the mobile phone when being pregnant (I2, 12) and reducing the duration of mobile phone use (I1). China Telecom was known for having weaker radiation and therefore chosen as mobile telecom operator (I1).

The perceived effects of mobile phone radiation played a role in the place where the mobile phone was kept. Sometimes the mobile phone was not kept in the pocket (I12). Also the mobile phone was kept in places further away from people, such as near the window (I7) or on the table during the night (I1, 8). For reducing radiation from computers, a cactus was placed next to the computer (I1).

Mother: "...I mean the cactus will weaken the radiation". "...就是仙人掌会降低辐射的那个。"
YL: "How does it weaken the radiation, in your mind"? "恩，怎么降低辐射啊，您看"？
Mother: "It seems to absorb it". "好像就是把那个给吸收了吧"。*(I1)*

5.1.2.2 Mobile phone bills

Table 15 shows that survey participants spent a median of ¥20 (about £2) (¥20-30) per month on their mobile phone.

Semi-structured participants mentioned to spent similar amounts of money on their mobile phones. Caregivers paid around ¥9 (about £0.90) each month to the mobile telecom operator, but they were unsure why (I2, 9). One service that was offered for this fee was showing the number of the person who called (I7). Some had a contract with a certain number of phone calls minutes, text messages and usage of Internet (I1, 5, 6). Others had pay-as-you-go SIM cards and paid ¥0.10 (about £0.01) per text message and ¥0.10 or ¥0.20 (about £0.02) per minute to make a phone call. These costs were seen as cheap (I2, 6, 7, 9).

5.1.2.3 Text messages

Table 15 shows that the median number of text messages sent was 0 per week (Q1-Q3; 0-4) and the median number of text messages received was 7 per week (Q1-Q3; 2-10). Table 16 shows that of 1433 surveyed mothers and 41 surveyed fathers, few mothers (120; 7.4%) and fathers (85; 5.9%) were unable to send text messages. However, of 142 surveyed grandparents only about one in four were unable to send text messages (35; 24.7%). Table 13 shows that when survey participants were asked the ability of their household members to text message these proportions were similar for parents, but a much higher proportion of grandparents were thought to be unable to send text messages (76.4% of grandfathers and 68.6% of grandmothers).

In semi-structured interviews, caregivers also did not usually sent text messages and mentioned more frequently receiving than sending text messages (I3, 7). Parents used text messaging more often than grandparents. Grandparents had much more difficulty with text messaging or could not use this function at all (I3, 4, 16, 17). Grandparents could still read text messages and sometimes asked others for help with sending text messages (I4). One grandfather could only type very short text messages (I17). A grandmother could use text messages with her previous mobile phone, but had not learnt it on her new mobile phone. Not remembering pinyin well was another problem (I4, 17). As making phone calls was sufficient, there was no need to learn to use text messages (I4).

Grandmother: "Eh, because there is no need to learn that. I did not read that. At our age, it has no use. I do not send text messages and so on, and just making and receiving calls is enough. Haha. . . . . " "呃…换手机后来没什么事了我都不看那，光着…咱这岁数了也没用，也不发短信也不干嘛，光能接能打就成了，就是那个…不要求说说干什么别的是吧（呵呵）那……" (I16)

Some parents disliked sending text messages, because they were not used to it (I5, I15). However, some liked to commonly send text messages (I9). Text messaging was particularly useful for simple things and when there was nothing urgent (I5, 10, 12). Text messages were mainly sent to friends, classmates, colleagues and sometimes to family members (I1, 2, 5, 6, 9-11). Text messaging was perceived to be something that younger people liked to do (I10).

Some never received text messages from people they knew (I14, 16). Receiving text messages that were perceived as "junk" or "scam" were quite common (I11-13, 15, 17) and included text messages from mobile telecom operators. Caregivers liked to receive useful text messages. Reminder messages about running out of mobile phone credit were valued, because they were informative (I15). Some subscribed to a text messaging service that provided the news or weather information (I1).

Mother: "There is a, send you a piece of (message) everyday…that's the news, it's included …" "有一个，每天给你发一条那个…就那个新闻，它这个套餐是包括…"
YL: "Each piece of news sent every day"? "每天发一条新闻"？
Mother: "Yes. Two…two pieces of it every…every day, One is in the morning, then the other is in the afternoon". "对。每…每天…2…2 条，早上一条，然后下午一条"。
YL: "Oh". "哦"。
Mother: "And weather forecast". "还有天气预报"。(I1)

It was also popular to receive text messages for fun, such as jokes, or blessings during Chinese festivals (I11) that were forwarded to others (I8).

Mother: "About sending text messages…I do not send too many text messages. Just…no… on the Laba festival (the eighth day of the twelfth month in the lunar calendar), I receive a few messages with well wishes". "发短信…没多少发短信。就是…不是…腊八那天吧，就是收几条祝福的短信"。 (I8)

5.1.2.4 Phone calls

Table 15 shows that the median number of calls made was 7 per week (Q1-Q3; 4-10) and this number was the same for the number of calls received per week. Table 16 shows that of 1433 surveyed mothers, 41 surveyed fathers and 142 surveyed grandparents, very few mothers (15; 0.9%), fathers (1; 2.5%) and grandparents (4; 2.8%) were not able to make a phone call. Table 13 shows that when survey participants were asked the ability of their household members to make a phone call these proportions were similar for all caregivers.

These survey findings were consistent with the semi-structured interview findings. All parents and grandparents were familiar with making phone calls. Some caregivers made phone calls frequently; often a number of calls on a day (I1, 2, 3, 9, 13, 14). Calls were made to family members when there was something urgent (5), to see how a family member was doing (I1, 6-8, 13, 14), to talk about daily things (I8, 10, 13) or to talk about the child (I1, 6, 9, 10). No calls were made later in the evening, because caregivers did not want to disturb others (I8). Grandparents often took care of their grandchild. They used the mobile phone to let the child and parents talk to each other when parents were away (I3).

Grandmother: "About something new that the child learned. (For example) the poetry of Tang Dynasty the child has learned, or the songs and the children's songs and the ballad she has learned. And I will make a call to let the child sing to her parents. That's all". "就是孩子学什么新本事了，学会唐诗了，学会唱歌了，学会说儿歌了，说歌谣了，打个电话唱歌叫他妈妈爸爸听听，就是这"。(I3)

Friends were not frequently called for chatting, because when taking care of children, caregivers were quite busy and did not have time to make long phone calls when there was nothing important to talk about (I2, 8). It was preferred to say what had to be said and then to end the phone call. Making calls to chat with friends was found to be something for younger people who had more time (I8). However, mobile phone calls were sometimes used to make an appointment with friends (I5).

Mother: "(laughs with sound) It's..just…just..when it's..ah, for example… I want to see you today and so on or go somewhere for fun..then we will make a phone call. Usually, you are busy with your things, I am busy with mine". "（呵呵） 这个…… 就是…… 也就是比较…啊 …… 今天我想去你那看看啦…怎么啦 去哪玩啦，然后打个电话，一般就是，啊，你忙你的，我忙我的"。(I5)

5.1.2.5 Comparison between phone calls and sending text messages

Table 14 shows that of the 1620 survey participants, the mobile phone's primary usage was calling for a high proportion of participants (1475; 91.0%). Only a very small proportion of participants mentioned text messaging as primary usage (33; 2.0%) and they were all mothers. Few participants mentioned to use both calling and text messaging in equal measure (106; 6.5%).

When participants were asked about their preference for text messaging or *QQ*, more than a third of the 1620 participants preferred text messaging (631; 39.0%) and a third preferred *QQ* (540; 33.3%). About 1 in 10 participants used text messaging and *QQ* in equal measure (198; 12.2%). A relatively high proportion of grandparents could not use either text messaging or *QQ* (110; 77.5%) compared to mothers (132; 9.2%) and fathers (3; 7.3%).

These survey findings were consistent with semi-structured interviews. All grandparents and most parents preferred making phone calls, though some said to prefer text messaging (I5, 9). In the following sections, factors related to preferences are described: (i) immediacy; (ii) clarity; (iii) ease of use; and (iv) costs.

Immediacy

Making a phone call as was quicker, because communication via text messaging took a longer time (I2, 3, 5, 15). When the mobile network did not function well, the text message could be delayed and waiting for a text message reply was found to take a long time (I1).

Mother: "Sometimes, it is clearer to talk; text messages… sometimes text message is not as quick as making phone calls. I mean…I mean, for communication, text message is a two-way process (laughing with sounds), like sending messages repeatedly, and wait… wait for the other's response. Now if you need… you can make a phone call to say it. Right?" "有的时候话说的明白，短信…而且有时候发短信不如打电话及时，就是…就是沟通是吧，短信还有一个来回，（笑）反复发送啊，等…等对方回信息.现在有什么事儿打电话就说了是吧"。*(I1)*

Phone calls were found to be more direct (I2, 3). Therefore, in urgent situations calling was preferred over sending a text message (I12). However, when being busy with work, it was better to receive a text message that could be read later. A text message was also sent when someone could not be reached via a phone call (I9).

Clarity

Communicating by making phone calls was found to be clearer than sending text messages (I1, 3, 6-8, 10, 15). Text messages only had a limited space and thus it was more difficult to make matters be clearly understood (I6, 14, 15).

Mother: "I can't make my point in a few sentences. (laughing with sound)". "那一句话两句话也说不清楚，呵呵"。(I6)

Conversely, text messaging was preferred when it was found difficult to express something in a phone calls and clearer to write (I9).

Ease of use

It was found too much effort to type a text message (I1, 6, 10, 15). Writing a text message took a long time. Caregivers did not have the patience to send text messages or the child asked for caregivers' attention whilst writing a text message (I3, 10). Even when text messaging was preferred, still it was found uneasy to write text messages. This was caused by the Chinese input methods, which were perceived to be more difficult to use compared to input methods based on the alphabet (I9).

Mother: "Because it is not like the....because my mobile phone does not have the input method for directly tracing the characters (does not have mobile phone with touch screen). I think it is faster to write/trace them. Input is only via pinyin typing... Pinyin... It is not the same as there are 26 symbols for 26 letters. There are many letters on one button, it is too slow to type". "因为她不是像那个，因为我这手机没有手写功能嘛，写的时候可能比较快一些，就是得拼写嘛，拼写，也不是 26 个字母都有 26 个字符表示，它一个键上有好几个字母得找那个太慢了"。(I9)

Costs

Costs were a noticeable consideration. Calling could save money compared to sending text messages (I8, 13). A short phone call was preferred when contacting someone local, because this was cheaper than sending multiple text messages. Local calls were cheaper than long-distance calls (I13, 15). However, when the person who received the call was in a different region, a text message was sent to save money (I15).

Father: "I'm not used to it and I think it is too much effort (text messaging). Unless I am far away from home, when I need to make a long distance call, I will send text messages". "就是不习惯回短信。嫌回个麻烦，除非出远门了在外边，打电话打长途了干嘛了，回个短信"。(I15)

5.1.2.6 Other functionalities

Only one survey participant mentioned Internet and one mentioned *QQ* as primary function of the mobile phone.

Semi-structured interview participants mentioned that other mobile phone functions they used included Internet (I8, 10-12), photos (I7, 9, 17), videos (I7, 9), recording sounds (I9), alarm (I1) and playing games (I10, 13). *QQ* was frequently used to chat with friends or colleagues, or to play games (I11, 13-15). Not all caregivers used the Internet, even when it was available on their mobile phone (I2, 7, 9).

Table 14 Usage of mobile phone for calls and text messages by survey participants, n (%)

	All (N=1620)	Mothers (n=1433)	Fathers (n=41)	Grandparents (n=142)	Other caregivers (n=4)
Functioning mobile phone*					
Functions for calls and text messages	1600 (98.8)	1422 (99.3)	41 (100.0)	133 (93.7)	4 (100.0)
Does not function for text messages	10 (0.6)	1 (0.1)	0 (0.0)	9 (6.3)	0 (0.0)
Does not function for calls	1 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)
Does not function for calls and text messages	7 (0.4)	7 (0.4)	0 (0.0)	0 (0.0)	0 (0.0)
Other	1 (0.1)	1 (0.1)	0 (0.0)	0 (0.0)	0 (0.0)
Primary usage of mobile phone calling versus texting					
Calling	1475 (91.0)	1297 (90.5)	39 (95.1)	135 (95.1)	4 (100.0)
Text messaging	33 (2.0)	33 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)
Both in equal measure	106 (6.5)	100 (7.0)	2 (4.9)	4 (2.8)	0 (0.0)
Other (Internet (2), *QQ* (1), do not know (3)	6 (0.5)	3 (0.2)	0 (0.0)	3 (2.1)	0 (0.0)
Primary usage of text messaging function					
Text messaging	631 (39.0)	579 (40.4)	25 (61.0)	26 (18.3)	1 (25.0)
QQ	540 (33.3)	532 (37.1)	6 (14.6)	1 (0.7)	1 (25.0)
Both in equal measure	198 (12.2)	184 (12.8)	7 (17.1)	5 (3.5)	2 (50.0)
Cannot use either	245 (15.1)	132 (9.2)	3 (7.3)	110 (77.5)	0 (0.0)
Do not know	6 (0.4)	6 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)

*One mother discontinued the interview and did not answer this question.

Table 15 Number of calls and text messages used and amount of money spend by survey participants, median (Q1-Q3)*

	All (N=1620)	Mothers (n=1433)	Fathers (n=41)	Grand parents (n=142)	Other caregivers (n=4)
Calls made per week	7 (4-10)	7 (4-10)	7 (4-25)	5 (2-7)	6 (6-6)
Calls received per week	7 (4-10)	7 (4-10)	10 (6-26)	7 (5-8)	6 (6-6)
Text messages sent per week	0 (0-4)	0 (0-5)	0 (0-4)	0 (0-0)	-
Text messages received per week	7 (2-10)	7 (2-10)	5 (2-7)	4 (0-7)	-
Money spend on mobile phone per month (¥)	20 (20-30)	20 (20-30)	30 (25-55)	20 (10-25)	35 (21-124)

*For number of participants who answered these questions see Table 16.

Table 16 Survey participants answering the question about number of calls and text messages, and mobile phone bill, n (%)

	All (N=1620)	Mothers (n=1433)	Fathers (n=41)	Grand parents (n=142)	Other caregivers (n=4)
Calls made per week					
Answered question	880 (54.3)	790 (55.1)	19 (46.3)	70 (49.3)	1 (25.0)
Do not know	725 (44.8)	633 (44.2)	21 (51.2)	68 (47.9)	3 (75.0)
Unable to make call	15 (0.9)	10 (0.7)	1 (2.5)	4 (2.8)	0 (0.0)
Calls received per week					
Answered question	847 (52.2)	758 (52.9)	20 (48.8)	68 (47.9)	1 (25.0)
Do not know	764 (47.2)	669 (46.7)	20 (48.8)	72 (50.7)	3 (75.0)
Unable to receive call	9 (0.6)	6 (0.4)	1 (2.4)	2 (1.4)	0 (0.0)
Text messages sent per week					
Answered question	960 (59.3)	857 (59.8)	27 (65.9)	76 (53.5)	0 (0.0)
Do not know	540 (33.3)	491 (34.3)	14 (34.1)	31 (21.8)	4 (100.0)
Unable to send text message	120 (7.4)	85 (5.9)	0 (0.0)	35 (24.7)	0 (0.0)
Text messages received per week					
Answered question	931 (57.5)	835 (58.3)	24 (58.5)	72 (50.7)	0 (0.0)
Do not know	641 (39.6)	575 (40.1)	17 (41.5)	45 (31.7)	4 (100.0)
Unable to receive text message	48 (2.9)	23 (1.6)	0 (0.0)	25 (17.6)	0 (0.0)
Phone bill per month (¥)					
Answered question	1443 (89.1)	1293 (90.2)	37 (90.2)	109 (76.8)	4 (100.0)
Do not know	177 (10.9)	140 (9.8)	4 (9.8)	33 (23.2)	(0.0)

5.1.3 Theme 3: Factors influencing replying to text messages

The third theme had the following five subthemes: (i) checking mobile phones; (ii) trusting the sender; (iii) emotion/feeling when receiving a text message; (iv) the importance of replying to text messages; and (v) ease of use of text messages.

5.1.3.1 Checking mobile phones

The frequency of checking mobile phones was variable. Some always checked their mobile phone (I13-15), while others usually did not check their mobile phone often (I10). When caregivers checked their mobile phone depended on the circumstances (I6, 13, 17), but caregivers said they generally responded when seeing a missed call or text message (I6, 10, 11). The following sections describe factors related to checking mobile phones, which were: (i) when the user is free; (ii) where the mobile phone is placed; (iii) mobile phone switched on; and (iv) mobile phone audio volume.

When the user is free

Checking mobile phones depended on the available time; usually the mobile phone was checked during free time and when it was not busy (I4, 10-12). Free time was when the child was asleep in the afternoon or evening. When taking care of the child, the mobile phone was often not checked (I10).

Where the mobile phone is placed

Table 17 shows that almost all surveyed fathers carried their mobile phone with them when leaving the house (40; 97.6%), but only about two third of mothers (975; 68.0%) and grandparents (96; 67.6%) carried their mobile phones outside the home.

The place where the mobile was kept varied for semi-structured interview participants. The mobile phone was often brought when going out, if it was not forgotten. When being home, the mobile phone was often kept at a particular place in the house (I1-3, 5, 6, 8, 10, 11-13, 15).

Mother：“Eh...I put it on the table at home. I keep the mobile phone in my pocket when I go out”. “恩...... 在家的时候放桌子上，在外边一般是放在那口袋吧”。(I8)

Sometimes it was forgotten to take the mobile phone out of the pocket at home (I9) or the mobile phone was purposely carried by the caregiver (I4, 14). Where caregivers shared a mobile phone, the person going out was given the phone (I2).

Photograph 24 Mobile phone placed on small table

Photograph from the PhD candidate's personal collection

Mobile phone switched on

Usually the mobile phone was kept switched on during both day and night (I1-3). Work sometimes required that a caregiver had to be contactable at any time. Even when there was no work requirement to keep the mobile phone switched on, it was left on in case of emergencies or when family members called. Only when the mobile phone was out of battery was it turned off (I1).

Mother: "Yes, I am used to that, eh, unless it runs out of battery I will, I mean, en, I will charge it and power it off, eh, I am used to keeping my mobile phone powered on, because sometimes it's like some mobile phone force of habit, I feel things like…like there will be something happening if I don't bring it (laugh with sounds about mobile phone force of habit)". "还有，习惯性的，恩，除非没电的时候再，就是，恩，就充电关机，恩，基本上我都是习惯性开手机，主要是有的时候就是手机……那种病一样，我感觉……老感觉手机一会儿不拿就感觉好像有事一样。有……呵呵"。 *(I1)*

Mobile phone audio volume

Usually the sound of the mobile phone was on and an incoming phone call or text message could be heard (I2-8, 10, 11). The sound was even kept on during the night for when something happened (I3). However, the sound was not always very clear when being further away from the mobile phone (I6) and less attention was paid to the mobile phone when taking care of the child (I10).

Mother: "I can hear it...sometimes when my child needs me or my child is naughty, I do not care about that, I will take care of my child first (laughing with sounds) ". "听见...有时候孩子正需要人咧，正淘呢，就不管那个了，就是以孩子为主先（妈妈笑了）" (I10)

5.1.3.2 Trusting the sender

Trust was related to who sent a text message. There were many text messages that were perceived as "scam" (I12, 15). Some of those text messages could easily be identified (I10).

Mother: "Yes. Or I can know it is a scamming message at a glance. Then I will not respond to it". "恩，一看就是那诈骗短信那样的，肯定就不回"。(I10)

Caregivers feared having to pay a lot for calls or text messages of which they thought that were scamming (I11, 17). Text messages about selling various goods or about sending money were frequently received and perceived as harassing (I12, 15, 17). These messages were sent by mobile telecom operators or companies without permission of the user to contact them. Often these text messages were not read, because they were useless (I12, 15). An application was useful to block unwanted text messages and those that came through the blockade were deleted immediately (I17).

Grandfather: "Such as junk text messages and harassing calls. There were many of this kind of messages before, but not now. For example, now, I had this experience today. I received a message about selling mobile phones today. And I'm curious how he gets my number and I also received a message sent by the China Mobile service centre, which wants you to interact with it, with the message. I just delete them after see them. I just delete them after see them. I will not read them and never take part. "那个骚扰电话或者是那个垃圾短信啊，他可能来的少。原先来的多。原先一天好几条短信，现在就是我现在吧，每天就是有这经历，你像今天吧，接来一个卖手机他的意思是搞活动，卖手机他不就知道怎么把我这个信息怎么搞到，他就给我发来的短信，说卖手机，怎么怎么。还一个就是意思是他们...内个内个，像今天还接了一个移动上，移动发来一个什么短信互动，那个现在我见了就删，见了就删，干嘛的我也不看，我也不参与"。(I17)

When it could not be easily seen whether the information in a text message was reliable or not, sometimes verification was sought by contacting the person who sent the text message. Some caregivers only responded to calls and text messages from known numbers of relatives and friends (I10, 11, 13-15), because there was no reason to reply to messages from unknown numbers (I13). However, sometimes when a relative changed their number and did not inform someone about this, a text message was ignored till a phone call was made by that person (I10).

5.1.3.3 Emotion/feeling when receiving a text message

Although only mentioned once, an interesting finding was that when being in a good mood, it was more likely to respond to a text message (I5).

Father: "I don't know how to say that. It just depends on my mood. I will reply when I am in a good mood". 那也说不清嘞，看心情嘞，心情好嘞就给他回下"。(I15)

5.1.3.4 The importance of replying to text messages

Some text messages did not require a response, for example, information text messages from a mobile telecom operator (I14). Text messages that contained a question needed a response (I12). When the content of a text message was perceived as important and urgent, a reply was sent quicker (I14).

YL: "Ok. How long will it take for you to reply to a message after you see a message? "哦，那收到短信之后，就是您看到短信之后您多长时间才能回短信啊"。
Mother: "It depends on the content of the message. If it is very important, I will reply immediately; if it is not very urgent, such as those messages sent from the China Mobile service centre. I will not reply to those messages. "那要看什么短信，如果是有事短信话，立马就回。如果没事的话，有些不是那个那个移动台上有时候给你发短信，那些短信都不回"。(I14)

Text messages that were perceived as unimportant were often not even read, because it was expected that a phone call would be made for important urgent matters (I10).

5.1.3.5 Ease of use of text messages

Some caregivers were only able to read the text messages, but were not used to responding to them (I15). The length of the reply that was required influenced the amount of effort it was to reply (I17). As mentioned in section 5.1.2, some caregivers and particularly grandparents found it hard to write text messages or were not able to text message (I17).

Grandfather: "Oh, it is too hard for me to reply. I will reply immediately if it just needs me to type yes, ok, but I'm not sure if it needs me to type many characters. Ten minutes, twenty minutes or more. You see". "哎呀，那个我得需要回一条短信啊我得费劲了，你要说你要说我来了，或者是什么嗯，是的，那个我能马上就回，但是你要我编，就那意思写点东西可就慢，不敢说，得十分八分的，二十分的，是吧"。 (I17)

5.1.3.6 Additional findings

Although not asked in the interviews (see Questionnaires in Chapter 4), some caregivers asked the interviewers about the text messaging data collection study (I1, 9-12, 14). The details described in the following phrases were not based on experiences, but on caregivers' ideas and need to be interpreted with caution. Caregivers said to be generally willing to respond to text message questions (I9, 11, 12, 14), but this depended on the importance of the text message (I10). They liked to know how often the text messages were sent (I1, 10). Also it was needed to know who sent the text message and meet the sender in person or by a phone call (I1, 14). The information in the text message was said to be verified by searching the Internet (I11). Concerns were expressed about whether information in a text message could be clear, whether a reply could be given on time, especially during work or later at night (I1). No replies were said to be given to messages when private sensitive information was asked (I12). Caregivers hoped to receive feedback from which they could learn and those messages would have to contain preventative advice about childhood diseases (I9, 11, 12).

*Mother: "If they ask this, I would like to tell them. Because I am worried about my child's health and I hope they can tell me how to take care of my child". "**如果他**问这个，愿意告诉他了，担心孩子生病了，也希望他告诉我怎么也给孩子看看"。 (I12)*

Table 17 Location where survey participants place the mobile phone when leaving the house, n (%)

	All (N=1620)	**Mothers (n=1433)**	**Fathers (n=41)**	**Grandparents (n=142)**	**Other caregivers (n=4)**
Location where mobile phone is placed when leaving the house					
Carry phone	1115 (68.8)	975 (68.0)	40 (97.6)	96 (67.6)	4 (100.0)
Leave phone in house	498 (30.7)	451 (31.5)	1 (2.4)	46 (32.4)	0 (0.0)
Someone else carries phone	5 (0.3)	5 (0.3)	0 (0.0)	0 (0.0)	0 (0.0)
Other (no fixed location, normally do not carry it)	2 (0.1)	2 (0.2)	0 (0.0)	0 (0.0)	0 (0.0)

5.1.4 Theme 4: Uses of mobile phones for health care

Table 18 shows that more than half of the 1619 surveyed households of caregivers with a mobile phone had the phone number of a health facility (936; 57.8%). Almost half (763; 47.1%) had the phone number of the village clinic, about one in five of the county (339; 20.9%) or township hospital (344; 21.2%). Table 19 shows that about one in four participants (432; 26.7%) had used their mobile phone in the past three months for health care. This proportion was the highest for fathers (15; 36.6%), followed by mothers (187; 27.9%), and grandparents (18; 12.7%). However, of the 1187 participants who had not used their mobile phone for health care, a very high proportion wished to use their phone to receive health information (1110; 93.5%).

The following sections describe the findings of the semi-structured interviews, in which the following was mentioned: (i) calling the doctor; (ii) calling family; (iii) health-related text messages; (iv) browsing the Internet for health-related information; and (v) health-related apps.

5.1.4.1 Calling the doctor

It was common to call a doctor (I2-5, 7, 10, 13, 14); often the village doctor (I3-5, 7, 10, 14). Generally the village doctor was called once in a while, but sometimes up to two or three times a day when there was an issue (I4). Calling was used as an alternative way of reaching the village doctor when the doctor was out of the clinic (I4), or when the caregiver was unable to go to the clinic in winter (I7). It was found to be convenient to call a doctor, because it provided caregivers with direct contact without having to go out (I5, 7). Some called the village doctor during the day (I14) and others in the evening when the doctor did not have time during the day (I10). Calling was perceived as a less intrusive way to contact a doctor late at night compared to a visit to the doctor's home, because the doctor might be sleeping (I5). Calls were used for advice about the child's symptoms or medicines (I5, 7, 13, 14). The advice of the doctor was followed (I4) and a ready available medicine was given (I7). Sometimes the doctor visited the participant after a mobile phone call (I4).

Grandfather: "Such as, he's out …for some business, or he's visiting a patient at home. I need to know how to find him and I will call him. On that occasion, when he's back, he will come here". "比如说他去…去办点什么事，他出诊了，出诊了没在，我得知道怎么回事找到他。就给他打电话。那种情况等他回来他就过来啦"。(I4)

The "immunization doctor" was called for advice about vaccinations (I2, 3, 13, 14), for example about side effects (I3), the number of vaccinations that should be given and whether vaccines were available (I2).

Mother: "....Last time there were drugs for flu or something else. He said it was very short of supply. Sometimes, when you get there, there are no drugs. You can make phone calls to him/her to see whether there is the supply of the drug. If there is, then you can bring your child to there, right? Sometimes, it turns out that he/she is not there. Your child might catch a cold from travelling there and to and fro too much". "他这一管针可能说说扎好几个孩子的，都用这个药，比如说你去了以后没这个药，就是上次有一个什么好像是流感药还是什么药，他说特别紧缺哈。有时候你去就没有这个药比如你打电话问他一下说看你们现在这个药到了吧？到了就带孩子去扎嘞，是吧，有时候你去了他没在，跑来跑去怕孩子受凉"。(I2)

A maternal, newborn and child health hospital doctor was called about which medicines should be given. The doctor was perceived as kind and advice was followed (I10). The gynaecologist's phone number was received during prenatal visits and could be called when something happened during pregnancy. The mobile phone number was received from the doctor directly, or received through personal connections with relatives who already had previous contact with a doctor (I2).

Mother: "About this, because, that, it's that my mother, because my mother, my sister-in-law and others, when they gave birth, both chose this doctor, so my mother got the doctor's mobile phone number, then when I got pregnant, I choose that doctor, and then if there was something, because I had the doctor's mobile phone number, I would call the doctor". "这个啊，因为那个，应该是说我妈妈，因为我妈妈哈、我嫂子他们生孩子都是找的这个医生，我妈妈有他的手机号，然后等到我怀孕的时候就找人家，然后人家我手机号也就有了，有就什么事儿我就给人家打电话"。(I2)

Some caregivers had never called a doctor (I1, 6, 11, 16, 17). Reasons for this varied and included not having thought about calling a doctor (17) and finding it unnecessary to call a doctor (I11, 16), because it was the role of the village doctor to be available at the clinic (I16). Also the husband of one mother worked in the hospital and he could easily ask health-related questions (I1). There was no use in calling when the village clinic had to be visited for medicines anyway. This was no problem, because it was easy to go when living near the village clinic (I11).

5.1.4.2 Calling family

Calls were made to family members when there was something wrong with the child (I9, 10). In addition, it was common for family members to call each other to check up on their health condition (I2, 3, 6, 8).

Mother: "The last time… why did I make a phone call to him or her. The last time because…last night…I made a phone call last night…because my sister's…there were several small scratches left on her body from scratching. I told her that I cared about her, and I can go with her to see the doctor when I have time. That is all". "最近的一次因为什么给人家打电话啊，最近因为……昨晚上吧哈，昨晚上打电话…因为我姐的，她那身上一抓，那个那个有那个小道道那个，我说那个…不是关心她病情嘛，然后说有时间陪他去看看。别的没事"。 (I8)

5.1.4.3 Health-related text messages

Text messages were not sent to ask for health advice, but text messages with health information were often received. Text messages from the immunization centre reminded caregivers to come to the centre for vaccination of their child (I10, 14, 15). Health information text messages commonly had general health advice and were sent by mobile telecom operators (I7, 10).

Mother: "Yes. I received some text messages from the operator (China Mobile) telling me to drink more water or eat more pears during the winter or some other things". "哦，那就是那个移动上边有时候发短信告诉那个多喝水啊，或者冬天里多吃梨啊，或者什么的嘛"。(I7)*
**Zhao County is famous for its pears [306].*

Other health text messages were about child feeding, development (length, use of left or right hand, crouching, standing, walking etc.) and prevention of colds by giving the advice to wear more clothes (I10, 13). These text messages were perceived as good, were read and the advice was followed (I10, 12). It was convenient that those messages did not need a reply. A mother was willing to pay ¥5 (about £0.50) per month for "the baby plan", a text message service with information about children. However, before singing up, first it was needed to visit the mobile telecom service centre or ask the village doctor to check whether the messages were truthful (I13).

Mother: "Eh…sometimes I would ask the doctor after reading the message, like who sent the message, did they send the message"? "恩。他发了有时候就问问医生 ……谁啊？有没有啊？"。 (I13)

5.1.4.4 Browsing the Internet for health-related information

The Internet was used to search for health information. Sometimes the mobile phone was used (I8), but mainly the computer in the home was used (I12). *Baidu* (Chinese web services company) was used as a search engine. Caregivers did not know the names of the websites they found by using *Baidu*. When a condition was not so serious, the Internet was searched first. This reduced worries and gave a safe feeling (I8). Searching the Internet was perceived as convenient, because information about the child's health could be found, for example about the child's height (I11) and for acute problems, such as when the child had a cold (I12).

Mother: "If he just has a cold with a runny nose, medicine is not needed, while it is necessary if he has a fever with coughing [according to the website]". "他就说是感冒似的，流鼻子不用吃药。如果是发烧咳嗽了吃点药"。(I12)

Conversely, the information on the Internet was unclear and a search had to be done many times (I8). The information on the Internet seemed useless, because the information was not reliable (I12). Seeing a doctor was then preferred, because a doctor was trusted more than information on the Internet (I8, 12). An approach was to visit the village doctor, then search information on the Internet and compare this information (I8). When asking other people in the village a similar approach was used. The symptoms of the child were compared to other children in the village and this was then compared to information on the Internet (I8, 12).

YL: "Why did you trust the results you searched on the Internet? The information people told you? You said you searched for the answer concerning what if children had a cold with a runny nose, and it told you that your child does not need to have some medicine if he didn't have a fever or cough". "您当时为什么相信网上的知识，那人告诉您的话啊？您说从网上查了一下，孩子感冒流鼻子那怎么办，然后他告诉您就是说那个如果不咳嗽不发烧就不吃药"。
Mother: "Some older generation in my family just told us things like this. It seemed to them that it is bad for children to take medicine when they only get cold. No fever, no medicine. I searched it on the Internet and I got the same answer". "一般家里边长辈地老点的也是这么说的。吃药对孩子不好啊，一般的说光是感冒，不发烧不咳嗽就不吃药。家里查了一下也是这么说的"。(I12)

5.1.4.5 Health-related apps

Although half of caregivers used a smartphone, no one claimed to use health apps. The reason for this was not clear, but downloading an app may be a barrier (I13).

Mother: "[I] needed to download something....what's the name....sorry, I forgot it. Anyway, I got nothing and I needed to download an application.... I think". 还得下什么 ......那叫嘛啊 忘了什么了，也反正是查不出来......得下那个应用好像"。(I13)

Table 18 Households having phone number of health facility (N=1620)*

	n (%)
Household having the phone number of a health facility	
Yes	936 (57.8)
No	680 (42.0)
Do not know	3 (0.2)
Household having the phone number of the county hospital or above	
Yes	339 (20.9)
No	1275 (78.8)
Do not know	5 (0.3)
Household having the phone number of the township hospital	
Yes	344 (21.2)
No	1269 (78.4)
Do not know	6 (0.4)
Household having the phone number of the village clinic	
Yes	763 (47.1)
No	853 (52.7)
Do not know	3 (0.2)

*One mother discontinued the interview and did not answer this question.

Table 19 Survey participants' mobile phone usage for health care (N=1620)

	All		Mothers		Fathers		Grand parents		Other caregivers	
	n (%)	N	n (%)	N	n (%)	N	n (%)	N	n (%)	N
Used phone to receive health information in past 3 months*										
Never	1187 (73.3)	1619	1033 (72.1)	1432	26 (63.4)	41	124 (87.3)	142	4 (100.0)	4
1x	90 (5.6)		80 (5.6)		4 (9.8)		6 (4.2)		0 (0.0)	
2x	97 (6.0)		92 (6.4)		1 (2.4)		4 (2.8)		0 (0.0)	
3x	125 (7.7)		116 (8.1)		6 (14.6)		3 (2.1)		0 (0.0)	
>3x	120 (7.4)		111 (7.8)		4 (9.8)		5 (3.6)		0 (0.0)	
Like to use mobile to receive health information										
Yes	1110 (93.5)	1187	973 (94.2)	1033	25 (96.2)	26	108 (87.1)	124	4 (100.0)	4
No	73 (6.1)		57 (5.5)		1 (3.8)		15 (12.1)		0 (0.0)	
Other	4 (0.4)		3 (0.3)		0 (0.0)		1 (0.8)		0 (0.0)	

*One mother discontinued the interview and did not answer this question.

5.2 Discussion

Overview of section

This section describes the principal findings, comparison with previous research, strengths and limitations and conclusions of this chapter. Areas for further research are described in the overall discussion of this thesis in Chapter 11.

5.2.1 Principal findings

Four main themes were found: (i) trends in mobile phone ownership; (ii) usage of mobile phone functions; (iii) factors influencing replying to text messages; and (iv) uses of mobile phones for health care. The principal findings and how these findings were relevant to the remaining parts of the study are described in the following paragraphs.

Theme 1: Trends in mobile phone ownership

The majority of the 1854 survey participants (1620; 87.4%) used mobile phones, but usage was much higher among mothers (1433; 92.6%) and fathers (41; 100.0%) compared to grandparents (142; 54.6%). Almost a third of participants (487; 30.1%) used a smartphone and they were almost all mothers and fathers (484; 99.4%). Qualitative findings showed that caregivers were familiar with using mobile phones as they had used them over the past 5 to 10 years in Zhao County. Reasons for starting to use a mobile phone were to replace landlines, because other people used mobile phones, for work and to easily contact family members and friends.

Survey findings showed that almost all households had more than one mobile phone (1806; 97.4%). A large proportion of participants (1347; 83.2%) had not changed their mobile phone number over the past year. These findings were consistent with the semi-structured interviews.

High usage of mobile phones, especially among parents, was a facilitator for the remaining parts of the thesis. Infrequent sharing and changing mobile phones may allow researchers to reach caregivers confidentially and follow a majority of caregivers up on the same mobile phone number. However, fewer grandparents may be able to participate in mHealth-based research as they less frequently used mobile phones.

Theme 2: Usage of mobile phone functions

The survey findings showed that of 1620 participants who used a mobile phone, almost all mobile phones functioned for calling and text messaging (1600; 98.8%). Qualitative findings showed that mobile phone occasionally had problems including the following: (i) not functioning mobile phone; (ii) phone running out of credit; (iii) empty battery; (iv) lost mobile phone; and (v) radiation. These problems were not a huge issue, because caregivers solved them relatively quickly. The difference between the survey and semi-structured interviews may have resulted from differences in questioning (see Questionnaires in Chapter 4). The money spent on mobile phones was around ¥20 (about £2) per month and qualitative findings showed that these costs were seen as cheap.

Most of the 1620 survey participants used their mobile phones primarily for calling (1475; 91.0%) and seldom sent text messages (median number of text messages send per week was 0.0 (Q1-Q3; 0.0-4.0)), but more frequently received text messages (median number of text messages received per week was 7.0 (Q1-Q3; 2.0-10.0). Most surveyed mothers and fathers (>90%) were able to send a text message. However, about one in four grandparents were not able to and they sometimes took care of children. When survey participants were asked the ability of their household members to text message these proportions were similar for parents, but at least two-thirds of grandparents were thought to be unable to send a text message. This difference might be explained by the possibility that survey participants felt that it was desirable to be able to text message.

Qualitative findings showed that caregivers preferred making phone calls over sending text messages because it was quicker, clearer to communicate, took less effort and was cheaper. Other functions used were mainly *QQ*, but mobile phones were also used for the Internet, making photos, videos, recording sounds and playing games.

Relevant to the remaining part was that though caregivers had a preference for calling, they were used to receiving text messages and most parents were happy to send text messages. However, grandparents may not be able to participate in text messaging data collection, because they had difficulty with writing text messages.

Theme 3: Factors influencing replying to text messages

Factors influencing replying to text messages were found in qualitative data and included: (i) checking mobile phones; (ii) trusting the sender; (iii) emotion or feeling when receiving a text message; (iv) the importance of replying; and (v) ease of use of text messages. Whether caregivers checked their mobile phone depended on when they were free, where the mobile phone was placed, whether the mobile phone was switched on and whether the audio volume could be heard. Caregivers often did not trust text messages from strangers and ignored those text messages. Scam and advertisement text messages are a common phenomenon in China (see section 3.3.3). A reply was sent quicker when being in a good mood and when a text message was perceived as important. Text messages that required a long response were found less easy to send.

Relevant to the remaining parts of the thesis was: send text message reminders; gain trust of caregivers by clearly identifying the sender of the text message; stress the importance of replying; and ask for short responses. Also text messaging data collection may benefit from informing caregivers how often the text messages were sent and at what times. Asking for sensitive private information via text messages may not be appropriate.

Theme 4: Uses of mobile phones for health care

Almost half of all households (47.1%) had the phone number of the village health clinic and about one in four participants (26.7%) had used their mobile phone for health care in the past three months. However, of participants who had not used their mobile phone for health care, a very high proportion wished to use their phone to receive health information (93.5%). Qualitative results showed that mobile phones were used: (i) to call doctors; (ii) call family members; (iii) receive health-related text messages; (iv) browse for health information on the Internet. They were not used for health-related apps.

Relevant to the remaining parts of the thesis was that caregivers were already familiar with using mobile phone for health care and receiving text messages with health information. The interest of caregivers to receive health information text messages about childhood disease prevention could be further used in mHealth-based studies.

5.2.2 Comparison with relevant research

The findings on mobile phone ownership and usage were consistent with previous observations in Zhao County [71,138] and with a mixed methods study in Chongqing Province in western China, in which, of 1248 patients with tuberculosis, 1137 (91.1%) owned mobile phones [314]. Qualitative findings in the study in western China revealed that mobile phones were “convenient”, “necessary” and “affordable” [314]; which was similar to the findings described in this chapter.

Lower rates of mobile phone ownership were found in two Kenyan studies. The first Kenyan study undertaken in 2009 showed that of 32,748 people surveyed, 85% used mobile phones and 44% owned a mobile phone. Rural women were the most under-represented group among mobile phone owners and mobile phone sharing practices were very common in rural areas [312]. The second Kenyan study undertaken in 2012 showed that of 1177 people (767 caregivers of sick children and 410 adult patients), 61.2% owned a mobile phone and 71.4% of phone owners used text messaging [313].

The study reported in this chapter found that some caregivers had received their mobile phones as a gift from a relative. A study in Hubei Province in Northern China provided a rich description of Chinese mobile phone gifting practices and the social relations underlying them. Also consequences of circulation of mobile phones and changing use when moving were described [325].

In a Kenyan study, of the 1137 mobile phone users, 914 (80.4%) could receive text messages, while 227 (20.0%) were unable to use text messaging and never read them [313]. In Zhao County, most parents were able to text message, but many grandparents were not. This was also found in a text messaging data collection study in Australia [161]. A study in the United Kingdom found that older participants would benefit from extensive training to implement appointment and medication reminder text messages [326].

Previously reported barriers to the usage of mobile phones on an individual level in low- and middle-income countries included costs, illiteracy, lack of electricity, network problems, sharing or borrowing a mobile phone and lost or stolen mobile phones [33,56]. In the current study costs, illiteracy, lack of electricity and sharing mobile phones did not seem to be large barriers to mobile phone usage. However, network problems and lost mobile phones were occasional problems.

In addition, caregivers expressed their concerns about radiation from mobile phones and also from computers and televisions. However, they used their mobile phones in any case, because they could take preventative measures that reduced exposure. The risks of mobile phone radiation has been a research area of interest, though definite conclusions have not been made [327]. Although this has been mentioned in the *mHealth* literature [30,35], no previous studies reported on the perception of participants in mHealth-based studies.

In the mixed methods study in Chongqing Province in China, the tuberculosis patients agreed with text messaging and they liked to "subscribe to a reminding service" and certainly "better for free" [314]. Caregivers in the study reported in this chapter even said to be prepared to pay a little amount of money for receiving text messages with relevant child health information. While the tuberculosis patients preferred to "consult with physicians" in the "daytime of work days" [314], caregivers in the study in this chapter showed that caregivers both consulted doctors during the day and in the evening.

5.2.3 Strengths and limitations

This study revealed insights in an underexplored research area. Use of mixed methods was beneficial, because quantitative and qualitative findings could be compared and complement each other. The survey provided quantitative data on mobile phone prevalence and usage, while the semi-structured interviews complemented these data by providing more in-depth insights.

The semi-structured interview sample included a variety of caregivers from semi-urban and rural Zhao County, of different ages, levels of education and using simple mobile phones and smartphones. These findings can be transferable to settings with similar characteristics as Zhao County in China.

However, only views of people with mobile phones were explored, because they could provide most insights in this topic in order to inform the cross-over study. A limitation is that people without mobile phones may have different socio-economic characteristics (poorer, lower education etc.) and their views were not explored.

A limitation of the survey was that it was part of the baseline survey of the randomised controlled trial and thus did not have a probability sample. Although the survey may not necessarily be representative of Zhao County, almost all caregivers (99.3%) were from rural areas of Zhao County. Therefore, the survey can mainly be generalised to caregivers living in rural areas, though most people in Zhao County live in rural areas (90.7%).

Furthermore, external validity of the study may be limited by the design and implementation of the survey. Caregivers were interviewed in the village clinic rather than in their households, which may influence validity of some indictors. However, most indicators were not sensitive in the study setting and therefore this effect is likely to be minor. The study's validity was also influenced by accuracy of the questions. The questions on demographic characteristics were taken from the World Health Organization Maternal Newborn and Child Health Household survey. The questions about income and expenses had a relatively high proportion of missing values, because participants did not know this information or did not want to give it. Misreporting of income is frequent in low- and middle-income countries [328].

The questions on mobile phone usage were specifically designed for this survey. Although they were tested and piloted, some questions' accuracy may be low. For example, survey participants often were unable to answer the questions about the number of mobile phone calls and text messages and thus these questions had high proportions of missing values (ranging from 33.3% to 44.7%). Participants said that their behaviour depended on whether something happened and that it was hard to give an estimation. Therefore, the answers to these questions about number of calls and text messages made per week were likely to be biased, but still can be used for a rough estimation.

Also, though caregivers were asked to bring their mobile phone to the survey interview, not everyone did. In those cases, caregivers were asked to give a description of the phone, but often they were unsure whether they had a smartphone (they did not know the operating system of the phone or whether apps could be downloaded). When the mobile phone was a gift from a family member, it was more frequent that they did not know the type of the mobile phone. Also there were many "fake" mobile phones; these mobile phones looked like a smartphone from a well-known brand, but they were actually a simple phone made by another company.

Often it was hard to tell whether a mobile phone was a smartphone or a simple mobile phone. This made it difficult to accurately register which brand the mobile phone had.

Social desirability, language and interpretation bias were threats to the semi-structured interviews and were reduced as far as possible. Firstly, YL and particularly the PhD candidate's presence as a foreigner could have introduced socially desirable answers. To reduce bias, the PhD candidate spent time in the local site and behaved in a culturally appropriate way. YL, who was very familiar with the study context, introduced the PhD candidate to the participants and explained the purpose of the PhD candidate's presence. The richness of the data showed that the influence of the social position of the PhD candidate and YL was minimal.

Secondly, all efforts were made to reduce bias from language. YL, who undertook the interviews, translated the findings, which were checked by WW and the PhD candidate. The main findings of the interviews were translated back by a bilingual translator.

Thirdly, misinterpretation of the findings was minimised by strong collaboration between YL and the PhD candidate. They analysed the interviews separately, YL in Mandarin and the PhD candidate in English. Also they spent a lot of time to compare each line of each interview, compare codes that were given and discuss their findings. The PhD candidate wrote several drafts of the analysis that were all discussed within the team to increase validity.

5.2.4 Conclusions

The findings of this study were used for the remaining parts of the thesis and the methodology can be used to explore mobile phone usage in other settings. High mobile phone prevalence and usage that were found in this study can serve as facilitators for mHealth-based studies in Zhao County and settings with similar characteristics in China. The factors that were found to influence mobile phone usage can be used to optimise mHealth-based interventions and improve user experiences. In addition, the exploration of the natural role of mobile phones in health care can facilitate integration of mHealth-based interventions in the health system.

Structured summary of chapter

This chapter described the results and discussion of a study addressing the first aim of this thesis. In sum:

1. Four themes were found:
    1) Trends in mobile phone ownership;
        - Quantitative data confirmed high mobile phone usage, but showed that grandparents were less likely to use a mobile phone;
        - Both quantitative and qualitative findings showed that mobile phones and SIM cards were infrequently shared and changed;
    2) Usage of mobile phone functions;
        - While caregivers experienced some problems with using their mobile phone, these were often quickly solved;
        - Caregivers preferred calling over text messaging, but text messages were commonly received;
        - Both quantitative and qualitative data showed that parents were able, but grandparents were often unable to send text messages;
    3) Factors influencing replying to text messages;
        - Qualitative data found that factors influencing replying to text messages were checking mobile phones, trusting the sender, emotion or feeling when receiving a text message, the importance of replying to text messages and ease of use of text messages;
    4) Uses of mobile phones for health care;
        - Both the quantitative and qualitative data showed natural usage of mobile phones for health care;
        - Caregivers wished to use their phone to receive health information.
2. Previously reported barriers to usage of *mHealth* such as costs, illiteracy, lack of electricity and sharing mobile phones [33,56], did not seem to be large barriers to usage of mobile phones in the setting of this study;
3. A strength of the study was that all efforts were made to reduce bias related to social desirability, language and interpretation. A limitation was that the survey was not based on a probability sample;
4. The findings were used to address objective 2, which are reported in Chapter 6 and 7.

6 Validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia: study methods

Overview of chapter

Following two chapters on a study addressing the first aim, this chapter introduces and describes the methods of a study addressing the second aim of this thesis. The results of this study are presented in the following chapter (Chapter 7).

6.1 Introduction

The mode of data collection can have effects on non-measurement errors (including those related to the response rate) and measurement errors (including those caused by the survey questionnaire) and thereby affect data quality [65]. Therefore, the validity of a novel text messaging survey needs to be established.

Studies on text messaging data collection were presented in section 1.4. The previously conducted text messaging data collection study in Zhao County in China found that fewer caregivers of young children responded to all nutrition-related text message questions (27.9%) compared to caregivers who completed the same survey in a face-to-face format (67.4%). Data collected via text messaging had reasonable agreement compared with data collected in the face-to-face survey [138]. However, validity of a household survey on care-seeking for childhood diarrhoea or pneumonia had not been tested yet.

6.2 Objectives

This study aimed to determine validity of the text messaging survey as a novel method to collect information on care-seeking for childhood diarrhoea and pneumonia. The objectives were to develop the text messaging survey and to assess the response rate, characteristics of responders versus non-responders and completers versus non-completers and the error rate of the text messaging survey. Further objectives were to compare the text messaging survey to the face-to-face survey (reference standard) in terms of: data equivalence; the amount of information in responses; and reasons for differences in responses.

6.3 Methods

Overview of section

This section describes the methodological orientation and design of the study, study setting and sample, randomisation, recruitment, interviewers/data collectors, questionnaires, data collection, participants, and data management and analysis of outcomes. The study was described according to the "*Guidelines for Reporting Reliability and Agreement Studies*" where applicable [329].

6.3.1 Methodological orientation and design

A mixed methods approach was used, whereby qualitative interviews and a quantitative study were sequentially combined in one study. Firstly, interviews and a pilot were conducted to develop the text messaging survey. Secondly, a feasibility study using a cluster randomised cross-over design (referred to as "cross-over study") was conducted to compare the novel text messaging survey to the standard face-to-face survey.

Participants were randomised according to the village in which they lived into group 1 and group 2. A randomisation ratio of 1:1.6 was used to allocate a larger proportion of participants to group 2 and to account for the expected higher drop-out (see *sample* section below). A total of 16 villages with 1600 children under five were randomised into group 1 and 30 villages with 2570 children into group 2.

Participants in group 1 first completed the face-to-face survey and after one day the text messaging survey, while this order of completing the surveys was reversed for group 2. The study used the results of the study that was presented in Chapter 4 and Chapter 5 and the previously conducted text messaging data collection study in Zhao County [138]. Where these results were used, they are described and referenced in the sections below.

6.3.2 Study setting and sample

The study took place in village clinics in Zhaozhou Township, Zhao County, Hebei Province, China in March 2013. Seven of the 16 townships in Zhao County were excluded, because the randomised controlled trial that was described in Chapter 4 had taken place in these seven townships. Of the nine remaining townships, Zhaozhou Township was chosen, because this is the largest township with 46 villages and an estimated under-five population of 4170 and it has both a semi-urban and rural population [304]. Studies that took place in the nine townships (described in section 4.3.2) finished before the cross-over study took place.

Caregivers were eligible if they took care of a child younger than five years, used a mobile phone and were able to send a text message. Caregivers were excluded if they were not willing to participate, if they were unable to read or understand the informed consent materials, if they did not have a mobile phone or if they could not send a text message. Based on previous experiences described in Chapter 5, it was known that many grandparents were unable to text message. Therefore, grandparents were not actively recruited. However, they were considered for eligibility, because grandparents sometimes take care of grandchildren and some of them could text message. Interviewers checked with care whether grandparents were able to text message. Grandparents were asked to send a test message in which they had to write the name of their grandchild or spell the “immunization card” (five Chinese characters, spelled 预防接种证).

It was not possible to conduct an accurate sample size calculation for the cross-over study, because it was a feasibility study and precise estimates from previous research that could inform a calculation were unavailable. Figure 2 presents a rough estimated number of caregivers who could be recruited in the study setting. The Zhaozhou Township hospital and four affiliated vaccination clinics provided a list with 4170 names (referred to as a “list of names”) of children and their caregivers, children’s date of birth and sometimes phone numbers of caregivers in Zhaozhou Township. Based on previous experiences, it was estimated that 70% of caregivers who were approached would participate, 40% would respond to at least one text message and 10% would respond to a reminder text message. This would mean that about 46% of participants would respond to either a text message or reminder text message [138].

A total of 1095 participants from Zhaozhou Township were aimed to be included in the data equivalence analyses: 516 participants in group 1 and 579 participants in group 2. For group 2, it was estimated that more participants dropped out, because a second visit to the clinic was required for the face-to-face interview. Therefore, the number of caregivers that was planned to be approached was oversampled in group 2.

After completion of the cross-over study, the power of the study based on the equivalence of data was calculated, which is presented in the discussion in Chapter 7.

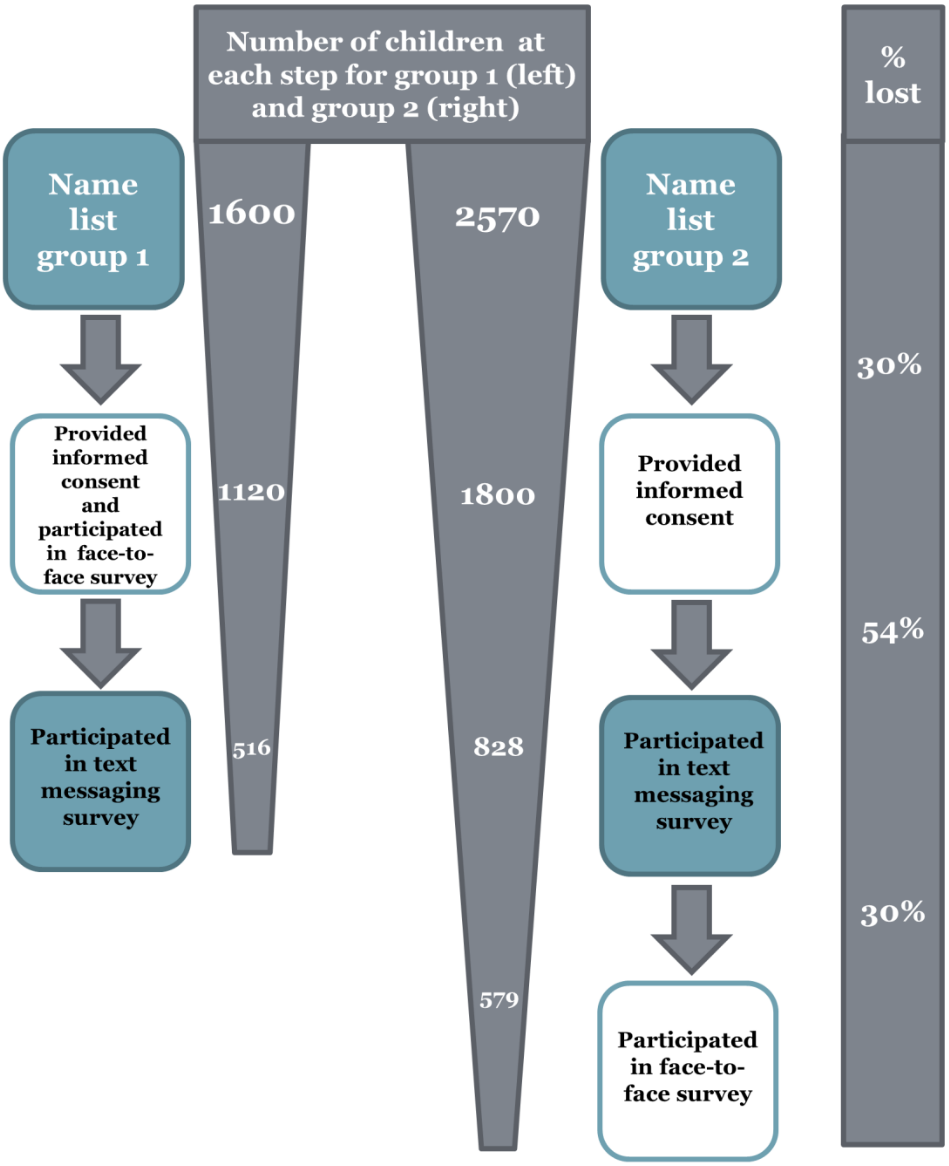


Figure 2 Sample size estimation for cross-over study

Rough estimation of the number of participants in the cross-over study.

6.3.3 Randomisation

Stratified randomisation was used to divide villages in Zhaozhou Township into two groups, whereby the size of the under-five population in the villages was taken into account. The villages had an estimated under-five population ranging between 20 and 335 children. As this population size per village was highly variable, the size of the under-five population had to be taken into consideration to prevent major imbalances in the groups. It was not possible to randomise the villages according to other particular characteristics, because this information was unavailable.

Cluster randomisation was preferred over individual randomisation, because individual randomisation could have introduced bias if participants from two groups living in one village showed each other the text messages. This could have influenced the responses that participants gave (contamination bias). In addition, participants could not be randomised on an individual level for organisational reasons; it was very difficult to double the number of visits to villages, while at the same time keeping the time interval between recruitment and administering the surveys the same.

SAS version 9.2 [321] was used for randomisation. WW ranked the 46 villages based on the size of their under-five population into three strata of 15, 15 and 16 villages each. A small number of strata were chosen, because a sufficient number of individuals in each stratum had to be ensured. An independent statistician provided a list of random numbers to determine the strata that had 16 villages. This ranking meant that the size of the village was randomly used for allocation to one of the strata. Then the villages in each stratum were randomised into group 1 or group 2 by giving a random number to each village and assigning villages to the groups.

6.3.4 Recruitment

A similar strategy for recruitment was used as described for participants of the survey in section 4.3.3. Township and county hospital doctors were asked to contact village doctors and to arrange a time for recruitment. Village doctors were asked to gather in their village clinic all caregivers of young children who lived in their village.

Before interviewers arrived in the village, village doctors were asked to make the following announcement with loudspeakers when possible: *"We are from the Capital Institute of Pediatrics and Maternal and Child Health Hospital in Zhao County. We are doing a survey of children and we will ask you about your child's health in the past two weeks. If you are a parent of a child younger than five years, come to the village clinic around: 'appropriate time'. You have to be able to receive and send text messages to participate. You do not need to bring the child, because we do not do physical examination. After the interview, you will get a towel to thank you for your time and effort to participate".*

In addition, village doctors were asked to make phone calls to caregivers and to visit caregivers' houses to invite them if phone numbers were unavailable. Village doctors received ¥50 (about £5) for recruiting 55 caregivers or fewer caregivers when their village had a smaller number of children under five. When village doctors recruited more than 55 caregivers, the amount they received increased by ¥10 (about £1) per 10 caregivers (¥60 for 55-65 caregivers, ¥70 for 66-75 and so on).

Interviewers visited the villages during the day and late afternoon to recruit parents who were working during the day (it was not possible to visit villages in the evening). Interviewers asked people on the street, went to places that caregivers visited and asked people to notify their neighbours. The interviewers were able to visit villages for a second time in group 1 to recruit more caregivers, so that caregivers who were not available during the first visit could be recruited. In group 2, this was not feasible due to time and resource constraints.

Interviewers obtained informed consent from eligible caregivers and administered the face-to-face survey in the village clinic. Interviewers informed caregivers about the study procedures, asked them to read the information sheet and gave them the opportunity to ask questions. Interviewers informed caregivers that the study results were not used to assess the health of their child, and that if they had any concerns about the health of their child, they should contact a health worker. Also, interviewers told caregivers that they could decide to withdraw from the study at any moment and that this would not influence the health care they received. Interviewers asked caregivers who were willing to participate if they understood what participation in the study included and to sign the informed consent form (Appendix D Consent and information forms).

Caregivers were asked to bring their personal mobile phone to the interview. Based on findings from the previous study on text messaging data collection in Zhao County, instead of asking village doctors to check the mobile phone number of caregivers, interviewers checked the mobile phone numbers themselves [138]. Interviewers paid special attention to correctly recording the mobile phone numbers of participants, because it was essential for the study to have the correct mobile phone numbers. Interviewers called the participants on the mobile phone number they provided to validate the number.

Caregivers were given a towel (worth ¥5 (about £0.50)) for their time to complete the face-to-face survey. Also a calendar with infant feeding information was provided, though this calendar was from the previous year, the health information in the calendar could still be used [219]. Interviewers told caregivers who participated in the text messaging survey explicitly that they were given ¥5 when they completed the text messaging survey. In addition, caregivers were told that the money they spent on sending text messages for the study were paid back (sending a text message in China costs ¥0.10 (about £0.01)) by mobile phone credit payment within two weeks. The payment was made before the interviews took place that aimed to explore reasons for not responding to text messages (see section 6.3.7). A minimum of ¥1 (about £0.10) was paid to each participant who sent at least one text message, because the mobile payment could not be less than ¥1. This amount of ¥1 was also paid to participants who only responded “not willing” to the first question (text message 2). In addition, ¥5 was paid to participants who responded to the last question (text message 20), but did not respond to the prompting question (text message 20a), because these participants may have felt that they completed the survey.

6.3.5 Interviewers/data collectors

Face-to-face survey

The face-to-face survey was conducted by 14 interviewers: 10 undergraduate medical students from a local university, one postgraduate medical student, two supervisors (WW and XD) and a county hospital doctor.

After recruitment of caregivers in the group 1, five students had to leave because of their studies and five new students were trained to interview participants in the second group. All interviewers were familiar with the dialect in Zhao County. The supervisors were experienced child health survey researchers who had done previous surveys in Zhao County.

The interviewers were trained as described in section 4.3.4. Both inter-observer agreement and intra-observer agreement were calculated during training. Inter-observer agreement is "*different raters, using the same scale, classification, instrument, or procedure, assess the same subjects or objects*", while intra-observer agreement is "*the same rater, using the same scale, classification, instrument or procedure, assesses the same subjects or object at different times*" [329]. There were a total of 50 questions and 100 variables (answer options) in the survey instrument. For the first round of interviewers, the intra-observer agreement for all questions was more than 96% for eight students. Two students scored lower, one had a score of 77% and the other one had 83%, because they misunderstood the principle of skipping some of the questions. Therefore, supervisors explained the questions with wrong answers to the two students and did the validation test again. Then the agreement increased to 98% for both students.

The inter-observer agreement was 95% for the first round (group 1) and 98% for the second round of interviews (group 2). For five students who replaced the five students who had to leave, the intra-observer agreement was more than 96% and inter-observer agreement was 98%. To further optimise agreement, the supervisors discussed and explained all questions that posed problems and provided help to students who needed assistance. The supervisors stood next to the interviewers during the whole interview process on the first field work day for every interview. In addition, the supervisors checked whether each interviewer was conducting the survey correctly during the field work.

Photograph 25 Interviewer and participant during face-to-face survey

Photograph courtesy of WW, personal collection

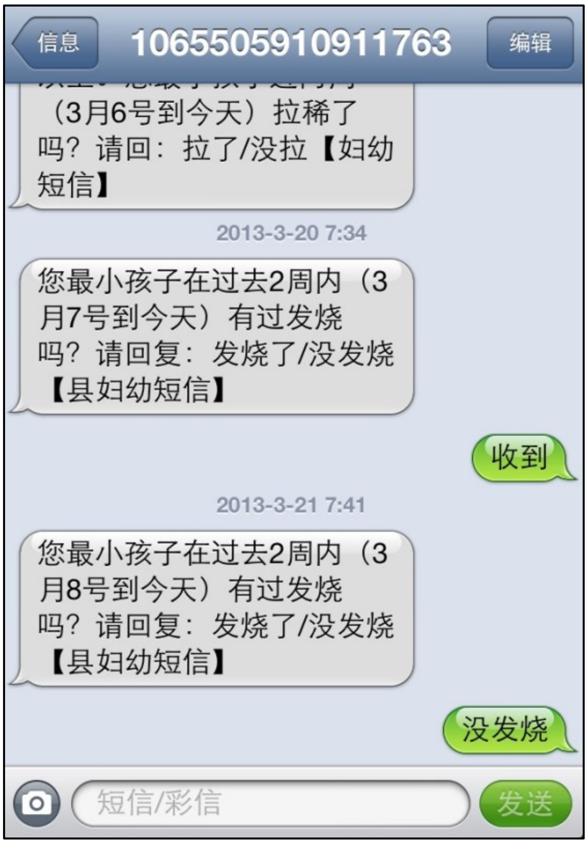
Text messaging survey

The text messages were sent from the Capital Institute of Pediatrics in Beijing. YL sent the text messages and a second researcher (first QW, then a trained student) checked the text messages. YL trained the second researcher by giving an introduction to the study, explaining the algorithm and how to check the text messages. To ensure that the second researcher understood the procedures, the initial checks that the second researcher did were checked by YL. Any problems or inconsistencies were addressed appropriately. The PhD candidate was at the Capital Institute of Pediatrics during the cross-over study and was consulted when needed.

The text messages were sent manually, because there was no Chinese text messaging system available that could accurately identify answers and send the appropriate follow-up text messages. YL checked the text messaging system for incoming text messages with responses. YL exported all the incoming text messages into an Excel file and prepared the appropriate follow-up text messages by following a protocol. This procedure could not be done automatically by the text message system. To prevent errors from occurring in this process, the second researcher checked the text messages that YL prepared before they were sent. In case there was disagreement or confusion, the PhD candidate was consulted for advice.

A Chinese text messaging system (Shāng jī bǎo 商机宝) was used for sending text messages to participants and receiving text messages from them. This was the best system based on experiences with three Chinese text message systems. In addition, several other Chinese text messaging systems were tried, but many could not send text messages to all three main Chinese mobile telecom operators. There are a number of open-source text message data collection such as CommConnect [330] and FrontlineSMS [331]. YL also tried several open-source text message systems, but none of these succeeded in sending and receiving text messages accurately. One reason for this may be that there are many scam text messages being sent in China by several organisations. Thus, the Chinese mobile telecom operators block certain text messages, including sometimes "normal" text messages (as previously explained in section 3.3.3). Therefore, a Chinese text message system had to be used. The chosen system was tested during pilots. Good technical support was received from the text messaging system company whilst using it.

The number of the text messaging system contained 16 numbers (1065-5059-1091-1763). This was a special number, because normal Chinese mobile phone numbers have only 11 digits without area codes. The functionality of the text messaging system was checked during the field work. The text message system company was asked for a report of successfully sent text messages. Also, every morning before sending text messages, YL sent text messages to eight mobile phone numbers of researchers in the team, which included the three major Chinese mobile telecom operators and asked them to reply. If no reply was received, phone calls were made to the researchers to confirm whether they had received a text message.



Photograph 26 Screen shot of mobile phone receiving text messages from text messaging system

Photograph courtesy of XD, personal collection.

6.3.6 Questionnaires

The survey that was used to assess caregiver's care-seeking behaviour for childhood diarrhoea and pneumonia was based on the diarrhoea module and cough and fever module (used to assess suspected childhood pneumonia) of the World Health Organization Maternal, Newborn and Child Health Household survey (unpublished, 2009). The Capital Institute of Pediatrics has used this survey for conducting face-to-face household surveys since 2010. The Chinese researchers previously translated the English questions in the modules into Mandarin, adapted them to the local context in Zhao County, tested them during three pilot studies and used them in large household surveys in 2010 and 2011 [220-222]. A local terminology study was undertaken to assess the most appropriate local words for childhood diarrhoea and pneumonia signs and symptoms (Appendix F Local terminology study) [332].

A total of 17 relevant questions related to care-seeking for childhood diarrhoea and pneumonia were selected from the diarrhoea module and cough and fever module (Table 20). Four questions of these modules were asked to all participants. This included one question about the presence of diarrhoea (question DI.1) and three questions about pneumonia signs and symptoms (question CO.1 about presence of fever, question CO.2 about cough and question CO.2.a about fast or difficult breathing) in the past two weeks. When participants responded that their child had diarrhoea, fever, cough, or fast or difficult breathing, depending on their response they were asked a number of the 13 additional questions on these symptoms. Nine of these 13 questions were for diarrhoea and four were for pneumonia.

The nine questions for diarrhoea were on the following topics: (i) blood in diarrhoea; (ii) ORS during diarrhoea; (iii) drinking recommended fluids; (iv) drinking other fluids; (v) amount of fluids consumed compared to normal; (vi) amount of food consumed compared to normal; (vii) whether care was sought outside the home; (viii) reasons for not seeking care; and (ix) places where care was sought. The four questions for fever or cough asked about: (i) whether breathing problems were caused by problems in the chest or a blocked nose; (ii) whether care was sought outside the home; (iii) reasons for not seeking care; and (iv) places where care was sought.

Moderate changes had to be made to the face-to-face questionnaire to make it appropriate for a text messaging survey format. It was aimed to develop a text message questionnaire in which the text message questions were interpreted by caregivers in a similar way as the face-to-face questions. The PhD candidate led this process with guidance of the Chinese researchers. Cognitive interviewing and usability testing was an adequate research strategy for this purpose as previously explained in section 2.4.2 [224]. The questionnaire that was used for the cognitive interviews can be found in Appendix C Questionnaires. Also the process of sending and receiving the text messages was tested in a pilot. Detailed information and additional tables on development of the text messaging survey can be found in Appendix E Development of face-to-face and text message questionnaires. This includes an overview of the face-to-face questions and text message questions with the changes for each phase in colour. In addition, the reasons for changes for each phase are shown.

The most significant findings were as follows. In the cognitive interviews was found that it was important to develop text messages that were clear, meaningful and could be trusted. A "label" saying "*Zhao County's Maternal and Child Health Hospital message*" was added to increase trustworthiness. It was found useful to receive information on paying back money for text message fees and the incentive for completing the survey. The questions and answers were combined together in one text message to reduce the number of text messages when possible. Responding via Chinese characters was preferred over responding by numbers. Additional information to clarify the meaning of text message survey questions was useful when it was simple and short. A "thank you" text message was needed to indicate the end of the survey.

In addition, in the pilot test it was found that it was needed to check words that are blocked by Chinese telecom operators. Also it was necessary to recheck the length of text messages, so that text messages would be sent without problems.

Photograph 27 Mother and YL during development of survey

Photograph from the PhD candidate's personal collection

Table 20 presents the final face-to-face and text messaging questionnaires that were used for the cross-over study (including the skipping pattern in bold letters). The text messaging survey included the same 17 selected questions from the diarrhoea and cough and fever modules that were used for the face-to-face survey. Of those 17 questions, 2 questions (text messages 13 and 20) had follow-up questions in the face-to-face interview, but these were recorded as one response, and 1 question (text message 10a) had a question before this question (text message 10). In the text messaging survey, these three questions had to be asked in separate text messages (10, 13a and 20a).

In addition, the text messaging survey had an introduction text message (text message 1), final "thank you" text message (text message 21) and two general questions: (i) agreement of the caregiver to participate (text message 2); and (ii) the relationship between the caregiver and the child (text message 3).

Table 20 Final face-to-face and text message questionnaires used in cross-over study

Face-to-face questions		**Text message questions**	
Identification number of question and content in English	**Content in Chinese characters**	**Text message number and content in English**	**Content in Chinese characters**
NA		1.Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*]	您好，我们是赵县妇幼，想了解您家里最小的那个孩子健康有关情况。您的回复对我们很重要，可以帮助我们改善儿童健康状况。【县妇幼短信】
NA		2.You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*]	回短信无额外费用，并会返还短信费 1 角/条。答完所有问题可另得 5 元话费。2 周内充到您手机。您愿意回答吗？请回复：愿意/不愿意【县妇幼短信】
NA		3.How does your child call you (the relationship between you and your child)? Please respond: mother/father/grandmother/grandfather/other.....(please specify) [*Zhao County's Maternal and Child Health Hospital message*]	您的孩子管您叫什么（您与孩子的关系）？请回复：妈妈/爸爸/奶奶/爷爷/其他（请列出）【县妇幼短信】

DI.1. Has (*name*)* had diarrhoea in the last 2 weeks (please think back from two weeks ago till today? Diarrhoea is the passage of 3 or more loose or watery stools, compared to usual, per day. 1.Yes 2.No →***Skip to CO.1*** 8.Do not know→***Skip to CO.1***	孩子过去两星期内（从今天算起往前推 2 星期，并强调日期）腹泻（拉稀/拉肚子）了吗？腹泻定义为一天稀便(和平常相比)或水样便三次或以上。 1.是 2.否 ——>结束 DI 部分，转到 CO.1 8.不知道 ——>结束 DI 部分，转到 CO.1	4.Diarrhoea is the passage of 3 or more loose or watery stools, compared to usual, per day. Has your youngest child had diarrhoea in the last 2 weeks (from *month/day* till *today*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*] ***When child didn't have diarrhoea→ skip to text message 14***	拉肚子（拉稀）指比平常稀的大便或水样便一天三次或以上。您家最小孩子过去两周内（...月...日到...今天）拉肚子/拉稀了吗？ 请回：拉了/没拉【县妇幼短信】
DI.2.Did (*name*) have blood in the stools? 1.Yes 2.No 8.Do not know	孩子大便中带血吗？(由于腹泻导致的大便带血) 1.是 2.否 8.不知道	5.Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*]	您家最小的孩子有过因拉肚子/拉稀导致的大便带血（拉粑粑里边带血）吗？ 请回复：带血/不带血【县妇幼短信】
DI.3.During this last episode of diarrhoea, did (*name*) drink any of the following: *read each item aloud and record response before proceeding to the next.* A fluid made from a packet called ORS? 1.Yes 2.No 8.Do not know	孩子在最近一次腹泻期间，你是否给了以下液体：（逐项读出，并记录每一个选项及答案。） 1.口服补液盐（一种治疗拉稀的药物） 1.是 2.否 8.不知道	6.During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近一次拉肚子/拉稀期间，喝了口服补液盐吗？(一种治疗拉稀的药)请回复：喝了口服补液盐/没喝口服补液盐【县妇幼短信】
One of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? 1.Yes 2.No 8.Do not know	2.母乳、配方奶、白开水、矿泉水、米汤、菜汤 1.是 2.否 8.不知道	7.During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近拉肚子/拉稀期间，是否喝了以下液体：母乳、配方奶、白开水、矿泉水、米汤、菜汤？ 请回：喝过这些/都没喝过【县妇幼短信】

Other fluids such as tea, drinks, water with honey or any sugary drinks? 1.Yes 2.No 8.Do not know	3. 其他液体，如茶或饮料、蜂蜜、甜水等 1.是 2.否 8.不知道	8.During this last episode of diarrhoea, did your youngest child drink other fluids such as tea, drinks, water with honey or any sugary drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*]	您家最小的孩子最近一次拉肚子/拉稀期间，是否喝了其他液体，如茶、饮料、蜂蜜水或任何甜水等？ 请回复：喝过其他液体/没喝其他液体【县妇幼短信】
DI.3.a During (*name's*) diarrhoea, did he/she drink much less, about the same, more than usual or none? *If less, probe*: Was he/she offered much less than usual to drink or somewhat less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 8.Do not know	孩子最近一次腹泻时，孩子喝的汤水和母乳是比平常少、与平常一样多、比平常多还是什么都没喝？（包括任何孩子能喝的东西，如母乳和配方奶）［如果比平常少，继续问：比平常少很多，还是少一点？］ 1.什么也没喝 2.少得多 3.少一点 4.一样多 5.比平常多 8.不知道	9.During your youngest child's diarrhoea, how much did he/she drink compared to usual (anything the child can drink, including breast milk or formula)? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子那次拉肚子期间，喝的（任何能喝的，包括母乳和配方奶）比平常怎样？ 请回：一点没喝/少得多/少些/一样/多些【县妇幼短信】
DI.3.b When (*name*) had diarrhoea, did he/she eat less, about the same, more food than usual or none? *If less, probe*: Much less or a little less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 6.Child never received solid or semi-solid foods 8.Do not know	孩子最近一次腹泻期间，吃的物件是比平常少、与平常一样多、比平常多还是什么都没吃？[如果比平常少，继续问：比平常少很多，还是少一点？如果没有吃，继续问：是从没吃过还是仅腹泻期间没有吃] 1.什么也没吃 2.少很多 3.少一点 4.一样多 5.比平常多 6.孩子还没有吃过任何固体或半固体的食物 8.不知道	10.Has your youngest child ever been introduced to foods such as rice, noodles, manto, meat, eggs, vegetables, fruits (excluding breast milk or formula)? Please respond: child received foods before/child never received foods before [*Zhao County's Maternal and Child Health Hospital message*] ***When child never received foods before→skip to text message 11***	您最小的孩子吃过米饭、面条、馒头、肉、蛋、蔬菜或水果这样的物件吗？（除母乳及配方奶）请回：吃过物件/从没吃过物件【县妇幼短信】

		10a.When your youngest child had diarrhoea, how much did he/she eat (including all foods, excluding breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	对已经添加了辅食的孩子发送： 您最小孩子那次拉肚子期间，吃物件（母乳和配方奶不算）的量比平常怎样？ 请回：没吃/少很多/少些/一样/多些？【县妇幼短信】
DI.4During this last episode of diarrhoea in (*name*), did you seek advice or treatment for the diarrhoea outside the home 1.Yes, outside the home→*skip to DI.4.b* 2.No, managed at home 8.Do not know	孩子最近这次腹泻期间，除了住在一起的家人，您还寻求过指导或治疗吗？ 1.是，到家庭外寻求指导或治疗 ——>转到DI.4.b （包括询问邻居、去医院、为孩子举行宗教仪式等。如医生到家中给予指导或治疗，也算在内。当母亲外出寻求指导或治疗时，是否带孩子一起去没有关系，如去药店买药没带孩子，也算在内；不要读出） 2. 否，在家里自行处理 ——>转到 DI.4a 8. 不知道 ——>结束本部分，转到下一部分	11.During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] ***When response is "yes outside the home" skip to text message 13***	您最小孩子最近这次拉肚子/拉稀时，除了住在一起的家人，您还寻求过指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】
DI.4.a During this last episode of diarrhoea in (*name*), why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify _________ 88.Do not know	孩子最近这次腹泻期间，没有寻求指导或治疗的主要原因？——> 答完此题，结束本部分 01.不严重/不需要别人帮助 02.家离卫生机构太远 03.费用（没钱支付服务或交通费） 04.卫生机构没有人/没有开门 05.卫生机构的服务质量差 06.没必要 07.宗教信仰 08.其他：________ 88.不知道	12.During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近这次拉肚子/拉稀时，除了住在一起的家人，您为什么没有寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】

DI.4.b Where did you seek care when (*name*) had diarrhoea? *Record all sources mentioned. Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1. Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: 1.Yes 2.No Specify: __	孩子最近这次腹泻期间，你到哪里寻求指导和治疗？（不要念出选项，记录所有的提到的地方。可提示“还有其他地方吗？”） 1.家中亲友 11 自己的家人 1.是 2.否 12 朋友或邻居 1.是 2.否 2.公立医疗机构 21.县级及以上医院（不含妇幼保健院） 1.是 2.否 22 县级及以上妇幼保健院 1.是 2.否 23.社区卫生中心 1.是 2.否 24.乡镇卫生院 1.是 2.否 25.社区卫生站 1.是 2.否 26.村卫生室 1.是 2.否 3.私营医疗机构 31.私营医院 1.是 2.否 32.个体诊所 1.是 2.否 33.药店/药贩 1.是 2.否 4. 社区 41.接生员 1.是 2.否 42.计生干事 1.是 2.否 5.其他：1.是 2.否_____	13.During this last episode of diarrhoea in your youngest child, where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] ***After response to 13 prompt:*** 13a.Did you go anywhere else during the last episode of diarrhoea in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近那次拉肚子/拉稀时您到哪里寻求指导或治疗？请回复去的所有地方。【县妇幼短信】 回复后，追问： 最小孩子最近那次拉肚子/拉稀时，您还去过其他地方吗？请回复列出所有去的地方。【县妇幼短信】
CO.1.Has (*name*) been ill with a fever at any time in the last 2 weeks, (please think back from two weeks ago till today)? 1.Yes 2.No 8.Do not know	您最小孩子在过去 2 星期内（从今天算起往前推 2 星期，并强调日期）发过烧吗？ 1.是 2.否 8.不知道	14.Has your youngest child had fever at any time in the last 2 weeks (from *month/day* till *today*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子在过去 2 周内（...月...日到...今天）有过发烧吗？ 请回复：发烧了/没发烧【县妇幼短信】

CO.2.Has (*name*) had an illness with a cough at any time in the last 2 weeks (please think back from two weeks ago till today)? 1.Yes 2.No 8.Do not know	您最小孩子在过去 2 星期内（从今天算起往前推 2 星期，并强调日期）生过病，且生病时有过咳嗽吗？ 1.是 2.否 8.不知道	15.Has your youngest child had cough caused by illness at any time in the last 2 weeks (from *month/day* till *today*)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子在过去 2 周内（...月...日到...今天）有过因为生病引起咳嗽吗？ 请回复：有过生病引起的咳嗽/没有过生病引起的咳嗽【县妇幼短信】
CO.2.a.Did (*name*) breathe faster than usual with short, fast breaths or have difficulty breathing *(local terms)* in the last 2 weeks (please think back from two weeks ago till today)? 1.Yes 2.No→***skip to* CO.3** 8.Do not know→ ***skip to* CO.3**	您最小孩子过去 2 星期内（从今天算起往前推 2 星期，并强调日期），呼吸是否比平时快而短，或有呼吸困难（喘不上气/憋得慌）吗？ 1.是 2.否——>转到 CO.3 核查 8.不知道——>转到 CO.3 核查	16.Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (from *month/day* till *today*)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*] ***When response is "no" go to "check answers"***	您最小孩子 2 周内（...月...日到...今天）有过呼吸比平时快而短，或者有喘不上气/憋得慌吗？ 请回复：有过/没有【县妇幼短信】
CO.2.b Were the symptoms due to a problem in the chest or a blocked nose? 1.Problem in the chest→ ***skip to* CO.3** 2.Blocked nose 3.Both→ ***skip to* CO.3** 4.Other, specify: ____→ ***skip to* CO.3** 8.Do not know→ ***skip to* CO.3**	这些症状是因为肺部有问题还是因鼻塞引起的？ 1.肺部问题——>转到 CO.3 核查 2.鼻腔堵塞——>转到 CO.3 核查 3.两者都有——>转到 CO.3 核查 4.其他原因______——>转到 CO.3 核查 8.不知道——>转到 CO.3 核查	17.What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*]	您的孩子呼吸快或喘不上气/憋得慌是因为什么？ 请回复：肺部问题/鼻腔堵塞/两者都有/其他原因（请列出）【县妇幼短信】
CO.3 ***Check answers in CO.1 for fever and CO.2 for cough:*** ***"No" for fever and "No" for cough→skip to end*** ***"Yes" for and/or "Yes" for cough →ask CO.4***	调查员核查： CO.1 或 CO.2 1.只要有一项选"1.是"——> 继续问 CO.4 治疗指导； 2.都没有选"1.是"——>结束 CO 部分，转到下一部分	***Check answers in text message 14 for fever and 15 for cough.*** ***"No" for fever and "No" for cough→sent text message 21*** ***"Yes" for fever and/or "Yes" for cough→ send text message 18***	

CO.4During this last episode of fever or cough in (*name*), did you seek advice or treatment for the fever/cough outside the home? 1.Yes→***skip to* CO. 4.b** 2.No→***skip to* CO.4.a** 8.Do not know	您最小孩子最近这次发烧/咳嗽时，除了住在一起的家人，您还寻求过指导或治疗吗？ 1.是，到家庭外寻求指导或治疗——> 转到 CO.4.b （"到家庭以外寻求指导或治疗"包括询问邻居、去医院、为孩子举行宗教仪式等。医生到家中给予指导或治疗，也算在内。当母亲外出寻求指导或治疗时，是否带孩子一起去没有关系，如去药店买药没带孩子，也算在内。不要读出） 2.否，在家自行处理——>转到 CO.4.a 8.不知道——>结束本部分，转到下一部分	18.During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home. [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近那次发烧/咳嗽时，除了住在一起的家人，您还寻求指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】
CO.4.a During this last episode of fever or cough in (*name*), why didn't you seek advice? Only one answer allowed. 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify ________ 88.Do not know	您最小孩子最近这次发烧/咳嗽时，没有寻求指导或治疗的主要原因？[单选] ——> 答完此题，转到下一部分 01.不严重/不需要别人帮助 02.家离卫生机构太远 03.费用（没钱支付服务或交通费） 04.卫生机构没有人/没有开门 05.卫生机构的服务质量差 06.没必要 07.宗教信仰 08.其他：________ 88.不知道	19.During this last episode of fever or cough in your youngest child, why did you not seek advice outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近那次发烧/咳嗽时除了住在一起的家人，您为什么没有寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】

CO.4.b Where did you seek advice or treatment when (*name*) had fever or cough? *Record all sources mentioned. Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1.Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: 1.Yes 2.No Specify: _	您最小孩子最近那次发烧/咳嗽时，到哪里寻求指导或治疗？[记录提到的所有地点。可提示"还有其他地方吗？"] 1.家中亲友 11 自己的家人 1.是 2.否 12 朋友或邻居 1.是 2.否 2.公立医疗机构 21.县级及以上医院（不含妇幼保健院） 1.是 2.否 22.县级及以上妇幼保健院 1.是 2.否 23.社区卫生中心 1.是 2.否 24.乡镇卫生院 1.是 2.否 25 社区卫生站 1.是 2.否 26.村卫生室 1.是 2.否 3.私营医疗机构 31.私营医院 1.是 2.否 32.个体诊所 1.是 2.否 33.药店/药贩 1.是 2.否 4. 社区 41.接生员 1.是 2.否 42.计生干事 1.是 2.否 5.其他：1.是 2.否 __________	20.During this last episode of fever or cough in your youngest child, where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] ***After response to 20 prompt:*** 20a. Did you go anywhere else during the last episode of fever and cough in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	您最小孩子最近那次发烧/咳嗽时您到哪里寻求指导或治疗？ 请回复列出去的所有地方。【县妇幼短信】 回复后，追问： 最小孩子最近那次发烧/咳嗽时，您还去过其他地方吗？请回复列出所有去的地方。【县妇幼短信】
NA		21.This is the end of the survey. Thank you very much for participating! You will receive ¥0.1 per text message and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*]	调查结束，非常感谢您的参与！您将在 2 星期内得到返还的短信费及 5 元话费的补偿，将直接充到您的手机上。【县妇幼短信】

*Name of the youngest child in the family.

6.3.7 Data collection

Field work schedule

On the first day of the cross-over study in group 1, the interviewers obtained informed consent and administered the entire questionnaire (on demographic characteristics, mobile phone usage and care-seeking for childhood diarrhoea and pneumonia) in a face-to-face interview. Interviewers informed participants that they would receive the text messaging survey the day after the face-to-face survey. Interviewers explained the format in which caregivers had to reply and asked caregivers to remember to reply.

After one day, YL sent the text message questions for two days. The one-day period between the face-to-face and text messaging surveys was a balance between memory and recall issues. This period was introduced so that participants were likely to have forgotten their previous answers, but still had a similar recall of the past two weeks.

On the first day of the study in group 2, the interviewers obtained informed consent and administered the face-to-face questionnaire on demographic characteristics and mobile phone usage (excluding the questions care-seeking for childhood diarrhoea and pneumonia). Interviewers informed participants that they would receive text messages two days after signing the informed consent form and would have to visit the village clinic again in four days to complete the face-to-face survey. There were two days between the informed consent and the first text message for logistical reasons, because the follow-up interviews could not coincide with recruitment days.

The text messaging survey took place on the third and fourth day of the study in group 2. Participants who responded to text message 4 were invited to visit the village clinic for the face-to-face interview on care-seeking for childhood diarrhoea and pneumonia. Responding to text message 4 was used because this text message contained the first question that was compared between the methods. A text message was sent to participants and they were asked to come to the clinic for the face-to-face interview. On the fifth day, villages were visited for the second time to administer the face-to-face survey on care-seeking for childhood diarrhoea and pneumonia. Directly after this face-to-face survey, interviews about participants' reasons for giving different responses in the face-to-face and text messaging survey took place.

Procedures

Face-to-face survey

The interviewers administered the face-to-face questionnaire after participants had signed the informed consent form with a smartphone, as had been validated in a previous study in Zhao County [71].

Text messaging survey

The first text message (an introduction text message which did not require a response) was sent at 9 am in the morning and the second text message, which asked about caregivers' willingness to participate, was sent directly after. Although caregivers had already provided informed consent for the study, in cognitive interviews it had been found that caregivers wished to be asked this again in the text messaging survey. YL called participants who had responded that they were unwilling to participate and asked for their reasons. If the reason was that they had misunderstood the question, YL gave an explanation and asked them to reply again.

When a caregiver was willing to participate, YL sent the third text message with a question about the identity of the participant. YL checked whether the identity of the participant was identical to the identity of the person who had signed the informed consent form and who had participated in the face-to-face interview. When the identity was different, YL called the mobile phone number and the person answering the phone was asked for their identity. If the person was related to the child on the list of names, YL asked the person to encourage the person who had signed the informed consent form and had participated face-to-face to reply to the text messages.

YL sent the diarrhoea and pneumonia survey questions to all participants who were willing to respond and who were the same caregiver as the person who had signed the informed consent form in the village clinic. When a response to a text message question was received, YL sent the appropriate follow-up question until the text messaging survey was completed. The survey algorithm for sending the appropriate follow-up questions was followed. When participants completed the survey, the final text message was sent (text message 21) and participants were thanked for their cooperation.

A time interval for checking incoming messages was chosen based on previous experiences [138]. The text message system was checked every 10 minutes between 9 am and 10 am, every 15 minutes between 10 am and 3 pm and every 30 minutes between 3 pm and 6 pm. Two reminder text messages were sent based on previous experiences [138]. At 6 pm, reminder messages were sent to all the participants who had not responded to any of the questions and to participants who had responded to one or more questions, but who did not complete the survey. Between 6 and 7 pm, the incoming messages were checked every 10 minutes. Between 7 and 9 pm, the incoming text messages were checked every 15 minutes. The final text messages were sent on the first day at 9 pm. A second reminder text message was sent on the next day at 9 am.

Participants were asked to respond in Chinese characters, because this was found to be the most convenient way in the cognitive interviews. The answer options of the questions were provided in the text messages, because the cognitive interviews showed that not giving participants the answer options resulted in unclear answers. It was considered asking participants to reply with a number, but some participants had ignored this request in the cognitive interviews. However, this meant that some unclear answers were anticipated.

When a text message was empty, the following response was sent: "*your text message is empty*" followed by the text message with question. When an answer phrase was unclear the following text message was sent: "*there is a problem with your text message, please respond again*" followed by the text message with question. If a participant asked a question, YL called the participant. When participants said that they did not want to continue, YL sent them the following text message: "*We are sorry to hear you wish to discontinue, you will not receive text messages from us anymore. Thank you for participating.*", and stopped sending text messages.

Interviews about participants' reasons for differences in responses

In group 2, interviews about participants' reasons for differences in responses given to the face-to-face and text messaging questions took place directly after the face-to-face interviews. Caregivers who participated in both the text messaging and face-to-face were asked structured questions about their reasons for giving a different response (Appendix C Questionnaires). Before the interviews, YL sent the responses of the text messages to the supervisors in the field (WW and XD). Directly after the face-to-face interview, the interviewers compared the responses to the face-to-face questions and text message question and marked differences in responses. The supervisors conducted the interviews and recorded one of the different answer options with pen-and-paper.

6.3.8 Participants

Number of participants recruited

Of the 4170 children on the list of names, a total of 1026 caregivers in 42 villages and 1014 participants were included: 371 participants in 15 villages in group 1 and 643 participants in 27 villages in group 2 (Table 21). All included participants provided written and oral consent, had a child in the family younger than five years (the youngest child if there was more than one child younger than five), used a mobile phone and were able to use text messages. A total of 12 caregivers were excluded for the following reasons: the child of one caregiver had just reached age five, text messages were not sent to three caregivers in group 1 by an administrative mistake and it could not be identified which child belonged to the text message responses for eight caregivers (which was only realised after the study). Those eight caregivers were four caregivers who gave the same mobile phone number as four other caregivers (they belonged to only four different families and gave one phone number per family). The remaining 3144 caregivers of children (4170 children on the list of names minus 1026 caregivers recruited) could not be recruited, because they were not present in the village, lists of names were incorrect, they did not meet the inclusion criteria or it was not possible to recruit caregivers in villages. One village doctor was not willing to participate in one village in group 1. In three villages in group 2, one village doctor was not willing to participate, one village doctor passed away and one village doctor was not available.

Table 21 Number of cross-over study participants recruited in villages per group (N=1014)

Number*	Group 1 (n=371) Village number	Group 1 Number of participants	Group 1 %	Group 2 (n=643) Village number	Group 2 Number of participants	Group 2 %
1	1	15	4.0	2	17	2.6
2	3	13	3.5	5	7	1.1
3	4	21	5.7	7	11	1.7
4	10	18	4.9	8	24	3.7
5	12	15	4.0	9	23	3.6
6	13	43	11.6	11	16	2.5
7	16	15	4.0	15	7	1.1
8	17	27	7.3	18	12	1.9
9	20	47	12.7	19	14	2.2
10	27	4	1.1	21	24	3.7
11	32	41	11.1	22	10	1.6
12	36	33	8.9	23	15	2.3
13	40	31	8.4	24	24	3.7
14	43	37	10.0	25	4	0.6
15	46	11	2.8	26	12	1.9
16				28	16	2.5
17				29	36	5.6
18				31	34	5.3
19				33	38	5.9
20				34	31	4.8
21				35	43	6.7
22				37	47	7.3
23				38	15	2.3
24				39	19	3.0
25				41	38	5.9
26				42	89	13.9
27				44	17	2.4

*In group 1, the total number of villages was 15 with a median number of 20 participants (Q1-Q3; 13-36) per village. In group 2, the total number of villages was 27 with a median number of 33 participants (Q1-Q3; 22-39) per village.

Characteristics of cross-over study participants

Of 1014 included participants, 796 were mothers (78.5%) 141 fathers (13.9%), 53 grandmothers (5.2%), 22 grandfathers (2.1%) and two were aunts (0.2%).

Characteristics between groups 1 and 2 were compared using the *Pearson's chi-square test* and *Fisher's Exact test* for nominal variables and *Mann-Whitney U test* for not normally distributed continuous variables and ordinal variables.

Of the 29 participant characteristics that were available, 21 were similar between the groups (Table 22). However, in group 1 there were more children with an urban *Hukou* ($P<0.001$), a higher proportion of participants were mothers ($P=0.003$), a higher proportion of participants were the primary caregiver of the child ($P=0.001$), mothers ($P=0.03$) and fathers ($P=0.007$) had a higher education level, fathers had a higher median number of years of education ($P=0.046$), the family income was lower ($P=0.03$) and a lower proportion of household had the phone number of a township hospital ($P=0.005$), compared to group 2.

Table 22 Characteristics of cross-over study participants

Variables	Total (N=1014)	Group 1 (n=371)	Group 2 (n=643)	Comparison Statistics*	P value
Gender, n (%)				χ^2=0.03	0.87
Boy	561 (55.3)	204 (55.0)	357 (55.5)		
Girl	453 (44.7)	167 (45.0)	286 (44.5)		
Age child groups, n (%)				MWU z=-0.41	0.68
0-11 months	212 (20.9)	74 (19.9)	138 (21.5)		
12-23 months	279 (27.5)	112 (30.2)	167 (26.0)		
24-59 months	523 (51.6)	185 (49.9)	338 (52.5)		
Number of children, n (%)				MWU z=-0.49	0.62
1	470 (46.4)	174 (46.9)	296 (46.0)		
2	521 (51.4)	192 (51.8)	329 (51.2)		
3	21 (2.1)	4 (1.1)	17 (2.6)		
4	2 (0.1)	1 (0.2)	1 (0.2)		
Mother's age in years, median (Q1-Q3)	28 (26-31)	28 (26-31)	28 (26-32)	MWU z=-0.30	0.76
Mother's education level, median (Q1-Q3)†	3 (3-3)	3 (3-4)	3 (3-3)	MWU z=-2.26	0.03‡
Mother's number of years of education, median (Q1-Q3)	9 (9-9)	9 (9-11)	9 (9-9)	MWU z=-1.41	0.16

Mother's occupation, n (%)				Fisher's exact test	0.33
Home	496 (48.9)	171 (46.1)	325 (50.5)		
Work	515 (50.8)	199 (53.6)	316 (49.1)		
Do not know	3 (0.3)	1 (0.3)	2 (0.4)		
Father's age in years, median (Q1-Q3)	29 (26-32)	29 (27-32)	29 (26-32)	MWU z=-0.15	0.88
Father's education level, median (Q1-Q3)[†]	3 (3-3)	3 (3-4)	3 (3-3)	MWU z=-2.68	0.007[‡]
Father's number of years of education, median (Q1-Q3)	9 (9-9)	9 (9-12)	9 (9-9)	MWU z=-2.00	0.046[‡]
Father's occupation, n (%)				Fisher's exact test	0.51
Home	12 (1.2)	6 (1.6)	6 (0.9)		
Work	998 (98.4)	363 (97.8)	635 (98.8)		
Do not know	4 (0.4)	2 (0.6)	2 (0.3)		
Relationship to the child, n (%)				Fisher's exact test	0.003[‡]
Mother	796 (78.5)	300 (80.9)	496 (77.1)		
Father	141 (13.9)	58 (15.6)	83 (12.9)		
Grandmother	53 (5.2)	9 (2.4)	44 (6.8)		
Grandfather	22 (2.2)	4 (1.1)	18 (2.8)		
Other[§]	2 (0.2)	0 (0.0)	2 (0.4)		
Participant is primary caregiver, n (%)				χ^2=14.87	0.001[‡]
Yes	687 (67.8)	279 (75.2)	408 (63.5)		
No	327 (32.2)	92 (24.8)	235 (36.5)		
Type of *Hukou* child, n (%)				χ^2=15.96	<0.001[‡]
Urban	55 (5.4)	34 (9.2)	21 (3.3)		
Rural	959 (94.6)	337 (90.8)	622 (96.7)		
Family net income in last year in ¥, median (Q1-Q3)[¶]	25,000 (20,000-40,000)	20,000 (15,000-35,000)	25,000 (20,000-40,000)	MWU z=-2.24	0.03[‡]
Do not know family income, n (%)	252 (24.9)	104 (28.0)	148 (23.0)		
Family living expenses in the last year in ¥, median (Q1-Q3)	20,000 (10,000-20,000)	20,000 (10,000-20,000)	20,000 (10,000-20,000)	MWU z=-0.55	0.58
Do not know family living expenses, n (%)	209 (20.6)	84 (22.6)	125 (19.4)		
Use smartphone, n (%)				χ^2=0.005	0.95
Yes	455 (44.9)	167 (45.0)	288 (44.8)		
No	559 (55.1)	204 (55.0)	355 (55.2)		
Primary usage mobile phone for calls and text messages, n (%)				Fisher's exact test	0.96
Calling	811 (80.0)	297 (80.0)	514 (79.9)		
Text messaging	29 (2.9)	10 (2.7)	19 (3.0)		
Both in equal measure	170 (16.8)	62 (16.7)	108 (16.8)		
Other[**]	4 (0.3)	2 (0.6)	2 (0.3)		

Primary usage mobile phone for *QQ* and text messages, n (%)				Fisher's exact test	0.21
Text message	330 (32.5)	124 (33.4)	206 (32.0)		
QQ	385 (38.0)	147 (39.6)	238 (37.0)		
Both in equal measure	86 (8.5)	22 (5.9)	64 (10.0)		
Do not use either	211 (20.8)	77 (20.8)	134 (20.8)		
Other (seldom use them (2))	2 (0.2)	1 (0.3)	1 (0.2)		
Number of calls made per week, median (Q1-Q3)	10 (7-20)	10 (7-21)	10 (7-20)	MWU z=-1.29	0.20
Do not know number of calls made per week, n (%)	156 (15.3)	47 (12.4)	109 (17.1)		
Number of calls received per week, median (Q1-Q3)	10 (7-20)	10 (6-21)	10 (7-20)	MWU z=-1.11	0.27
Do not know number of calls received per week, n (%)	142 (14.0)	48 (12.7)	94 (14.7)		
Number of text messages sent per week, median (Q1-Q3)	1 (0-7)	1 (0-7)	2 (0-8)	MWU z=-0.68	0.49
Do not know number of text messages sent per week, n (%)	59 (5.8)	22 (5.9)	37 (5.9)		
Number of text messages received per week, median (Q1-Q3)	10 (5-15)	8 (5-15)	10 (5-15)	MWU z=-0.76	0.45
Do not know number of text messages received per week, n (%)	80 (8.0)	26 (6.9)	54 (8.5)		
Households having phone number of any health facility, n (%)				Fisher's exact test	0.06
Yes	662 (65.3)	245 (66.0)	417 (64.9)		
No	343 (33.8)	126 (34.0)	217 (33.8)		
Do not know	9 (0.9)	0 (0.0)	9 (1.3)		
Households having phone number of county hospital or above, n (%)‖				χ^2= 4.12	0.13
Yes	296 (29.2)	102 (27.5)	194 (30.2)		
No	704 (69.4)	267 (72.0)	437 (68.0)		
Do not know	14 (1.4)	2 (0.5)	12 (1.8)		
Households having phone number of township hospital, n (%)				χ^2= 10.78	0.005‡
Yes	227 (22.4)	101 (27.2)	126 (19.6)		
No	772 (76.1)	268 (72.2)	504 (78.4)		
Do not know	15 (1.5)	2 (0.6)	13 (2.0)		

Households having phone number of village clinic, n (%)				Fisher's exact test	0.09
Yes	496 (48.9)	182 (49.1)	314 (48.8)		
No	510 (50.3)	189 (50.9)	321 (49.9)		
Do not know	8 (0.8)	0 (0.0)	8 (1.3)		
Number of times mobile phone was used to obtain health information in past 3 months, n (%)				MWU z=-1.54	0.12
Never	646 (63.7)	248 (66.8)	398 (61.9)		
Once	50 (4.9)	17 (4.6)	33 (5.1)		
Twice	64 (6.3)	19 (5.1)	45 (7.0)		
Three times	39 (3.8)	16 (4.3)	23 (3.6)		
More than three times	215 (21.3)	71 (19.2)	144 (22.4)		
Would like to use mobile to receive health information, n (%)				χ^2= 2.56	0.26
Yes	603 (93.3)	236 (95.2)	367 (92.2)		
No	25 (3.9)	8 (3.2)	17 (4.3)		
Other (neutral (1), it is hard to tell (1), it does not matter to have it or not (16))	18 (2.8)	4 (1.6)	14 (3.5)		

[*]Chi-square (χ^2), Mann-Whitney U (MWU), z-score (z).
[†]3=junior high school, 4=senior high school/technical school.
[‡]*P*<0.05
[§]child's aunt (wife of brother of father), child's aunt (wife of brother of mother).
[||]including county hospital, county children's hospital, private hospital.
[¶] n=646 for total group: n=248 for group 1 and n=398 for group 2.
[**]*QQ* (1), depends (1), neither (2).

Flow of cross-over study participants

In group 1, all 371 participants completed the face-to-face survey directly after recruitment in the village clinic. This included both the demographic characteristics questions and the survey questions on diarrhoea and pneumonia that were compared between the methods. The next day, the text messaging survey was sent and 189 participants responded to the text messaging survey. Of these 189 participants, 183 participants (97%) were the same caregivers participating in both the face-to-face and text messaging survey.

In group 2, all the 643 participants completed the demographic characteristics survey (questions that were not compared between the methods) directly after recruitment in the village clinic. Then the text messaging survey was sent to all 643 participants and 349 participants responded. The day after the text messaging survey ended, 302 came back to the village clinic and completed the face-to-face survey. Of those 302 participants, 226 participants (75%) were the same caregivers participating in both the face-to-face and text messaging survey (Figure 3).

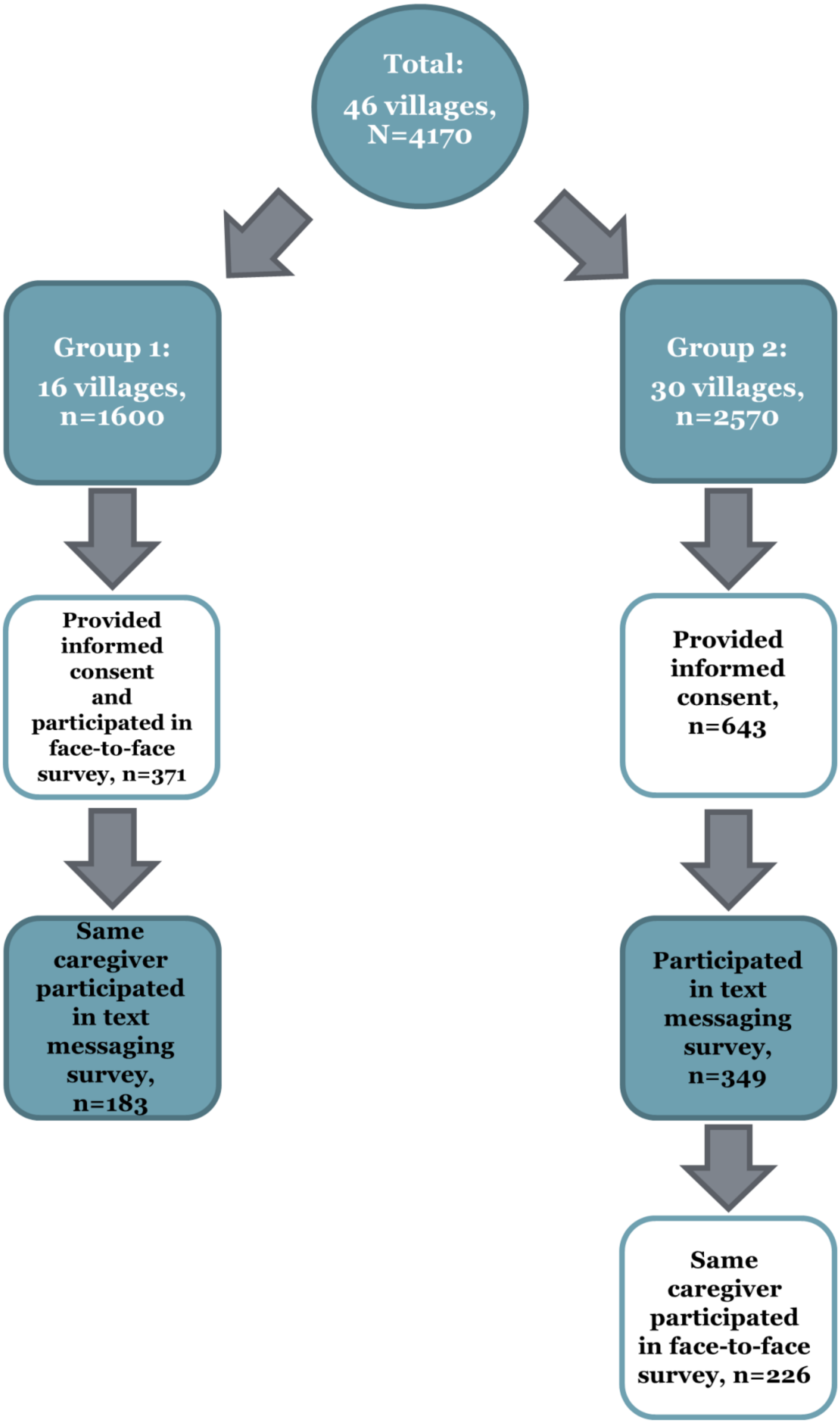


Figure 3 Flow diagram of cross-over study participants

"N" is the total number of children under five in Zhaozhou Township, "n" is the number of caregivers of children under five participating in cross-over study.

A total of 93 caregivers who came to the village clinics for the face-to-face survey were not the same person who participated in the text messaging survey (Table 23): eight participants in group 1 of whom six replied to the first survey text message question; and 85 participants in group 2 of whom 76 replied to the first survey text message question and then participated in the face-to-face survey. This was mostly because mothers (46; 49%) or fathers (40; 43%) replied to the text messages, but others came to the face-to-face interview. These participants had to be excluded from the data equivalence analyses.

Table 23 Number of different caregivers participating in face-to-face and text messaging survey (n=93)

Face-to-face	Text messaging				
	Mother	**Father**	**Grandmother**	**Grandfather**	**Other caregiver**
Mother	0	25	2	1	3
Father	10	0	0	0	1
Grandmother	26	11	0	0	0
Grandfather	9	4	0	0	0
Other caregiver	1	0	0	0	0
Total	46	40	2	1	4

6.3.9 Data management and analysis of outcomes

Data management of the face-to-face survey was similar to the survey described in section 4.3.8. For the text messaging survey, only YL was able to enter the text message database. Each participant was given an identification number and the databases with participant information linked to the identification numbers could only be accessed by YL. Data were anonymised for analysis and reporting. *P* values less than 0.05 were considered significant. Missing data were not imputed.

The following outcomes were assessed: (i) the response rate; (ii) characteristics of responders versus non-responders and completers versus non-completers; (iii) the error rate of the text messaging survey; (iv) data equivalence; (v) the amount of information in responses; and (vi) reasons for differences in responses. These outcomes and their analysis are described in the next paragraphs.

The PhD candidate used SPSS version 16.0 [320] for the statistical analysis outcomes i, ii, iv, and v, apart from the weighted kappa, which WW analysed using SAS version 9.2 [321]. YL and the PhD candidate used Excel version 2010 [333] to analyse outcomes iii and vi.

Response rate

The response rate encompassed the item response rate and completion rate. The item response rate was defined as the proportion of participants responding to each question separately. The completion rate was defined as the proportion of participants who completed the text messaging survey. For this outcome, the number of questions that participants had to answer depended on the responses they gave to questions about the condition of their child. There were five conditions that determined the questions participants had to answer: (i) diarrhoea; (ii) complementary feeding; (iii) fever; (iv) cough; and (v) fast or difficult breathing. A total of 24 "statuses" that represent all combinations of these 5 conditions were created. The number of participants completing each of the 24 different statuses was calculated. However, only the proportion of participants who completed the entire survey for all of the 24 different statuses combined could be calculated (Appendix G Additional tables for cross-over study, Table 48). The proportions for each different status could not be calculated, because participants who did not reply did not provide information on their status and thus could not be classified.

This outcome is presented in Chapter 7, Figure 4 and Appendix G Additional tables for cross-over study Table 49.

Characteristics of responders versus non-responders and completers versus non-completers

In group 1, characteristics of participants who responded to text message 2 (responders) were compared to characteristics of participants who did not respond to text message 2 (non-responders). In addition, characteristics of participants who completed the survey (completers) and those who did not complete the survey (non-completers) were compared. These comparisons could not be made in group 2, because only those participants who responded were asked to visit the village clinic for the face-to-face survey on care-seeking for childhood diarrhoea and pneumonia. The comparisons were made using the *Pearson's chi-square test* and *Fisher's Exact test* for nominal variables and *Mann-Whitney U test* for not normally distributed continuous variables and ordinal variables (the same statistical tests as for the comparison of characteristics between group 1 and group 2).

This outcome is presented in Chapter 7 and Appendix G Additional tables for cross-over study Table 50 and 51.

Error rate of the text messaging survey

The error rate of the text messaging survey was evaluated by incorrect text message questions that were sent to participants and incorrect text message answers that were received from participants. For the face-to-face survey method, this was not relevant, because the smartphone was programmed to avoid errors. The smartphone guided the interviewer through the interview and when a value was missing or out of range, the interviewer could not continue the survey without entering a valid response. However, despite efforts to minimise errors in the text messaging survey, this could not be eliminated due to the manual process of sending text messages. Incorrect questions sent were defined as text messages that were not sent or not sent in the right format because of researcher-related errors. Incorrect text message answers were defined as responses of the participants that were empty, unclear, or out of range and that had to be assessed and those that needed a follow-up text message.

An overview of the text messages sent and received with proportions of incorrect text message questions sent and answers received is presented in Chapter 7, Figure 5 and 6.

Data equivalence

The survey on care-seeking for childhood diarrhoea and pneumonia included 17 questions that could be compared between the two methods: (i) 10 questions with a nominal scale (dichotomous "yes" or "no" answers); (ii) 5 questions with a nominal non-dichotomous scale for which kappa values were calculated when possible; and (iii) 2 questions with an ordinal scale (answers varying from "none" to "more") for which weighted Cicchetti-Allison and Fleiss-Cohen kappa values were calculated. The results for group 1 and 2 were calculated together and comparison of kappa values and 95% Confidence Interval (CI) was performed for the two groups separately. The results on equivalence of different questions were presented separately, because pooling this was not considered appropriate. The questions were answered by different subgroups of participants, because participants dropped out in the text messaging survey and questions that were sent depended on the answers that caregivers gave. Therefore, individual questions were compared to assess what the equivalence of each question was.

Agreement was measured to test data equivalence, which was defined as the degree to which the responses to the face-to-face questions and text messages were identical [329,334]. There is frequently interchangeable use of the terms agreement and reliability, but these concepts are different [134,329,335]. Agreement is "*the degree to which scores or ratings are identical*". Reliability can be defined as "*the ability of a measurement to differentiate between subjects or objects*" [329].

Kappa is a useful statistic for measuring agreement and to test measurement equivalence [224]. Cohen's kappa can be used to indicate the strength of agreement for a nominal scale used on separate occasions [336]. Cohen's kappa compares the observed agreement with agreement that is expected by chance alone, which makes it a chance-corrected index of agreement. A kappa value of zero means that there is no agreement beyond chance, while a kappa value of 1 indicates that there is perfect agreement. There is no accepted standard for rating the different values for kappa. Kappa values higher than 0.60, 0.70 or 0.80 are generally considered to be the minimum standard for group-level comparisons or for research purposes. However, these strengths of agreement do not indicate the practical relevance of results. There are a number of interpretations, which all are arbitrary [337,338]. The Landis and Koch interpretation was chosen, because it has the most detailed description of agreement [337].

Disagreements between different ratings are not equally important for ordinal data. To take this into account, Cohen introduced weights for the calculation of a weighted kappa [339]. Weighted kappa takes account of the distance between disagreements and is therefore appropriate for ordinal scales with more than two categories. Different weights can be given to weighted kappa, but most commonly used are Cicchetti-Allison [340] and Fleiss-Cohen weights [341]. Fleiss-Cohen gives quadrant weights and can be similar to the intraclass correlation coefficient [341,342]. Cicchetti-Allison gives linear weights and is more appropriate for questions with many answer options [343]. The linearly weighted kappa coefficient can be simply derived from K-1 embedded 2x2 classification tables [344]. The value of weighted kappa is sensitive to the choice of weights [345]. The survey included two ordinal questions with five answer options. Thus, as the number of answer options was relatively high, Cicchetti-Allison was the most appropriate choice for the weights. However, also this is arbitrary and thus both Fleiss-Cohen and Cicchetti-Allison weights are presented.

A combination of kappa statistics (including kappa values, 95% CIs, *P* values) and the percentage of agreement was reported, which allowed for a detailed impression of data agreement [329]. For the proportion of agreement, the proportion was not presented when the number of participants was fewer than 10.

This outcome is presented in Chapter 7, Table 24-27 and Appendix G Additional tables for cross-over study Table 52-58.

The amount of information in responses

The amount of information was analysed by the number of places caregivers reported for text message 13 and 20 (places where caregivers sought care) by comparing the number of places given between the face-to-face method and the text message method.

This outcome is presented in Chapter 7, Table 28 and Appendix G Additional tables for cross-over study Table 59 and 60.

Reasons for differences in responses

YL transcribed the paper questionnaires in Excel version 2010 [333] and translated the reasons for differences in responses, which were checked by WW. The number of reasons for differences were counted for the face-to-face and text messaging methods.

This outcome is presented in Chapter 7 and in Appendix G Additional tables for cross-over study Table 61.

Structured summary of chapter

This chapter introduced and described the methods of a study addressing the second objective of this thesis. In sum:

1. Cognitive interviewing, usability testing and a feasibility study using a cluster randomised cross-over design took place;
2. The study setting was Zhaozhou Township and the sample included caregivers of children younger than five who used a mobile phone and were able to use text messages;
3. In the cross-over study, stratified randomisation was used to divide villages (clusters) into two groups;
4. Caregivers were asked by their village doctor and recruited by trained interviewers;
5. YL conducted the cognitive interviews and usability testing. Interviewers for the face-to-face survey were trained local students. For the text messaging survey, YL sent the text messages and a second researcher checked the text messages;
6. The text messaging survey included 17 questions that were also asked in the face-to-face interview. In addition, the text messaging survey had three follow-up questions, one question on willingness to participate and one on the identity of the participant;
7. Participants in group 1 first completed the face-to-face survey and after one day the text messaging survey, while this order of completing the surveys was reversed for group 2;
8. A total of 1014 participants were included: 371 in group 1 and 643 in group 2. Most participants were mothers (78.5%). A total of 183 participants in group 1 and 226 participants in group 2 participated and were the same caregiver in both the text messaging and face-to-face surveys;
9. Six outcomes were assessed: (i) the response rate; (ii) characteristics of responders versus non-responders and completers versus non-completers; (iii) the error rate of the text messaging survey; (iv) data equivalence; (v) the amount of information in the responses; and (vi) reasons for differences in responses.

7 Validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia: study results and discussion

Overview of chapter

After introducing and describing the methods of the study addressing the second objective of this thesis in Chapter 6, the current chapter presents the results and discussion of this study.

Photograph 28 Child and mother with mobile phone

Photograph from the PhD candidate's personal collection

7.1 Results

Overview of section

This section describes the results of the six outcomes of the cross-over study: (i) the response rate; (i) characteristics of responders versus non-responders and completers versus non-completers; (iii) the error rate of the text messaging survey; (iv) data equivalence; (v) the amount of information in the responses; and (vi) reasons for differences in the responses.

7.1.1 Response rate

Figure 4 illustrates the item response rate for each question separately and the completion rate (for exact numbers see Appendix G Additional tables for cross-over study, Table 49).

Of the 1014 participants, 65.3% (n=662) responded to text message 2 (asking about willingness to participate) and 64.2% (n=651) were willing to participate. Both proportions were not significantly different between group 1 and group 2.

The item response rate was >90% for the four questions that all participants had to answer. For the 13 additional questions, the item response rate was at least 90% for six questions, >75% for six questions and 4 out of 10 participants responded to one question that asked about reasons for not seeking care outside the home (text message 19).

The item response rates were significantly different between the groups for two questions out of the 19 text message questions (text message 15 about the child having an illness with a cough, P=0.03 and text message 18 about seeking care for a child with a fever or cough, P=0.049). The response rates for these questions were higher in group 1 compared to group 2.

Of the 651 participants who responded that they were willing to participate, 54.7% (n=356) completed the text messaging survey and there was no significant difference between the groups (P=0.05).

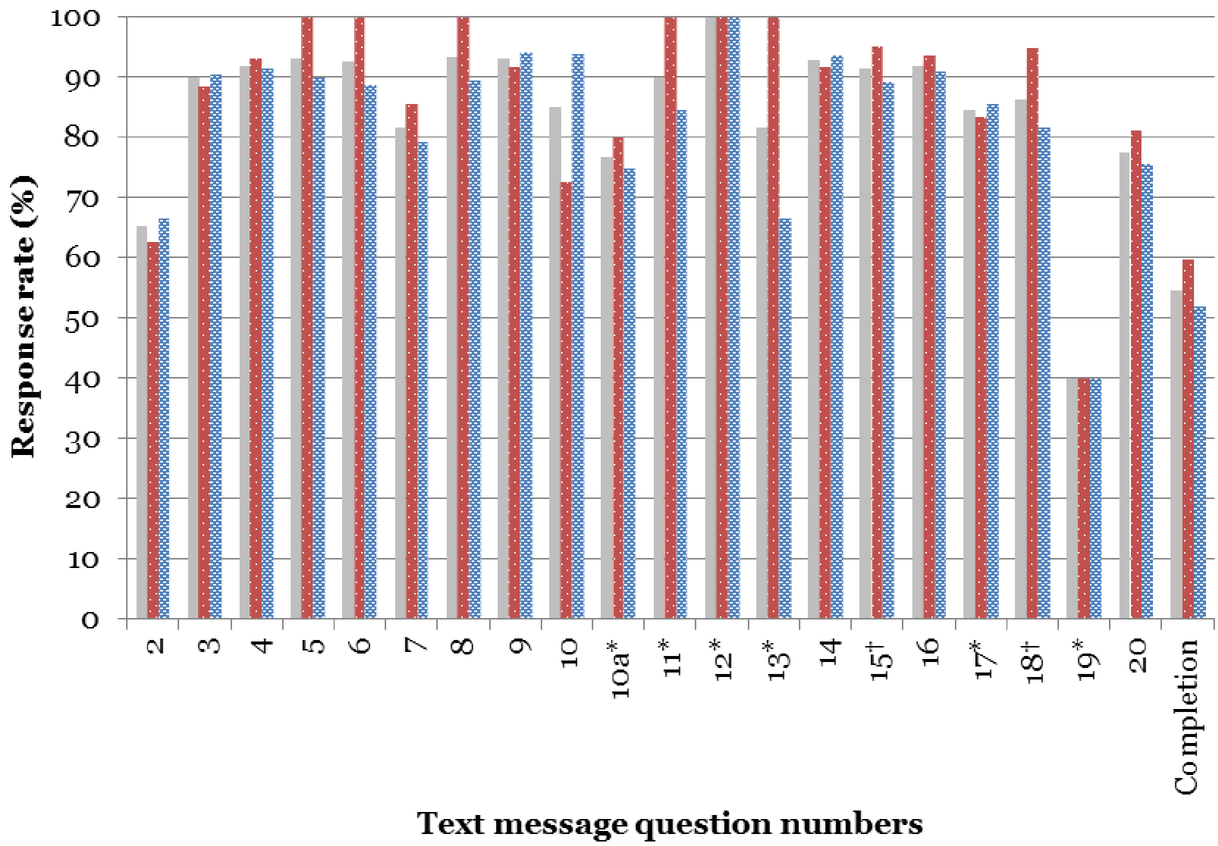


Figure 4 Item response rate and completion rate for the total group (N=1014), group 1 (n=371) and group 2 (n=643)

Total group
Group 1
Group 2

*number of participants <10 in group 1 and/or group 2

†P<0.05; significantly different response rate between groups 1 and 2

7.1.2 Characteristics of responders versus non-responders and completers versus non-completers

Two variables were significantly different between responders and non-responders for text message 2 in group 1. Firstly, there was a significantly higher proportion of rural *Hukous* in the non-responder group compared to the responder group (P=0.004). Secondly, the median number of text messages received was significantly lower in the non-responder group compared to the responder group (P=0.046) (Table 50).

There was only one significant difference between participants who completed the survey and those who did not complete the survey based on the set of variables that were available for the study. There were more children with diarrhoea in the non-completers group (P=0.03) compared to the completers group (Table 51).

7.1.3 Error rate of the text messaging survey

No technical issues were experienced during the study, such as network problems or issues with the text messaging system. The researcher sent files containing 10 messages to the second researcher who checked them. About one in five files contained one or two mistakes, which had to be revised. However, errors occurred even after these checks, because some participants said that they did not receive follow-up text messages and therefore could not complete the survey. This was checked and it was found that indeed some text messages had not been sent to participants.

A total of 7971 text messages were manually sent to participants of which 145 text messages (1.8%) were in an incorrect format by mistake: 70 with an additional number (minor editing error), 38 wrong questions and 37 repeated questions.

A total of 4033 text message replies were received from participants of which 1358 text messages (33.7%) were in an incorrect format and had to be assessed (Figure 5). After inspection, the meaning of 1181 text messages (29.3%) was clarified and no text messages had to be sent to follow up these responses.

These text messages were not in the exact format for the following reasons: participants replied in their own words; wrote their answer with commas; typed the wrong Chinese characters; said other things not related to the text messaging survey; replied to text message 1 or 21 which did not require a response; refused to participate; asked a question; sent text messages with the same signature as the text messages (saying "*Zhao County's Maternal and Child Health Hospital message*"); or sent a signature of the mobile phone.

For the remaining 177 text messages (4.4%), the meaning of the text messages could not be clarified and the text message question had to be resent. Unclear text messages were mainly blank text messages and unclear answers to text messages 13 and 20.

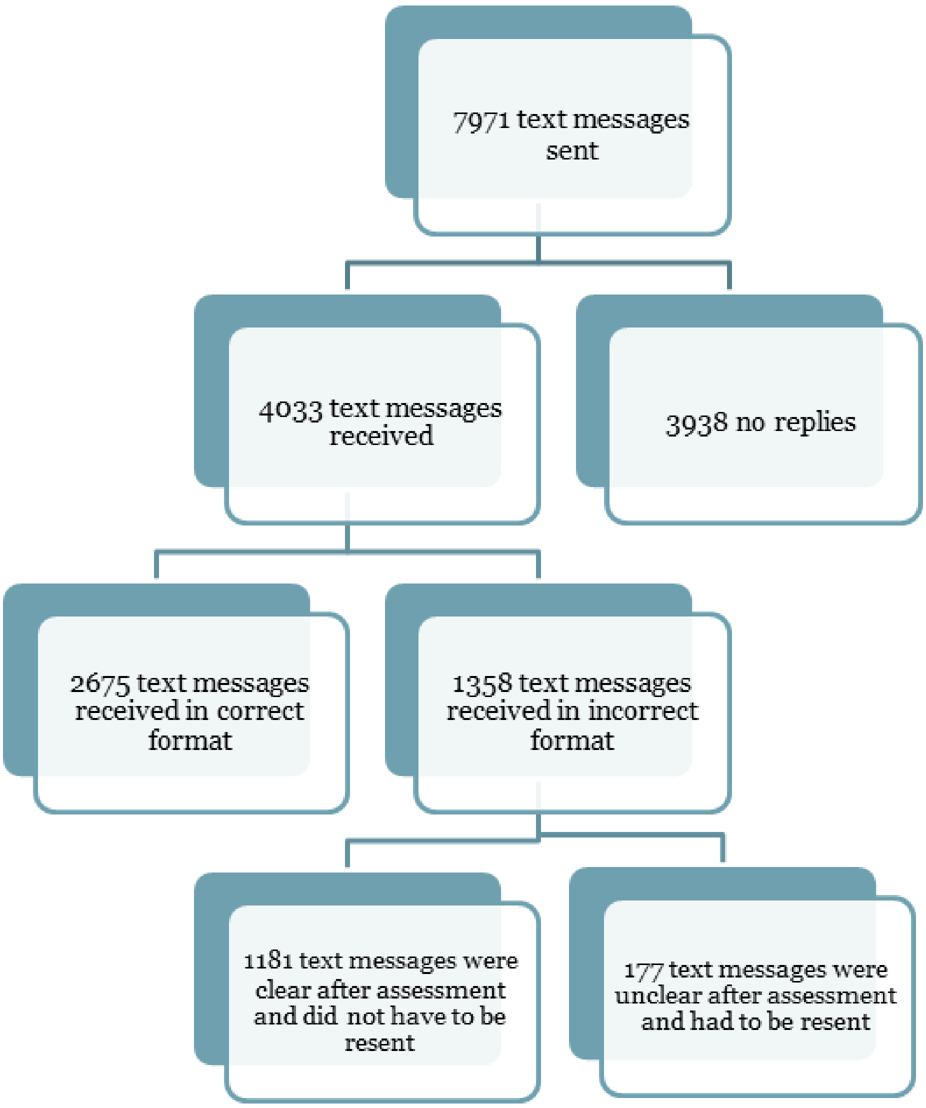


Figure 5 Incorrect text messages sent

The 177 text messages that had to be resent included 137 text messages that had to be sent for the second time, 31 text messages for the third time, 8 text messages for the fourth time and 1 that had to be sent for the fifth time (Figure 6).

This process involved a total of 116 participants (17.5%; total number was 662 participants responding to text message 2): 72 participants with 1 unclear text message, 32 participants with 2 unclear text messages, 7 participants with 3 unclear text messages and 5 participants with 4 unclear text messages.

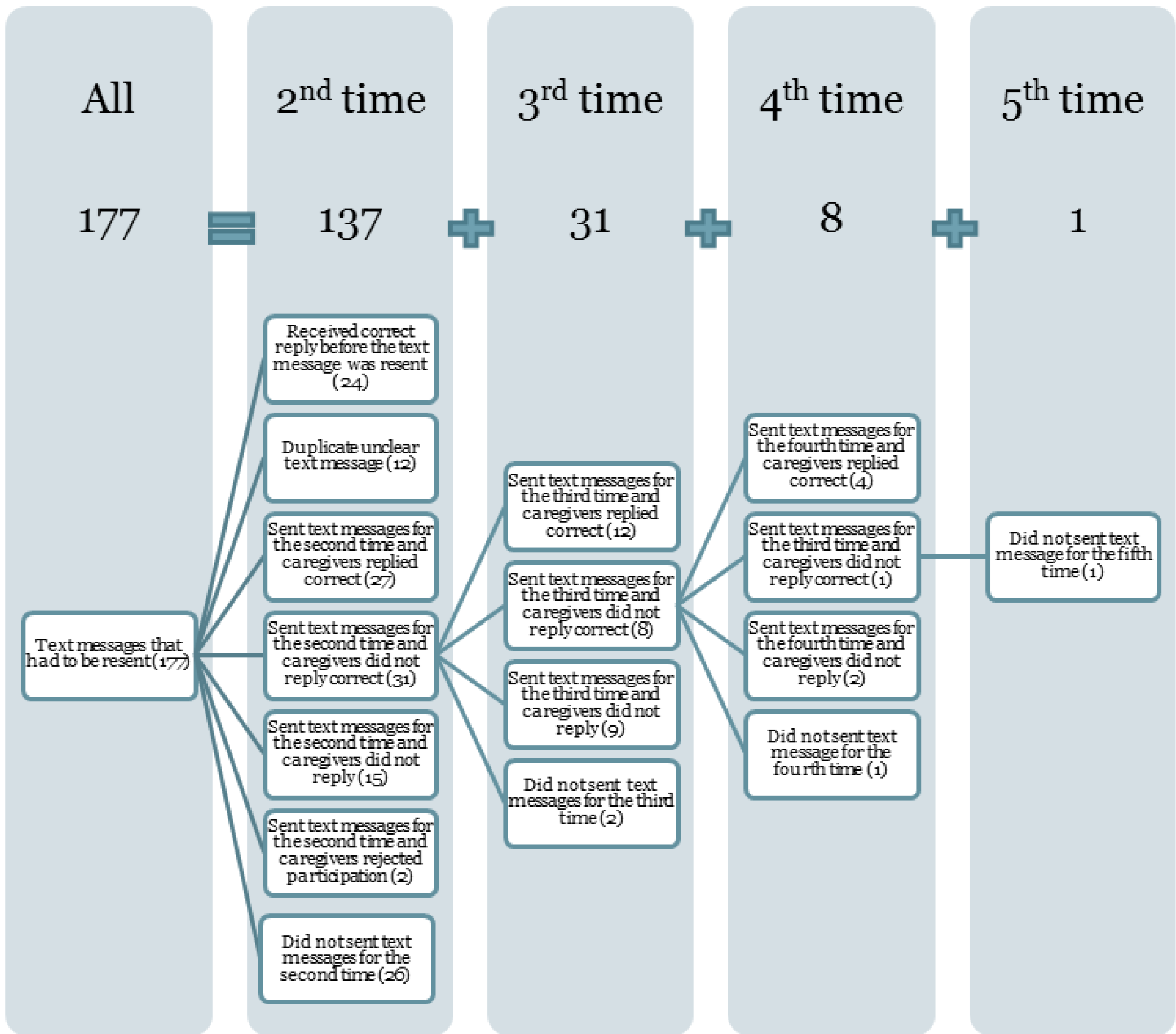


Figure 6 Unclear text messages that had to be resent

7.1.4 Data equivalence

Kappa and proportional agreement are presented for 15 nominal questions of which 10 were dichotomous (text message 4, 5, 6, 7, 8, 11, 14, 15, 16, 18) and 5 were non-dichotomous (text message 12, 13, 17, 19, 20). Cicchetti-Allison and Fleiss-Cohen weighted kappa were presented for two ordinal questions (text message 9 and 10a). Kappa was categorised according to the Landis and Koch interpretation as follows: <0.00 poor; 0.00–0.20 slight; 0.21–0.40 fair; 0.41–0.60 moderate; 0.61–0.80 substantial; and 0.81–1.00 almost perfect [337].

Total group

Nominal questions

The proportion of agreement was as follows for the 10 nominal dichotomous questions: >90% for 5 questions; between 80% and 90% for 4 questions; and 70.0% for 1 question (Table 24). Kappa was as follows for these 10 nominal dichotomous questions: substantial for 6 (text message 4, 8, 14, 15, 16 and 18); fair for whether care was sought for diarrhoea (text message 11) and whether an ORS was given (text message 6); and could not be calculated for 2 questions (text message 5 and 7) that had an insufficient number of values for each cell in the 2x2 classification table (also see Appendix G Additional tables for cross-over study Table 52).

Out of the 5 non-dichotomous questions, 1 question had agreement of 65.0% and agreement is provided in numbers in Table 24 for 4 remaining questions that had fewer than 10 participants. For these 5 nominal non-dichotomous questions, kappa was moderate for the question on what had caused the fast or difficult breathing (text message 17) and kappa could not be calculated for the remaining 4 questions; 3 questions (text message 12, 13 and 19) had fewer than 10 participants who had to answer those questions and 1 question (text message 20) had an insufficient number of values (also see Appendix G Additional tables for cross-over study Table 53-56).

Table 24 Nominal questions, agreement and kappa coefficients for total group (N=409)

Text message: brief content	n of pairs	% agreement	Kappa	95% CI	*P* value
4: child had diarrhoea	409	96.8	0.76	0.64-0.89	<0.001‡
5: child had blood in stools	21	100.0*	-	-	-
6: child drank ORS	19	84.2	0.31	-0.27-0.90	0.16
7: child drank recommended fluids	16	87.5*	-	-	-
8: child drank other fluids	16	87.5	0.74	0.41-1.00	0.002‡
11: sought care for diarrhoea	10	70.0	0.35	-0.24-0.94	0.26
12: why care was not sought for diarrhoea†	2	2/2 agree*	-	-	-
13: where care was sought for diarrhoea†	4	¾ agree*	-	-	-
14: child had fever	365	95.1	0.71	0.59-0.84	<0.001‡
15: child had an illness with a cough	332	88.9	0.70	0.61-0.79	<0.001‡
16: child breathed fast or with difficulty	308	97.1	0.65	0.44-0.86	<0.001‡
17: cause of fast or difficult breathing†	8	6/8 agree*	0.58	0.16-1.00	0.03‡
18: sought care for the child during fever or cough	55	94.5	0.77	0.52-1.00	<0.001‡
19: why care was not sought for fever or cough†	2	2/2 agree*	-	-	-
20: where care was sought for fever or cough†	40	65.0*	-	-	-

*Kappa cannot be calculated.
†Non-dichotomous.
‡*P*<0.05

Ordinal questions

The weighted kappa values were substantial for Cicchetti-Allison and moderate for Fleiss-Cohen for the question about drinking during diarrhoea (text message 9). Both weighted kappa values were fair for the question about eating during diarrhoea (text message 10a) (Table 25 and Appendix G Additional tables for cross-over study Table 57).

To answer the question about eating during diarrhoea, children had to have been introduced to complementary food (this excluded children who had only been breastfed). In the face-to-face survey, the interviewer first asked whether the child had been introduced to complementary food and then asked the question about eating during diarrhoea. This answer was recorded as one of the options for this question.

However, this involved two text messages in the text messaging survey (text message 10 and 10a). Participants were first asked whether their child had been introduced to complementary food (text message 10) before they were asked the question about feeding during diarrhoea (text message 10a). Only one out of five participants gave the same response "child had not been given complementary foods yet" for both the face-to-face and text messaging surveys. The remaining four participants answered "child was not given complementary foods yet" in the text messaging survey and said "about the same" (n=3) or "none" (n=1) in the face-to-face survey (Appendix G Additional tables for cross-over study Table 58).

As this may explain the low kappa value for the feeding question, the kappa value was also calculated for the question about feeding during diarrhoea after exclusion of those participants who had children that had not been introduced to complementary foods. When those five participants who said that the child had not been given complementary foods were excluded from the analysis, the weighted kappa was substantial.

Table 25 Ordinal questions, agreement and weighted kappa coefficients for total group (N=409)

Text message: brief content	n face-to-face	n of pairs	% agreement	Cicchetti-Allison and Fleiss-Cohen kappa	95% CI	*P* value
9: how much did the child drink during diarrhoea	27	14	85.7	0.66, 0.60	0.23-1.00, 0.07-1.00	<0.001, 0.01†
10a: how much did the child eat during diarrhoea	27	11	45.5	0.37, 0.37	0.05-0.70, -0.08-0.83	0.02†, 0.09
10a: how much did the child eat during diarrhoea*	24	6	4/6 agree	0.64, 0.74	0.21-1.00, 0.35-1.00	0.03, 0.049†
10: child had been introduced to complementary foods	24	12	8/12 agree	-	-	-

*This excluded children whose caregivers said that they had not been introduced to complementary feeding either in the face-to-face or text messaging survey.
†$P<0.05$

Comparison between group 1 and group 2

Nominal questions

Of the 15 nominal questions, five questions had overlapping 95% CIs (text messages 4, 14, 15, 16 and 18). Eight questions had too small a number of participants to calculate 95% CIs: two questions had perfect agreement (text message 5 and 19) and six questions had fairly similar agreement (text message 6, 7, 8, 11, 17 and 20). The remaining two questions could not be compared: one question had not been answered by participants in group 1 (text message 12) and one question had not been answered by participants in group 2 (text message 13) (Table 26).

Table 26 Nominal questions, kappa coefficients comparison between group 1 (n=183) and group 2 (n=226)

Text message: brief content	Group 1			Group 2		
	n of pairs	Kappa and/or agreement	95% CI	n of pairs	Kappa and/or agreement	95% CI
4: child had diarrhoea	183	0.90	0.77-1.00	226	0.68	0.50-0.86
5: child had diarrhoea with blood in stools	10	10/10 agree*	-	11	11/11 agree*	-
6: child drank ORS	10	0.41 (8/10 agree)	-0.18-1.00	9	8/9 agree*	-
7: child drank recommended fluids	9	7/9 agree*		7	7/7 agree	-
8: child drank other fluids	9	0.57 (7/9 agree)	0.10-1.00	7	7/7 agree*	-
11: sought care for diarrhoea	5	4/5 agree*	-	5	3/5 agree*	-
12: why care was not sought for diarrhoea†	0	-	-	2	2/2 agree*	-
13: where care was sought for diarrhoea†	4	¾ agree*	-	0	-	-
14: child had fever	164	0.77	0.61-0.93	201	0.66	0.47-0.84
15: child had an illness with a cough	156	0.66	0.53-0.79	176	0.74	0.62-0.86
16: child breathed fast or with difficulty	146	0.70	0.42-0.98	162	0.60	0.28-0.92
17: cause of fast or difficult breathing†	5	0.38 (3/5 agree)	-0.21-0.96	3	3/3 agree*	-
18: seek care for child during fever or cough	31	0.71	0.34-1.00	24	0.83	0.52-1.00
19: why care was not sought for fever or cough†	1	1/1 agree*	-	1	1/1 agree*	-
20: where care was sought for fever or cough†	23	13/23 agree*	-	17	13/17 agree*	-

*Kappa cannot be calculated.
†Non-dichotomous.

Ordinal questions

Cicchetti-Allison and Fleiss-Cohen weighted kappa values were moderate for group 1, but perfect for group 2 for the question about how much the child drank during diarrhoea (text message 9).

For the question about how much the child ate during diarrhoea (text message 10a), the weighted kappa was substantial for Cicchetti-Allison kappa and almost perfect for Fleiss-Cohen kappa in group 1, but slight for both in group 2 (Table 27).

Table 27 Ordinal questions, weighted kappa coefficients comparison between group 1 (n=183) and group 2 (n=226)

Text message: brief content	**Group 1**			**Group 2**		
	n of pairs	**Cicchetti-Allison and Fleiss-Cohen kappa**	**95%CI**	**n of pairs**	**Cicchetti-Allison and Fleiss-Cohen kappa**	**95%CI**
9: how much did the child drink during diarrhoea	8	0.53, 0.44	0.005-1.00, -0.18-1.00	6	1.00, 1.00	1.00-1.00, 1.00-1.00
10a: how much did the child eat during diarrhoea	5	0.70, 0.83	0.34-1.00, 0.58-1.00	6	0.13, 0.05	-0.10-0.36, -0.26-0.36

7.1.5 Amount of information

Only four participants answered the question about places where care had been sought for diarrhoea (text message 13). Three participants reported that they went to one place in both the face-to-face and text messaging survey, but one caregiver reported three places in the face-to-face interview and only one via text messaging (Table 28 and Appendix G Additional tables for cross-over study Table 59).

Forty participants answered the question about places where care was sought for fever or cough (text message 20). The number of places were not significantly different between face-to-face and text messaging according to Fleiss-Cohen (P=0.38), but they were borderline significant as to Cicchetti-Allison (P=0.046) (Table 28). Thirty participants reported the same number of places in the face-to-face interview and via text messaging. However, three participants reported more places in the face-to-face survey and seven participants reported more places in the text messaging survey (Appendix G Additional tables for cross-over study Table 60).

Table 28 Amount of information, number of places recorded for total group (N=409)

Text message: brief content	n of pairs	% agreement	Cicchetti-Allison and Fleiss-Cohen kappa	95% CI	P value
13: where sought care for diarrhoea	4	¾ agree*			
20: where sought care for fever or cough	40	75.0	0.23, 0.13	-0.06-0.53, -0.23-0.49	0.046†, 0.38

*Kappa cannot be calculated.
†*P*<0.05

7.1.6 Reasons for differences in responses

Of the 226 participants in group 2, 51 participants gave 42 reasons for disagreement and 9 reasons were missing (Appendix G Additional tables for cross-over study Table 61). For eight questions (text messages 4, 6, 10a, 11, 12, 14, 15 and 16) there were disagreements between the face-to-face and text messaging answers.

There were 17 reasons related to the text messaging method: 8 participants did not see the date (there were dates in the text messages to ask about the past two weeks); 3 misunderstood the question; 3 replied carelessly and did not pay attention; 1 put a wrong answer in the text message; 1 forgot how the response was given; and 1 did not see the definition of diarrhoea symptoms.

There were 22 reasons related to the face-to-face method: 8 participants did not know the accurate definition of a symptom; 7 misunderstood the question; 4 did not understand the date clearly; 2 did not hear the question clearly; and 1 said that the interviewer was in a hurry.

There were three other reasons that could not be directly related to the methods: two participants could not recall the information that was asked; and one participant had a change of mind.

7.2 Discussion

Overview of section

This section describes the principal findings, comparison with previous research, strengths and limitations and conclusions of this chapter. Areas for further research are described in the overall discussion of this thesis in Chapter 11.

7.2.1 Principal findings

Response rate

Of the 1014 participants, 65.3% (n=662) responded to text message 2 (asking about willingness to participate) and 64.2% (n=651) were willing to participate. Of the 651 participants who were willing to participate, 54.7% (n=356) completed the text messaging survey.

The four questions that all participants had to answer had a response rate of more than 90%; most participants had children without symptoms and only had to answer those questions. Also the proportion of participants responding to follow-up questions was higher than the response rate to the first text message question. The only exception was the question about reasons for not seeking care for fever or cough, but this question only had to be answered by 10 participants.

There were no significant differences in response rates for most questions between the groups. Only for the question about cough (text message 15) and the question about seeking care for fever or cough (text message 18), was there a significantly higher proportion of caregivers answering these questions in group 1, though this was borderline significant for text message 18. These caregivers had already answered the questions in the face-to-face interview and thus this may indicate that caregivers were more likely to respond when they were more familiar with the questions. However, overall, the likelihood of participants to respond to questions did not seem to be influenced by whether they had already answered the comparison survey questions in the face-to-face interview (group 1) or had not (group 2).

Characteristics of responders versus non-responders and completers versus non-completers

When comparing responders and non-responders in group 1, there were more participants with a rural *Hukou* in the non-responders group than in the responders group (*P*=0.004). Participants in the non-responders group seemed to receive a slightly lower number of text messages than participants in the responder group (*P*=0.046), but all other mobile phone-related variables were not significantly different between the groups. Also, there was no indication that the health condition of the child or care-seeking behaviour of the caregiver was different for non-responders.

When comparing completers and non-completers, there were more children with diarrhoea in the non-completers group (*P*=0.03) compared to the completers group. This may be explained by that a participant who had a child with diarrhoea symptoms was required to answer the largest number of questions. In addition to the two general questions and four symptom-related questions that all participants had to answer, a participant with a child with diarrhoea symptoms had to answer between 8 and 10 additional questions about diarrhoea (at least 14 or 16 questions in total). For comparison, a caregiver with a child with cough, fever or fast breathing symptoms had to answer only between one and four additional questions (at least 7 or 10 questions in total). Therefore, participants seemed to be less likely to complete the survey when they were asked more than about 10 questions.

Error rate of the text messaging method

Even though the text messages that were sent were checked by a second researcher, manually sending the text messages introduced errors in the text messaging survey; the proportion of incorrect text messages sent was 1.8% (144 text messages).

Despite carefully designing the text messaging survey, a large proportion (33.7%) of the 4033 responses that participants gave was not in the exactly requested format and had to be assessed. After assessment, most of these responses were clarified and only a small proportion (4.4%) of unclear responses had to be followed up for further clarification, which was mainly for text messages 13 and 20 that asked about places where care was sought. This resulted in delayed follow-up of participants.

Data equivalence

Overall, moderate to substantial data agreement was found. For nominal questions, kappa was substantial for four questions that all participants had to answer and thus were based on a relatively large number of participants.

The power was calculated based on these results. The following assumptions were taken into consideration: (i) an alpha of 0.50 in a two-sided test, (ii) a null hypothesis of kappa=0.40 (kappas above this value are at least moderate); (iii) a threshold kappa value of 0.70 to accept the null hypothesis; and (iv) the proportions of caregivers giving each response (yes, no, do not know) in the face-to-face interview. For the four questions that all participants had to answer (4, 14, 15, 16), power was >0.95 for question 4, 14 and 15 which had kappa values of at least 0.70, while question 16 only had a power of approximately 0.60 with a kappa value of 0.65. Power was insufficient for the remaining questions with small sample sizes.

The prevalence of attributes influences the magnitude of kappa [346] and this may explain the low kappa value for the question about ORS (text message 6). Few participants said to have given ORS. Therefore, while this question had the lowest kappa value, it had a relatively high proportion of agreement. Other questions had considerably smaller numbers of participants and kappa could not be calculated for six questions.

For two ordinal questions, weighted kappa values were substantial and moderate for the question about drinking and fair for the question about feeding during diarrhoea. The latter was relatively complicated; there was inconsistency between the methods in recording the outcomes as explained in the results section. A possible explanation for the inconsistencies is that the interviewers may have recorded this incorrectly in the face-to-face interview. To more accurately describe drinking and feeding of the child, it has recently been recommended that the question about breastfeeding should be separated from other fluids and foods in all questions for diarrhoea [131].

When comparing the two groups for nominal questions, kappa values were comparable for most questions. Therefore, there did not seem to be a difference between asking the questions first face-to-face and then via text messaging and when the order was reversed. For questions with an ordinal scale, weighted kappa values were not comparable between the groups. This can be explained by the previously explained complexity of the question about drinking and feeding, high number of answer options and the small number of people answering those questions (wide 95% CIs).

The proportion of agreement was quite high for all but one question that asked about where care was sought for fever or cough (text message 20). This question had an additional question that asked “anywhere else”, which was asked until the participant could not mention any other places. Many unclear text message responses were found for this question, as participants did not specify the place clearly in the text messages, which may explain low agreement.

Amount of information

The amount of information reported was comparable for the question about number of places where care was sought for diarrhoea (text message 13). For fever and cough (text message 20), the number of places was not significantly different between face-to-face and text messaging according to Fleiss-Cohen, but it was borderline significant as to Cicchetti-Allison.

Reasons for different responses

There were a similar number of reasons for differences in responses related to the text messaging and face-to-face method. The face-to-face method is currently accepted as standard and was undertaken according to the survey guidelines. The text messaging survey was carefully developed, tested and revised. Still, for both methods was mentioned that inconsistency resulted from misunderstandings. For text messaging, some participants said to reply without care or made mistakes by accident. For the face-to-face survey, some participants said to not hear the questions clearly. These findings suggest that differences in responses were both caused by the face-to-face and text messaging methods.

7.2.2 Comparison with relevant research

Few grandparents could be included in the cross-over study, because they were often unable to text message. This may be less of a problem in other settings where elderly people are more commonly able to text message [326]. Previous mHealth-based data collection studies frequently only included younger participants [164,165,168,169,171,173,347]. While in other settings socio-economic factors may influence usage of mobile phones [312], this did not seem to be of large influence in the study setting as the costs of text messaging were very low.

The response rate was insufficient according to the minimum requirements for a household survey (minimum response rate of 90%) [67]. The previous and later text message data collection studies in Zhao County [138,159] found a lower initial response rate and completion rate than this study, which may be explained by differences in the study designs and questionnaires.

Rural residence, receiving a lower number of text messages and having to respond to a larger number of text messages negatively influenced the response rate in the study reported in this chapter. Other studies found different results. A later conducted text messaging study in Zhao County found no significant differences in infant and young child feeding behaviours between responders and non-responders of the text messaging survey [159]. Another study recently conducted in Zhao County showed that caregivers who were younger and whose children had a lower haemoglobin test value were more likely to reply to text messages [YL, personal communication]. That the health condition of participants influences the response rate was also found in a text messaging data collection study in Sweden which reported no significant differences in the baseline characteristics of high and poor compliant respondents, but that compliance was possibly influenced by low back pain symptoms [166].

The later conducted study used the same text messaging system as the study reported in this chapter [159], while in the previously conducted study in Zhao County a smartphone was used to send the text messages [138]. Manually sending text messages introduced errors, but this would not be completely resolved with an automated text message system.

A study in the United Kingdom used an automated text messaging system, but out of 2952 text messages sent in total, still 214 (7%) text messages had to be sent manually [164]. As a result of system or researcher errors, about 6% of participants were sent the wrong number of text messages (too many or too few), while for about 2% of participants there were other problems [164]. However, an automated system would be a huge benefit for researchers. Sending text messages manually was a labour intensive process as YL was continuously sending text messages 12 hours a day (from 9 am till 9 pm) during the study period (14 days). Also before and after sending text messages, she had to do additional work for the study (communicate with the field workers and preparation and checking work). A private software company was used to provide support for the text messaging system. Open-source software is an important issue for mHealth-based research in low- and middle income countries, because limited budgets would benefit from free software. However, in some circumstances private software has value too [69].

The moderate to substantial data agreement that was found was similar to another text messaging study in this setting, though the studies had different participants, questions and study designs [138]. The study reported in this chapter found that there were differences in data agreement between the data collection methods for complex questions. Trained interviewers explained complex questions to participants in the face-to-face survey. However, though a short explanation could be added to some text messages, the limited space and number of text messages did not allow for a detailed explanation. This suggested that text messaging may be more suitable for simple questions, which was also found in a later study on text messaging data collection in Zhao County [159]. Similar reasons were found for differences in responses in the previous text messaging data collection study in Zhao County [138].

Other studies showed that the accuracy of indicators related to the survey questions was low [94,130,131,348]. The questions on care-seeking are still valid as they depend on the caregivers' perception of disease [94]. Whether this perception is right was not attempted to be verified, because the focus of the study was to compare the face-to-face and text messaging survey methods. However, it has been suggested that an improvement may be to ask for care-seeking for any illness. Thereby, construction of differential diagnosis based on caregivers' reports would be avoided [130].

7.2.3 Strengths and limitations

This is the first study to use a cluster randomised cross-over design in order to assess the validity of text message data collection in a middle-income country. The study took place in one township of one county in rural China with both semi-urban and rural areas. The study was open to caregivers who had any mobile phone, as long as it could be used to text message. Mobile phone usage was high in the study setting and mobile phones were generally personal and kept by the user (as was found in Chapter 5). This allowed researchers to reach participants directly and to ensure privacy.

Recruitment of participants was challenging as only 1026 caregivers of 4170 children on the list of names could be recruited. This is further explained in Chapter 8 and Chapter 9. Many caregivers could not be found in the villages and the accuracy and completeness of the list of names was questionable. However, no information on non-coverage was collected as this was not among the objectives of the study.

The illiteracy rate was low and no problems were found with illiteracy in current and previous research in Zhao County [138,159]. However, the number of caregivers who could not participate was not collected and thus reasons for non-response could not be provided. In most cases, if only grandparents were the available caregivers they could not be included, because they were not able to text message. Of those grandparents who wanted to participate, interviewers carefully checked whether they were able to text message. Interviewers carefully checked the correctness of the numbers when recruiting participants; they asked caregivers to bring their mobile phone and called the mobile phone number they provided.

The text messaging survey was developed in cognitive interviews and tested. To increase the response rate, previous research experiences were used to send text messages at appropriate times, participants were given two days to send text messages, two reminder text messages were sent, text message costs were paid back and a ¥5 (about £0.50) mobile phone credit incentive for completing the text messaging survey was provided [138]. However, the exact effects of these measures could not be assessed in this study. Moreover, data were collected at one particular point in time and thus the study did not explore use of text messaging for longitudinal data collection.

Despite stratified randomisation, there were differences in characteristics of the participants between group 1 and group 2. This may be explained by the cluster randomised design of the study in which it was more difficult to achieve balance between groups than in an individual randomised controlled study. In general, participants in one cluster are more likely to have similar characteristics compared to participants in other clusters. Also cluster randomised studies have a smaller number of allocated units compared to individual randomised controlled trials [349]. A limitation of the analysis is that participants were analysed at an individual level and no cluster analysis was applied.

Four of the outcomes were part of six indicators for data quality [65,136]: data equivalence (similarity of the responses); amount of information; item response rate; and completion rate. Two quality indicators could not be assessed: a validity check of the data against the true values; and the absence of social desirability bias (the proportion of socially desirable answers to a question).

The kappa values were only compared when the participant in the face-to-face and text messaging interview was the same person, but this was self-reported. Therefore, it was unsure whether the participant who responded to the text messages was the same participant and whether the same person replied to all the text messages. However, it was expected that this did not happen often, because participants were asked to provide their own mobile phone number and to reply to the text messages by themselves.

There was a relatively high number (9 out of 52) of missing values for the reasons for different responses; mainly because the interviewer forgot to record the reason for this question (eight reasons). These reasons were recorded with pen-and-paper, because the comparison of text messaging and face-to-face responses could not be done with the smartphone. This is likely to have happened randomly and therefore, there is no indication that these missing reasons were different from the reported reasons. In addition, some misclassification errors may have occurred for these reasons. The reason “misunderstood questions” was non-specific and may have had an overlap with other reasons.

7.2.4 Conclusions

This study found promising usage of text messaging data collection in household surveys on care-seeking for childhood diarrhoea and pneumonia, but several challenges remain. Improving coverage and response rate is of particular importance, because text messaging surveys could be of greater value in rural remote areas due to the cost saving potential. Text messaging could facilitate data collection and potentially fill the large gaps in care-seeking behaviour of caregivers for ill children in low- and middle-income countries [89,108,115].

Structured summary of chapter

This chapter presented the results and discussion of the study addressing the second objective of this thesis. In sum:

1. The results for the six outcomes showed that:
    1) Of the 1014 participants, 65.3% (n=662) responded to text message 2 (asking about willingness to participate). Of 651 participants who were willing to participate, 54.7% (n=356) completed the text messaging survey, which was insufficient for usage in a household survey;
    2) A significantly higher proportion of participants who were not willing to participate in the text message survey were from rural areas (P=0.005). They also received a lower median number of text messages (P=0.046). A significantly higher proportion of participants who did not complete the text messaging survey had children with diarrhoea (P=0.03);
    3) A total of 7971 text messages were manually sent to participants, of which 145 text messages (1.8%) were in an incorrect format by mistake. Of 4033 responses of participants, a large proportion (33.7%) was not in the exactly requested format and had to be assessed. After assessment, most of these responses were clarified and only a small proportion (4.4%) of unclear responses had to be followed up;
    4) Overall, data were moderately to substantially equivalent between text messaging and face-to-face methods;
    5) The amount of information reported was comparable between text messaging and face-to-face methods;
    6) There were a similar number of reasons for differences in responses related to the text messaging and face-to-face method;
2. Similar to a later conducted study in Zhao County [159], the findings suggested that text messaging surveys may be more suitable for simple questions;
3. Strengths of the study included the cluster randomised cross-over study design and large number of participants. A limitation of the study was that only 1014 out of 4170 caregivers of children on the list of names could be recruited;
4. Challenges with recruiting and following up participants were addressed by the study described in Chapters 8 and 9.

8 Factors influencing participation in mHealth-based studies: study methods

Overview of chapter

Following two chapters on the study addressing the second objective of this thesis, this chapter introduces and describes the methods of a study addressing the third objective. The results of this study are presented in the following chapter (Chapter 9).

8.1 Introduction

Recruitment and retention are important issues for evaluation of mHealth-based studies. When sample size targets are not met, this can lead to an underpowered study in which differences between groups are not statistically significant. Also extending the recruitment period increases costs and introduces logistical issues. Moreover, when the number of participants who are recruited is low and loss to follow-up high, the risk of selection bias and retention bias is considerable, which limits generalizability of results [350]. Problems with recruitment and retention are common; a review of 73 randomised controlled trials reported that only 40 (55%) achieved their original recruitment target [351]. mHealth-based studies face some specific difficulties with participation [352]. Selection bias occurs when a large number of people do not use mobile phones. Furthermore, follow-up of people in mHealth-based studies has been shown to face several challenges [169]. Effective follow-up is particularly important for text messaging-based studies [186] as those studies have reported variable response rates [160-169,171-180].

Recruitment and follow-up of participants in the cross-over study was challenging. Only one in four potential participants (1014 caregivers of 4170 children on the list of names) could be recruited and only one in three participants who were included completed the text messaging survey (356 out of 1014 participants).

8.2 Objectives

This study aimed to explore factors influencing participation in mHealth-based studies. The objectives were: (i) to explore factors influencing recruitment and follow-up in the cross-over study (described in Chapter 6 and Chapter 7); and (ii) to suggest strategies that could improve recruitment and follow-up.

8.3 Methods

Overview of section

This section describes the methodological orientation and theory of the study, the study setting and sample, interviewers/data collectors, questionnaires, data collection, participants and data management and analysis of outcomes. Firstly, structured interview methods are described, followed by observation methods.

8.3.1 Methodological orientation and theory

A mixed methods approach was used, whereby observations and structured interviews were combined in one study. Data were collected around the same time shortly after the cross-over study and used to explain findings from objective 2. The observations were used to explore factors influencing recruitment and to provide recommendations for improving recruitment and follow-up. The structured interviews were used to explore factors influencing follow-up and provide recommendations for improving follow-up. Mixing the observations and structured interviews only occurred at interpretation-level.

Thematic analysis was used as described in section 4.3.8 for the open-ended questions of the structured interviews. The themes that were found had overlap with variables in the Technology Acceptance Model proposed by Davis in 1989 [353] and later modified versions of this model [354-358]. Therefore, data was organised according to variables in this model. The Technology Acceptance Model proposes that a person's acceptance of a technology is determined by its perceived usefulness and perceived ease of use. The model predicts that ease of use and usefulness will influence a person's attitude toward, intention to use and acceptance of the technology. Thus, consequent factors of perceived usefulness and ease of use are attitude, behavioural intention to use and usage [353].

In this study, perceived usefulness encompassed participants' perceptions that the survey methods enhanced the process of participation in the study and that participation had a useful outcome. Perceived ease of use was a participant's perception that the survey methods were free of effort.

Additional variables proposed in modified models are variables that influence perceived ease of use or usefulness. These variables depend on the context and include prior usage, gender [359], trust, perceived financial costs [360], culture [361] and subjective norm [358]. Subjective norm is an individual's perception of the degree to which it is important that other people approve or disapprove of behaviour.

8.3.2 Study setting and sample

Structured interviews

Participants were recruited from the cross-over study described in section 6.3.2. Interviews took place either face-to-face in the village clinic or through a telephone call. It was anticipated that there were differences in characteristics of non-responders, non-completers and completers. Therefore, these three groups of participants of the cross-over study were interviewed.

The aim was to interview 50 participants in each group. It was anticipated that 50% of the participants asked were willing to participate. Therefore, a sample of approximately 100 participants for each group was randomly selected. It was considered that participants who completed the text messaging part of the study may have been more likely to participate in the interviews. However, it was also considered that participants who did not complete the text messaging part could have been more willing to answer a phone call than respond via text messaging. Therefore, the numbers were not adjusted and a similar number of participants for each group was used.

Simple random sampling was used with SAS version 9.2 [321] to select random samples of non-responders, non-completers and completers. For the first group, a total of 125 non-responders out of 352 non-responders were randomly selected. For the second group, a total 93 non-completers out of 306 non-completers were randomly selected. For the third group, a total of 110 completers out of 356 completers were randomly selected.

Observations

Observations were made during the field work in the cross-over study.

8.3.3 Interviewers/data collectors

Structured interviews

WW and XD, the supervisors of the cross-over study, interviewed non-completers in group 2 were when they returned to the village clinic for the face-to-face interview. WW, XD, YL and QW conducted telephone interviews with completers and non-responders in both groups and non-completers in group 1, because these participants could not be interviewed face-to-face. Before the interviews took place, all interviewers were trained and practiced the interview process.

Observations

Observations were made by the supervisors of the cross-over study, WW and XD.

8.3.4 Questionnaires

Structured interviews

Three specific structured questionnaires were developed for the three different groups of participants (Appendix C Questionnaires). The questionnaire included open-ended questions about how caregivers found it to reply to text messages and which method of answering questions they preferred. Also, the questionnaire included closed questions for which participants were asked to respond with a number, such as how many text messages caregivers were willing to answer. These types of questions were considered most appropriate, because a number of factors were known from the previous parts of the study. Non-responders were asked for their views on the text messaging method and non-completers and completers for their views on the face-to-face and text messaging methods.

Observations

Observations were made about: (i) the setting of the observations; (ii) date and time; (iii) whether the loudspeaker was available and used; (iv) whether phone numbers were provided by the township hospital; (v) whether phone numbers were provided by the village doctor; (vi) whether other recruitment strategies were used; (vii) whether the village doctor was cooperative; and (viii) other observations regarding village doctors, caregivers and conditions during the field work.

8.3.5 Data collection

Structured interviews

The face-to-face interviews were conducted directly after the cross-over study. WW and XD interviewed non-completers in group 2 when they returned to the village clinic for the face-to-face interview. The telephone interviews took place in the week following completion of the field work. The interviewers called caregivers at a time convenient for them. When the phone call was unanswered, they called caregivers back up to three times. The interviewers used a pen-and-paper questionnaire to record the interview.

Observations

WW and XD wrote down their observations on paper during the field work.

8.3.6 Participants

Structured interviews

A total of 57 out of 125 non-responders could not be reached for the interview, 68 non-responders were reached and 62 non-responders were included: 55 mothers (89%) and 7 fathers (11%). Six non-responders had to be excluded: four did not want to participate and two quit before giving an answer to the first question.

A total of 35 out of 93 non-completers could not be reached for the interview and 58 non-completers who answered questions were included: 42 mothers (72%), 12 fathers (22%), 2 grandmothers (3%) and 2 grandfathers (3%). Of those 58 included non-completers, 56 finished the interview and two non-completers quit the interview before the end, but gave answers to questions.

A total of 37 out of 110 completers could not be reached for the interview and 73 completers were included: 58 mothers (80%), 13 fathers (18%), 1 grandmother (1%) and 1 grandfather (1%). Of those 73 completers, 68 finished the interview and six caregivers quit the interview before the end, but answered questions.

Observations

Participants of the cross-over study and village doctors who were involved were observed.

8.3.7 Data management and analysis of outcomes

Structured interviews

The paper interview sheets were securely kept by WW and XD. Two students transcribed the pen-and-paper forms into an Excel database and YL compared the data and completed the final database. Any discrepancies were addressed by discussing this with XD. The databases with participant information linked to their identification numbers could only be accessed by YL. All data were anonymised for analysis and reporting.

Excel version 2010 [333] was used for the analysis. The PhD candidate calculated proportions and medians (Q2) with 25 (Q1) and 75 (Q3) percentiles for the questions where the interviewers categorised the response of the caregiver and for questions where a number was asked.

For the open-ended questions, a simplified version of a thematic analysis was undertaken [317], because the structured interviews allowed less for in-depth probing. YL and WW independently read through the data several times, identified the main themes in the data and summarised the results in Mandarin. There was one important difference between the analysis of these structured interviews and the semi-structured interviews described in section 4.3.8: the structured interviews were undertaken by Chinese researchers and analysed by YL and XD in Mandarin with help of the PhD candidate. After analysing the data in Mandarin, YL and XD independently translated the themes into English. They compared the two Mandarin-English translations and discrepancies were solved by consulting WW. The bilingual translator translated the final English translation back into Mandarin. Then YL compared them with the original Mandarin concepts and discrepancies were resolved by consulting the translator and WW [323]. The PhD candidate structured the themes according to the Technology Acceptance Model in discussion with YL and wrote the narrative of the open-ended questions.

Observations

The paper interview sheets were securely kept and WW and XD transcribed the pen-and-paper form in an Excel database, compared their findings and completed the final database. After the field work, WW and XD discussed their observations with the PhD candidate who wrote a narrative of the observations.

Structured summary of chapter

This chapter introduced and described the methods of a study addressing the third objective of this thesis. In sum:

1. Structured interviews with caregivers and researchers' observations took place concurrently. Researchers' observations were used to explore factors influencing recruitment and provide recommendations for improving recruitment and follow-up. Structured interviews with caregivers were used to explore factors influencing follow-up and provide recommendations for improving follow-up;
2. The sample for the structured interviews consisted of participants of the cross-over study and observations took place during the cross-over study;
3. WW, XD, YL and QW conducted the structured interviews. WW and XD made observations;
4. Three specific structured questionnaires were developed for non-responders, non-completers and completers. Observations were made about different aspects of recruitment of caregivers for the cross-over study;
5. Face-to-face and telephone interviews were conducted shortly after the cross-over study. Observations were written down on paper during the field work;
6. A total of 62 completers, 58 non-completers and 73 non-responders participated in the structured interviews. Participants of the cross-over study and village doctors who were involved were observed;
7. For the structured interviews, simple descriptive analysis was undertaken for the closed questions, while a simplified version of a thematic analysis was undertaken for the open-ended questions. WW and XD discussed their observations with the PhD candidate who wrote a narrative of the observations.

9 Factors influencing participation in mHealth-based studies: study results and discussion

Overview of chapter

After introducing and describing the methods of a study addressing the third objective of this thesis in Chapter 8, the current chapter presents the results and discussion of this study.

Photograph 29 Children playing outside a nursery in Zhao County

Photograph courtesy of WW, personal collection

9.1 Results

Overview of section

First, factors influencing recruitment and recommendations for ways to improve the recruitment of caregivers are reported. Second, factors influencing follow-up and recommendations for improving follow-up are reported.

9.1.1 Factors influencing recruitment

Table 29 shows an overview of themes and related factors influencing the recruitment of caregivers that were found based on the researchers' views. The detailed observations are presented in Table 62-64 in Appendix H Additional tables for researchers' observations. In the following sections, a detailed description is provided of factors related to: (i) organisation; (ii) village doctors; and (iii) caregivers.

Firstly, in general there were no problems with reaching villages, but road problems did not allow the researchers to visit one village for the second recruitment round in group 1. Village doctors did not have their own lists of names, so researchers relied on the list of names from the township hospital. The township's list of names was inaccurate, because children on the list did not always seem to live in the specified villages and children were found who were not on the list of names for that village. The township hospital provided phone numbers of caregivers for a number of villages. Also some village doctors had phone numbers of caregivers they knew. However, it was common that there were mistakes in the phone numbers due to wrong recording, or phone numbers were no longer in use. Many of these phone numbers were incomplete (numbers were replaced by *), because the township hospital could not provide the complete numbers. Available complete numbers were mainly mobile phone numbers, but several landline telephone numbers were also found. However, most of the landline telephone numbers were invalid. People preferred to use a mobile phone and therefore did not pay the fee for the telephone, which resulted in the line being shut off. Some village doctors also made phone calls to caregivers and researchers called caregivers when village doctors were unable to do this. Only few village doctors visited caregivers' houses, because this was time-consuming and they did not always knew where caregivers lived.

Some villages had no loudspeakers. Villages that had a loudspeaker either had a private loudspeaker which had to be paid for, or a free loudspeaker. When loudspeakers were available, most village doctors used them. For a number of village doctors, this was the only way they tried to recruit caregivers. Some village doctors read the names of caregiver on the list of names one-by-one when making the announcement. The ability of the loudspeaker to make a clear announcement differed hugely per village; some loudspeakers did not work well, while others could reach the whole village. Also the effectiveness of the speaker in recruiting caregivers differed per village. In some villages, after making the announcement only one or two caregivers came to the village clinic, while in other villages many caregivers came. When parents did not hear the announcement, others told them, or grandparents came.

Other recruitment methods included asking caregivers to notify others and going to the street and to places where caregivers often came. The effectiveness of the different strategies depended on the specific context of the village.

Secondly, most village doctors were available to help with gathering caregivers. However, when they were unhelpful this often resulted in only finding a small number of caregivers. Village doctors' cooperativeness depended on: their understanding of the study; whether their normal work interfered with the study; experiences with recruiting caregivers; and the financial incentive. Village doctors did not always understand the aim of the research well and sometimes found it not useful. It seemed that the township hospital doctors' explanation of the research was insufficient to inform village doctors well.

At the time of the study (March 2013), village doctors were not busy and mainly worked in the morning and evening. Village doctors did not experience delays in their normal work, but during busy times in the year, they would not participate when the study interfered with their work. Village doctors' work included treating patients and selling medicines. However, researchers found that village doctors also did other work to increase their income. Some village doctors had their own village clinic, while others shared their clinic with other village doctors.

Some village doctors had previous experiences with recruiting caregivers for vaccination. Also researchers knew some village doctors who had participated in previous studies. Some village doctors minded about the compensation that was provided for their time. For example, one village doctor in a large village was able to recruit about 70 participants during the first recruitment visit and was the only village doctor who received more than the standard incentive of ¥50 (about £5). The supervisor only had a note of ¥100 (about £10) and told the village doctor that ¥70 (about £7) was paid and asked for change. However, the village doctor said they deserved ¥100 for the work and did not return the ¥30 (about £3) change. For the second visit, increasing the incentive to ¥10 (about £1) for every four participants recruited by village doctors did not result in recruitment of significantly more caregivers. Only the village doctor who recruited about 70 caregivers during the first visit (village 42) was able to recruit a considerable number of participants and again wanted ¥100 for the work.

Thirdly, many parents were not home during the time that the villages were visited (during the day), while grandparents were often home and took care of children. Many caregivers were out of the home during the day and worked all days of the week. Parents who were working in a city in another county or province were often away for weeks or months. It was more common that parents were not at home in downtown villages than in rural villages.

As many village doctors did not have a good understanding of the study, they did not seem to explain the study well to caregivers when they asked them to come to the village clinic. Caregivers did not always understand why they had to come and did not find it useful when their child was well. However, while some caregivers did not understand the study well, most gave the impression of a good understanding.

As previously mentioned, parents could usually text message, but grandparents often could not. Grandparents sometimes said *“I am taking care of the child, why don't you ask me?”*. Grandparents’ text messaging skills were tested to ensure that only grandparents were included who could use text messages. Sometimes grandparents tried asking others to help them with replying so that they could participate and receive the towel. When it was not sure whether grandparents could use text messages, the interviewers asked them again and carefully watched them typing the text message.

Caregivers found it difficult to trust the researchers, because caregivers were concerned about being misinformed or deluded. Sensitive questions about income and expenses were perceived to be useless and caregivers did not understand why these had to be asked, because the study was about child health. When caregivers asked interviewers about the purpose of some questions, they explained the reason for asking those questions. In general, most caregivers were able to understand interviewers' questions, were likely to tell the truth and keen to talk to the interviewers about their child. On rare occasions, the interviewers could judge from the way a caregiver acted in the interview that the caregiver untruthfully answered the questions. Sometimes grandparents had difficulty with understanding the survey questions, because their education was generally lower than parents' education.

Researchers noticed that while a small number of caregivers only participated for the towel, most did not, though they appreciated the reward. Grandparents often liked to receive the towel for participation. A number of caregivers seemed interested in health information. The aim of the study was not to provide health information, but the infant feeding calendar that was given may have encouraged some caregivers to come to the village clinic. However, it was found to be less useful, because the calendar was from the previous year.

Table 29 Factors influencing recruitment of caregivers

Category	Factors
Organisation	Reachability of villages Time of recruitment Availability and accuracy of the lists of names and mobile phone numbers Availability of villages' loudspeaker Ability to call caregivers Opportunity to visit caregivers' houses Use of other recruitment methods
Village doctors' cooperativeness	Interference with work Understanding of study Experience with recruiting caregivers Money incentive
Caregivers' cooperativeness	Interference with work Understanding of study Ability to text message Trust Perspective on sensitive questions Incentives

9.1.2 Approaches that could improve recruitment

To improve organisation, recruitment strategies should be tailored to the specific context of villages. More caregivers could be recruited when the list of names and phone numbers were given in advance. Going to the villages early in the morning and in the evening may be a good strategy. However, village doctors' and interviewers' working hours would have to be taken in consideration. Continuing to use the village's loudspeakers, make phone calls and send text messages to caregivers would be an appropriate approach.

To improve village doctors' cooperativeness, more efforts should be made to inform village doctors well by developing and testing specific information material. Village doctors should be contacted further in advance to see whether they are busy. Use of monetary incentives could be continued in the Chinese study context, because it seemed to motivate village doctors.

To improve caregiver's cooperativeness, new information materials for caregivers should be developed and tested to address factors that negatively influenced recruitment. Sensitive questions may have to be considered for omission from the survey. Providing health information via text messaging may be used to increase caregiver's interest in participating.

9.1.3 Factors influencing follow-up

This section reports on views from: (i) non-responders; (ii) non-completers; and (iii) completers.

Non-responders

Table 30 shows the quantitative results of non-responders. Out of the total of 62 non-responders who were interviewed, 43 (68%) recalled that they had received a text message. Of those 43 non-responders, 27 (63%) said they had received a reminder text message. A total of 31 non-responders did not know, or were not sure whether they received a text message or reminder text message and were asked for the main reason. The most frequently mentioned reason was "*do not know*" (10; 32%), a broken mobile phone (4; 13%), or not checking the mobile phone (4; 13%). The main reasons of the 43 participants for not replying to text messages were: did not have time (13; 30%); did not bring the mobile phone (7; 16%); or mobile phone was switched off (6; 15%).

Table 30 Non-responders' experiences with the text messaging survey and reasons for not responding (N=62)

	n (%)
Received text message? (N=62)	
Yes	43 (69)
No	11 (18)
Do not know	8 (13)
Received reminder? (n=43; "yes" for "received text message?")	
Yes	27 (63)
No	7 (16)
Do not know	5 (12)
Missing (interviewer forgot to ask)	4 (9)
Reasons for not receiving text message (n=31; "no" or "do not know" for received text message or reminder)	
Do not know (not related to their mobile phone)	10 (32)
Broken mobile phone	4 (13)
Did not check mobile phone	4 (13)
Software to block messages	3 (10)
Forgot what happened	3 (10)
Did not bring mobile phone	1 (3)
Text message box was full	1 (3)
Child played with mobile phone	1 (3)
Father used mobile phone	1 (3)
Missing (interviewer forgot to ask)	3 (10)
Reasons for not responding to text message question (n=43)	
Did not have time	13 (30)
Did not bring the mobile phone	7 (16)
Mobile phone switched off	6 (15)
Did not know how to reply	5 (12)
Did not trust the text message	3 (7)
Did not see the text message	3 (7)
Did not have enough credit	3 (7)
Forgot to reply	1 (2)
Child deleted text message	1 (2)
Did not receive a new text message	1 (2)

Table 31 presents qualitative findings relating to the positive and negative views of non-responders on factors influencing follow-up of the text messaging survey. Factors that only had negative views were as follows: mobile phone usage; ability to use the mobile phone; problems with the mobile phone; checking the mobile phone; available time; subjective norm; being in the "sitting month"; trust; perceived usefulness of process; and attitude. There were both positive and negative views on perceived usefulness of outcome and ease of use. There were only positive views for actual use; it was mentioned that a respondent had replied, but it was too late to reply or a follow-up text message might not have been sent by mistake.

The previously mentioned reasons for not receiving the text message or not responding were also mentioned when asking further in-depth. While participants were selected based on their ability to text message, some said they could not reply to text messages. Additionally, non-responders said not to send text messages very often. Many reasons for not responding were related to having problems with the mobile phone or not checking the mobile phone. Some non-responders were too busy to respond, especially when the child was naughty. A mother said that the father did not let her reply or that he used her mobile phone.

Trust was a frequently mentioned issue; the text messages were not trusted when the phone number was unusual or when irrelevant questions were asked in the face-to-face interview.

Text messaging was perceived as not useful, because no questions could be asked and it took a lot of time to reply. The usefulness of the outcome of the study was perceived to be important and good for child health. However, some perceived the study as not important when the aim of the study was not well understood. Not many views were related to perceived ease of use.

Non-responders' attitudes included not wanting to use the text message function for surveys and that it was less good than a face-to-face interview or phone call interview. Positive was that some non-responders had the intention to reply when they saw the text message and had time.

Table 31 Non-responders' positive and negative views on text messaging survey

Factors	Positive	Negative
Mobile phone usage		Do not send text messages very often Not used to sending text messages Do not have the habit of replying to text messages
Ability to use mobile phone		Cannot use mobile phone very well Cannot reply to text messages
Problems with mobile phone		Mobile phone was broken Did not have battery Did not have mobile phone credit Mobile phone signal was bad Text message box full Sending the text message failed Software to block text messages Child deleted text message, could not find it

Checking mobile phone		Did not check the mobile phone Did not pay attention Was asleep when receiving text message Was too late when saw text message Did not see the text message Did not bring the mobile phone Did not have a ringtone for text message
Available time		Busy, did not have time Child was very naughty Had something to do at that time
Subjective norm		The child's father did not let mother reply Child was playing with mobile phone and father was not at home Child's father used mobile phone
Culture		In "sitting month"[*]
Trust		Did not trust it Did not trust it; there were irrelevant questions in the face-to-face interview Thought that the phone number should be from Beijing, but text message said "Zhao County Maternal and Child Health Hospital"[†] Phone number was too long Thought it was a "trash" text message Worried about charging fees for text messaging
Perceived usefulness of process		A limitation of the method is that no questions can be asked It said to send reminders about raising a child, but these were not send to me It took a lot of time to reply The face-to-face and text message questions were the same
Perceived usefulness of outcome	It is important It is very good Good for child's health Want to make contribution to society	Did not think it was important, because the child did not have the condition that was asked Did not know why text messages had to be sent Did not understand why diarrhoea and pneumonia Did not matter whether reply was given or not Could not benefit from it directly
Perceived ease of use	Can talk in detail Can understand text messages	It was too much effort to reply Forgot to reply
Attitude		It is inferior to face-to-face or making phone calls Do not want to use text message function for surveys
Behavioural intention to use	Will reply when I see it Will reply if I have time	Did not really want to participate, but cannot say the reason clearly
Actual use	Did reply to text message Replied, but it was late	

[*]In Chinese culture, "sitting month" in brief or "zuoyuezi", literally means "sitting the first month after delivery" and restricts women from going out of their home or receiving visits from others, see section 3.2.6.
[†]Researchers had explained to caregivers that they were from the Capital Institute of Pediatrics in Beijing.

Non-completers

Table 32 presents quantitative data on non-completers' views on the surveys. All 58 non-completers recalled having replied to a text message that they received (100%). A total of 36 non-completers (62%) said they had received a reminder message. The most frequently mentioned reasons for not replying were that non-completers replied, but did not receive a new message (34; 59%), did not have time (10; 17%), or forgot to reply (7; 12%).

Table 32 Non-completers' experiences with and views on surveys (N=58)

	n (%)
Received text message?	
Yes	58 (100)
No	0 (0)
Received text message reminder?	
Yes	36 (62)
No	16 (28)
Not known	5 (9)
Missing (interviewer forgot to ask)	1 (1)
Reasons for not responding to the text message question	
Did not receive a new text message	34 (59)
Did not have time	10 (17)
Forgot to reply	7 (12)
Did not have enough credit	3 (5)
Time reading text message was too late	2 (3)
Did not bring the phone	1 (2)
Concerned about privacy	1 (2)
Views on receiving ¥1 for text message costs	
Was enough	36 (62)
Was not enough	2 (3)
Did not mind	18 (32)
Missing (participant quit)	2 (3)
Preferred study incentive	
Health information	42 (72)
¥5 mobile phone credit	6 (10)
Towel (worth ¥5)	4 (7)
No preference	4 (7)
Missing (participant quit)	2 (4)
Preferred survey method	
Face-to-face	23 (40)
Text messaging	18 (31)
No preference	17 (29)

Qualitative data is presented in Table 33 on the face-to-face and text messaging survey and in Table 34 on study incentives. The following factors had only negative views: mobile phone usage; ability to use mobile phone; problems with mobile phone; available time; and trust. There were both positive and negative views on: checking the mobile phone; study incentives; perceived usefulness of process; perceived usefulness of outcome; perceived ease of use; and attitude. There were only positive views on paying back text message costs and actual use.

Non-completers were sometimes not used to the mobile phone or not used to sending text messages. In addition, they experienced some problems with their mobile phone. They did not always check their mobile phone, but could reply when they brought their mobile phone in their pocket. Both for the face-to-face and text messaging survey there were non-completers who said that they did not have time.

Paying back ¥1 (about £0.10) for the text messages was enough for 36 out of 58 non-completers (62%). Non-completers said that paying back the text message costs was good, but also mentioned not minding about the money, because it was for the child's sake and honest. However, more money was found to be better and if there were more questions, ¥1 would not be enough.

As incentive, 42 out of 58 participants liked to receive health information (72%). Health information was found to be useful and important, because it could be used for a long time and there was a need for more information. In addition, health information was harder to obtain than the towel that was given for the face-to-face interview or the ¥5 (about £0.50) mobile phone credit (which was promised to be given if non-completers responded to all text message questions). However, some non-completers also mentioned that they would not have minded if they had not received any incentives, explaining that they did not need them.

Non-completers found it hard to trust the text messages and concerns about privacy were raised, because sensitive questions had been asked about income and expenditure in the face-to-face survey. Some non-completers only wanted to reply to questions about the child.

There were many comments related to perceived usefulness and ease of use. The face-to-face survey was perceived to be more useful than the text messaging survey, because questions could only be asked during the face-to-face interview. Both methods were found to be time-consuming. However, a perceived benefit for the text messaging method was being able to respond at a self-chosen time.

While some did not know what the aim of the text messaging survey was, others perceived the aim to be OK or good. It was found to be too much effort to participate in the face-to-face survey, because it required going out.

There were some contradictory views on ease of use. For example, replying via text messaging was found to be both not much effort and too much effort, both easy and hard, and both convenient and inconvenient. The questions were found to be clear and detailed for both methods, but text message questions were also found to be unclear and mistakes were likely to happen via text messaging.

Out of the 58 non-completers, 23 (40%) preferred the face-to-face survey method and 18 (31%) the text messaging method. When asked in-depth, many non-completers expressed to have no preference and that the methods were equally OK. However, non-completers also said that there were too many text messages.

Table 33 Non-completers' positive and negative views on face-to-face and text messaging survey

Factors	Face-to-face survey Positive	 Negative	Text messaging survey Positive	 Negative	Other
Mobile phone usage	-	-		Not used to mobile phones Not used to sending a lot of text messages Used to making phone calls	
Ability to use mobile phone	-	-		Mobile phone was not easy to use	
Problems with mobile phone	-	-		Mobile phone did not function well Did not have credit	
Checking mobile phone	-	-	Took the mobile phone with me	Did not check mobile phone	
Available time		Did not have time for interview		Did not have time; busy, taking care of the child Could not reply in a timely manner	
Paying back text message costs			The amount of money was OK Good to be paid back		Do not mind about money It would be OK even without; it was for the child, it was honest Did not matter; did not have time If there were more questions, it would not be enough The more the better
Study incentive (see Table 34)					
Trust		Asked sensitive questions face-to-face		It was hard to trust text messages	Only wanted to reply to questions about the child
Perceived usefulness of process	Useful because could get information from interviewers			Not useful; could not get information It is too late, afraid the survey ended, think it is not useful to reply	

		Time-consuming to participate		Time-consuming to reply	
			Faster to reply	Slow to reply	
		Could not participate in own time	Could reply in own time		
			Could reply when nothing else to do		
Perceived usefulness of outcome			Aim of survey was OK, or good	Did not know the aim of survey	
			It was for the child's sake	Not useful; child was not ill	
				Only asked question, did not tell how to prevent diseases	
Perceived ease of use		Too much effort to participate, have to go out	Not too much effort	Too much effort to reply	
		Not easy to conduct for researchers	Did not have difficulties, easy to reply	Hard to reply	
				Very likely to make a mistake with a mobile phone	
	Convenient to participate		Convenient to reply	Inconvenient to reply	
				Sending time was not appropriate, was sleeping	
				Will not reply if forget	
				Text messaging scares the child	
	Questions are clear		Questions are clear	Questions are not clear	Questions were the same
	Detailed questions		Detailed questions		
Attitude				Too many text messages	Not so many questions for text messaging, many questions in face-to-face survey
					No preference, methods are equally OK
					Methods are almost the same
Actual use			Did reply to text message		

Table 34 Non-completers' positive and negative views on study incentives

Towel		¥5 mobile phone credit		Health information		
Positive	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**	**Other**
Useful	Less useful	More useful	Small amount of credit, was useless	Useful	Will ask village doctor for health problem	Is OK if it is caring about the child, or beneficial
Practical	Can only use the towel once	More practical	Afraid to not receive credit	Cannot get health information		Did not lack these things
Use more towels with a child	Can buy towels	Inconvenient to buy credit in village	Can buy credit	Can use health information for a long time		All the same
	Did not like colour of towel	Use credit more		Health information text messages do not need reply		Will cooperate, no matter what the gift is
	Not worth a lot			On paper is convenient		Do not mind about gift
				You researchers know more than caregivers		
				Important		
				Need to know		

Completers

Table 35 presents the quantitative results of completers. Qualitative data is presented in Table 36 on the face-to-face and text messaging survey and in Table 37 on study incentives.

The following factors had only negative views: mobile phone usage; ability to use the mobile phone; and checking the mobile phone. There were both positive and negative comments for available time, study incentives, trust, perceived usefulness of process, perceived usefulness of outcome, perceived ease of use and attitude. There were only positive views on problems with the mobile phone and paying back text message costs.

Although completers replied to all text message questions, limited usage and ability to use text messages were seen as hindering factors when responding to text messages. Completers did not mention problems and had enough mobile phone credit to respond. Completers were not able to reply immediately when they did not see the text message. Both for the face-to-face and text messaging survey there were completers who said they did not have time for the interviews.

It was hard to trust the text messages, because there were a lot of text messages that were perceived as deceiving and thus no reply was given to a strange number. However, having first face-to-face contact encouraged completers to reply and honest replies were given.

A total of 63 out of 73 completers (86%) found being paid back ¥1 (about £0.10) for their text message costs to be enough. This was also found to be good and practical. Some said that they did not have to send so many text messages and that sending text messages did not cost a lot.

The incentive of ¥5 (about £0.50) was found to be enough by 60 completers (82%) and this was the preferred incentive for 35 completers (48%). Most comments about incentives were related to the positive aspects of receiving ¥5 credit; some said that they did not expect the credit and that it was a nice surprise. Also, credit was found to be convenient, because it was not easy to buy the credit in the villages. However, some felt the amount was too much and that their effort did not justify receiving ¥5. Negative comments included that it was felt that the survey might have other purposes when ¥5 was given.

Only 16 completers (22%) preferred health information. Health information was valued, because it was important and needed. However, the received calendar with infant feeding information was from last year (2012) and hence less useful. Some completers said that the child liked the towel that they received for the face-to-face interview, while others found it not worth much and did not want a small gift.

There were many comments related to perceived usefulness and ease of use and many of them were contradictory. Both methods were perceived to not take much time, but also to be time-consuming. For the text messaging method, it was valued that a reply could be given at a self-chosen time and without having to be in a certain place. However, the text messaging survey was found to be less useful, because no questions could be asked. Both methods were found to be convenient, but it was inconvenient to reply to text messages, especially for grandparents.

The aim of the text messaging survey was perceived as OK or good, because the child's health condition could be followed and it showed care about the child. However, it was not perceived to be useful when the child did not have the disease symptoms were asked about.

Both the face-to-face and text messaging surveys were perceived as easy, but also as too much effort. The text messages were found to be clear, detailed and understandable, but also unclear. For the face-to-face interview, feeling good was mentioned, but also feeling embarrassed. For the text messaging survey, completers said to feel at ease, but also to feel bothered.

The text message method was found to be good. Completers wanted to cooperate with researchers' work and make a contribution to society. Frequently mentioned was that all methods were OK and that completers did not have a preference. However, when completers had to choose, 35 (48%) preferred the face-to-face and 35 (48%) the text message method.

The time of receiving the text messages was acceptable for 48 participants (66%). The evening or afternoon was the most preferred time to receive text messages and 15 participants said that any time was OK (21%).

Out of the total of 73 completers who were interviewed, 26 (36%) said to have received a text message reminder and the majority of them (24; 92%) found receiving one, two or three reminders OK. Nevertheless, some completers still worried about forgetting to reply.

Most completers were willing to receive at least 3-4 or more text messages a day (63; 79%) and more than eight text message questions in total (61; 84%). However, it was also mentioned to get annoyed when receiving too many text messages. A total of 51 participants (70%) said they would be willing to complete a text messaging survey at least once a month.

Table 35 Completers' experiences with and views on surveys (N=73)

	n (%)
Received text message reminder? (N=73)	
Yes	26 (36)
No	41 (56)
Do not know	1 (1)
Missing (participant quit)	3 (4)
Missing (interviewer forgot to ask)	2 (3)
Acceptability text message reminder (n=26)	
Received 1 reminder; is OK	15 (58)
Received 2 reminders; is OK	7 (27)
Received 2 reminders; is too much	1 (4)
Received 3 reminders; is OK	2 (7)
Missing (interviewer forgot to ask)	1 (4)
Time receiving text message acceptable? (N=73)	
Yes	48 (66)
No	22 (30)
Do not know	1 (1)
Missing (participant quit)	2 (3)
Preferred time for text messaging survey (N=73)	
Morning	4 (6)
Morning or afternoon	5 (7)
Morning or evening	2 (3)
Afternoon	16 (22)
Afternoon or evening	11 (14)
Evening	17 (23)
Any time	15 (21)
Do not know	1 (1)
Missing (participant quit)	2 (3)
Views on receiving ¥1 for text message costs (N=73)	
Was enough	63 (86)
Was not enough	1 (1)
Did not mind	5 (7)
Missing (participant quit)	3 (5)
Missing (interviewer forgot to ask)	1 (1)

Views on receiving ¥5 mobile phone credit for completing text messaging survey (N=73)	
Was enough	60 (82)
Was not enough	1 (1)
Was too much	2 (3)
Did not mind	6 (9)
Do not know	1 (1)
Missing (participant quit)	3 (4)
Preferred incentive (N=73)	
¥5 mobile phone credit	35 (48)
Towel (worth ¥5)	6 (8)
Health information	16 (22)
No preference	13 (18)
Missing (participant quit)	3 (4)
Number of text message questions willing to answer on one day? (N=73)	
1-2	4 (6)
3-4	14 (19)
5-6	23 (32)
7-8	1 (1)
>8	20 (27)
All OK	5 (7)
Missing (participant quit)	6 (8)
Number of text message questions willing to answer in total? (N=73)	
3-4	1 (1)
5-6	3 (5)
7-8	1 (1)
>8	56 (77)
All OK	5 (7)
Missing (participant quit)	6 (8)
Missing (interviewer forgot to ask)	1 (1)
How often willing to respond to text messaging survey? (N=73)	
Once a month or more often	51 (70)
Once every 2 months	4 (6)
Once every 3 months	6 (8)
Once every 6 months	2 (3)
All OK	1 (1)
Do not know	3 (4)
Missing (participant quit)	6 (8)
Preferred survey method (N=73)	
Face-to-face	35 (48)
Text messaging	35 (48)
Phone call	1 (1)
No preference	2 (3)

Table 36 Completers' positive and negative views on face-to-face and text messaging survey

	Face-to-face survey		Text messaging survey		
Factors	**Positive**	**Negative**	**Positive**	**Negative**	**Other**
Mobile phone usage	-	-		Did not use text messaging very often	
Ability to use mobile phone	-	-		Not easy to communicate via text messaging	
Problems with mobile phone	-	-	Had enough credit		
Checking mobile phone	-	-		Sometimes would not reply immediately, because did not see text message	
	-	-		Afraid that I cannot receive the text messages	
	-	-		I am unsure whether I can see the text message	
Available time	Had time for interview	Did not have time for interview	Will reply in spare time	Normally do not have time Did not have time to send text messages	
Paying back text message costs	-	-	OK or good to be paid back		Did not know
	-	-	Practical		Did not mind
	-	-	Did not mind about that, but better to be paid back		
	-	-	Did not need to send many text messages, did not cost a lot, not enough if there were more text messages		
	-	-	Good that parents did not have to pay		
	-	-	Depends on the aim, it was for the child, so does not matter		
	-	-	Did not have to pay for it		
Study incentive (see Table 37)					

Trust			Gave honest replies	Text messages are hard to trust	
			Replied because you first contacted me face-to-face	There are a lot of scamming text messages	
				Could not reply as you required, afraid that replying in format results in higher costs	
				Did not reply to a strange number	
Perceived usefulness of process	Not time-consuming	Time-consuming	Faster than face-to-face interview	Took a long time to reply	
	Could ask questions directly			Inconvenient for me to ask questions	You can easily ask questions in phone calls
			Saves time		Phone calls save time
			Saves time, could continue work	Could not reply at work	Phone calls take a long time
			Could reply in own time when not busy		
	Convenient		Convenient to reply	Inconvenient to reply	Phone calls are convenient
		Had to be at the clinic at a set time	Did not have to be at a particular place	Inconvenient for grandparents to reply	
			Did not need to go out	Inconvenient to reply when taking care of child	
			No time limit for replying to text messages		
	More detailed		Questions were detailed	Text messages were not detailed	
			You can get specific information; you asked a lot of questions	It was too simple, you only asked a few questions	
Perceived usefulness of outcome			Aim of survey was OK, good, or very good	Aim of your work was not so useful	You asked the same questions face-to-face and via text messaging
			You cared about the child		
			You could follow the child's health condition	Child did not have symptoms you asked	Worth replying if I can ask questions
			You could understand my child's health condition immediately		
			It made me conscious about my child's health condition		

Perceived ease of use	Easy	Too much effort	Simple	Too much effort	
				Will not always reply	
				It was easy to forget to reply	
			Good to have a long interval between text messages	Text message software was slow, too long interval between text messages	You could explain things in phone calls
			Did not need to talk	When having questions, will not ask	
	Clear		Text messages were clear	Text messages were not clear	Phone calls were clear
			Could understand the text messages	Not easy to understand the text messages	
			Content of text messages was good/questions were good	Did not understand the question	
	Felt good because it was intimate	Felt embarrassed	Felt at ease	Bothering	
			Easy to recall	Some of the text messages were repeated	
			Had time to think about it	There are things that you cannot say in text messages (complicated things)	
			Better to read than listen	Will be distracted when sending text messages	
Attitude			Text messaging method was good	Text messaging was less good than making phone calls	All methods are OK
			Way to do it was good	Text messages were too frequent	Like both methods
			Want to cooperate with your work	Got annoyed when receiving many text messages	Both methods have their own benefits
			Wanted to make contribution to society		Methods are (almost) the same, no preference
			Willing to participate		

Table 37 Completers' positive and negative views on study incentives

Towel (worth ¥5)		¥5 mobile phone credit			Health information		
Positive	**Negative**	**Positive**	**Negative**	**Other**	**Positive**	**Negative**	**Other**
		It was OK, or good		It depends, it is hard to say	Need health information		All of them were OK
		Nice gift, shows that you are kind	Made me feel that it had other bad purposes	Does not matter, would have replied anyway	Hope to know more about child health		
Child liked the gift		Nice surprise		It was for the child	Child health is important		It was OK to get it or not, if it was for the child
							Wanted the child to be happy
Useful		Useful					
		Convenient					
	Easy to get gift, not precious	Good you recharged credit, it is inconvenient to recharge					
Benefit	Worried about quality of gift	Benefit				2012 calendar was not good	
	Was not worth much	It was a lot, not necessary	Reward was not a lot	Small amount of money, did not mind			
	Did not want a small gift	Would like to reply when getting ¥5	It only paid back the credit I used	The more the better			
		It is an incentive, made it more likely that I replied					
		Good that parents did not have to pay for text messages		If there were many participants, it is a lot of money			
		Good to be paid, because it takes some of my work time to reply					
		Money for the time I spent					
		Feel that I did not do so many things					

9.1.4 Approaches that could improve follow-up

Table 38 presents recommendations from participants and researchers that could improve follow-up. Non-completers provided more recommendations than non-responders and responders and wanted the aim of the study to be clearer. Increasing trust was another important recommendation, which could be done by using a familiar mobile phone number and mentioning the Capital Institute of Pediatrics. Participants wanted to receive health information.

A number of participants said to not know what could be changed to improve follow-up. This was just the situation in rural areas in China, by which it was meant that now more parents had to go to work and grandparents then took care of the child. It would be better to do the research at a place where more parents took care of the child. There were no good solutions for changing the text messaging survey, because caregivers could not take the mobile phone with them all the time or would forget to bring it, some parents and many grandparents could not text message and the text messaging method depends on the initiative of caregivers.

Table 38 Participants' and researchers' recommendations for improving follow-up

Participants' recommendations		Researcher's recommendations
Non-responders	Explain purpose more clearly	Develop and test new information materials
	Should pay attention to hand, foot, mouth disease*	Explore sending participants health information that corresponded to their interests
	Using a normal mobile phone number to send text messages	Was technically not feasible; instead informing participants about the phone number
	Should mention "Capital Institute of Pediatrics" in text message	Feasible
	Send text message at an appropriate time	Explore giving participants the option of choosing a time of their convenience at which text messages are sent
	It is convenient to make phone calls	Not feasible, too time-consuming and costly
	Do not know/ Do not have comments	-
Non-completers	Explain the aim more clearly	Develop and test new information materials
	Inform in different ways, village doctors, advertisement and so on	Explore different ways of informing caregivers
	Increase trust: use a familiar number, sending a greeting, providing consultation	Explore these ways to increase trust
	Need to tell what to do with symptoms	Explore sending text messaging with health information of interest
	Send feedback	Explore sending text messages with feedback
	Pay for text messages immediately	Was technically not feasible; explore having a free text message number
	Send text messages at an appropriate time	Explore giving participants the option of choosing a time of their convenience when text messages are sent
	Hope (the investigator) can send text messages quicker	Was technically not feasible; explore option with automated text messaging system
	Send all questions in one text message Should not be so many text messages	Not feasible, does not fit in one text message and sending all text messages simultaneously was also not possible because questions depended on answers
	Send more text message reminders Send fewer text message reminders	Explore giving participants the option of choosing how many reminders are sent
	Using text messaging for follow-up study	Good strategy
	Ask questions by making phone calls	Not feasible, too time-consuming and costly
	Not so much needs to be changed	-
	Do not know	-
Completers	Focus on more common diseases	Explore sending text messaging with health information of interest
	Hope you can give consultation about child's health Need feedback for the text messages sent	Explore sending text messages with feedback
	Do not have comments	-

*Infectious child disease, usually caused by Coxsackie virus. Symptoms are blisters at hands, feet and mouth and fever.

9.2 Discussion

Overview of section

This section describes the principal findings, comparison with previous research, strengths and limitations and conclusions of this chapter. Areas for further research are described in the overall discussion of this thesis in Chapter 11.

9.2.1 Principal findings

Recruitment

Based on the researchers' experiences, several factors influencing recruitment were found and recommendations for ways to recruit more caregivers were made.

Factors influencing recruitment

There were a large number of factors influencing recruitment, related to organisation, village doctors' cooperativeness and caregivers' cooperativeness (Table 29), such as availability of lists of names, mobile phone numbers and loudspeakers, understanding of the study, incentives and interference with work.

Recommendations to improve recruitment

A number of recommendations were made to improve recruitment, of which a number were specific to the study setting in Zhao County. Some generic lessons can be learnt. To improve organisation, recruitment strategies should be tailored to the specific context where caregivers are recruited. To improve village doctors' and caregivers' cooperativeness, more efforts should be made to inform them well by developing and testing information materials.

Follow-up

Based on the interviews with participants' experiences several factors influencing follow-up were found. Recommendations to improve follow-up were made based on participants' and researchers' views.

Factors influencing follow-up

The main reasons non-responders gave for not replying to text messages were: not having time, not bringing the mobile phone, or the mobile phone was switched off. Non-completers' reasons for not replying were to have replied, but not have received a new message, not having time or forgetting to reply.

There were mainly negative views on factors influencing follow-up related to mobile phone usage, ability to use the mobile phone, problems with the mobile phone, checking the mobile phone, available time, trust and culture. Non-responders seemed to have more problems with their mobile phone and with checking their mobile phone than non-completers and completers. Some factors, such as not having time, also applied for the face-to-face survey. The text messages were not trusted when the phone number was unusual or when irrelevant/sensitive questions (about income and expenditure) were asked in the face-to-face interview. Non-responders only had negative views on the perceived usefulness of the process, while non-completers and completers also had positive views. All had both positive and negative views on the perceived usefulness of the outcome and perceived ease of use.

Those who received payments for their text message costs (non-completers and completers) perceived this as positive and had varying views on the incentives. Non-completers seemed to have been keener to participate when health information was provided, while completers seemed happy with the ¥5 (about £0.50) reward for completing the survey (which non-completers did not receive).

A large proportion of completers were willing to receive at least 3-4 or more text messages a day (79%) and more than eight text message questions in total (84%). However, annoyance with receiving too many text messages was also mentioned. In addition, many completers (70%) said they would be willing to complete a text messaging survey at least once a month.

Recommendations for improving follow-up

Recommendations to improve follow-up were various and included the following: sending health information and feedback text messages; exploring ways to increase trust; and tailoring the text messaging survey to participants' preferences so that text messages could be sent at preferred times.

9.2.2 Comparison with relevant research

A systematic review of 45 randomised controlled trials that used activities to improve recruitment identified a number of strategies and found that promising strategies included telephone reminders and financial incentives, but for many of these strategies the evidence was too inconclusive to make recommendations. However, some strategies identified in other research could be further explored such as those for obtaining consent (such as the interviewer reading out the form), approaching participants (such as video delivery, telephone call reminders, text message reminders) and training for recruiters [362].

Although the Technology Acceptance Model stems from business research and was not specifically developed for the health care context, it has been used by a large number of studies for health care and is increasingly seen as fitting [363]. The model has mainly been used for predicting and explaining health workers’ acceptance and use of health care information technology [364,365], but has also shown predictive value for peoples’ adoption of health care information technology [366-368]. The model predicts a substantial portion of the use or acceptance of health care information technology, but may benefit from several additions and modifications. It has been recommended to further contextualise the Technology Acceptance Model to health care, which can uncover the specific meaning of generic variables [363]. A number of mHealth-based studies have used the Technology Acceptance Model [364,366,367].

Trust was an important factor influencing the response rate, which has been previously reported [177,355]. In this study, having face-to-face contact with caregivers before beginning the text message survey seemed to be beneficial for increasing caregivers’ trust, but this remained hard as participants mentioned not trusting the text messages in the survey. Similar to the results presented in Chapter 5 of this thesis, it was found that receiving scam text messages was a reason to not trust the text messages.

Similar to the findings in this study, previous research found that text messaging was more likely to work when there was follow-up, the text message was personally tailored and the content and frequency were highly relevant [186]. Negatively influencing the response rate was using a foreign phone number [177] and including questions of a sensitive nature [369]. Participants in the study described in this chapter did not appreciate sensitive questions about income and expenses, in both the face-to-face and text messaging survey. This was also shown in the survey reported for objective 1 of this thesis, which found that more than 60% of caregivers did not provide information on income and expenses.

Researchers have successfully followed participants up in mHealth-based data collection studies by having face-to-face contact, sending text message reminders, making phone calls and sending letters [164,166,173,177]. Phone calls were made and text messages sent to participants in group 2 to ask them to go to the village clinic for the face-to-face interview and achieved a high return of participants (87%). Two text message reminders were sent and participants seemed to find this acceptable. Some participants perceived the text messages a reminder for their child health and a similar finding was reported by a Kenyan study that found that data collection text message served as medication reminders [169].

Moreover, the literature on retention of participants in cohort studies [370] and postal surveys or electronic (email/online) surveys [369] and telephone surveys [135] has identified several strategies that could be beneficial to improve the response rate. Also studies have shown why and how the use of incentives for increasing the response rate and quality of responses in surveys [371]. A study on text message data collection conducted after the field work of this thesis evaluated the effectiveness of three interventions to increase the response rate. This study showed that three interventions – providing feedback, giving mobile phone credit as a reward and prolonging the time of text messaging survey – were effective in increasing the response rate of text messaging data collection in Zhao County. However, sending text messages during a second day contributed marginally to the response rate. In addition, other study related factors, such as a complementary food recipe booklet, the food blender, and face-to-face group counselling on anaemia and feeding, may have generated trust and thereby increased the response rate [YL, personal communication].

9.2.3 Strengths and limitations

This study provides insights into the factors influencing participation as provided by evaluating views from participants of the cross-over study and observations made by researchers. The study was exploratory and only provided insights into factors that influenced recruitment and follow-up. While a strength of the study was that the evaluation took place during a real study, a limitation was that the effects of strategies used to improve recruitment and follow-up were not assessed.

While the Technology Acceptance Model was used to categorise the themes, it was not incorporated in the interview guide [365], nor were the actual scales that are specific about task performance used.

Despite random selection, there were no grandmothers or grandfathers and in the sample of non-responders. Therefore, views of those participants mainly represent parents' views.

For practical reasons, a combination of face-to-face and telephone interviewers were used to interview participants of the cross-over study. Telephone interviews have their own benefits and shortcomings. It was possible to interview a relatively large number of participants in a short amount of time without having to revisit all the villages, which practically would have been very difficult. Nevertheless, multiple methods of communication that are used in face-to-face interviews (body language and other visual cues) could not be used to interpret and communicate with the participants in telephone interviews [372,373]. In addition, interviews were not audio taped and relied on written responses of the interviewers. However, differences in recording were minimised through training of interviewers.

To ensure that the interpretation of the meaning of the data was correct, data were collected and analysed in Mandarin, the main findings were translated into English, and the English main findings were translated back into Mandarin, compared this with the original data and disagreements were resolved. In addition, several discussions took place in the research team to confirm validity of findings.

9.2.4 Conclusions

The lessons learned in this study emphasise the importance of assessing recruitment and follow-up in mHealth-based studies in a new setting. More work is needed to evaluate the suggested strategies and assess their effectiveness. This work would be valuable as there is currently limited information available that can guide sample size calculations for mHealth-based studies. Knowing more about recruitment and retention of participants in mHealth-based studies would be an important step in improving evaluation of mHealth-based interventions [186].

Structured summary of chapter

This chapter described the results and discussion of a study addressing the third objective of this thesis. In sum:

1. The findings showed that:
   1) Several factors related to organisation, village doctors and caregivers influenced recruitment, such as availability of lists of names, mobile phone numbers and loudspeakers, understanding of the study, incentives and interference with work;
   2) To improve organisation, recruitment strategies should be tailored to the specific context where caregivers are recruited. To improve village doctors' and caregivers' cooperativeness, more efforts should be made to inform them well by developing and testing specific information material;
   3) A number of factors influenced follow-up, including mobile phone usage, available time, incentives, subjective norm, culture, trust, perceived usefulness and ease of use;
   4) Recommendations to improve follow-up were various and included the following: sending health information and feedback text messages; exploring ways to increase trust; and tailoring the text messaging survey to participants' preferences so that text messages can be sent at preferred times;
2. As previously reported, trust was an important factor influencing the response rate [177,355];
3. A strength was that both perspectives from participants and researchers were provided. A limitation was that the study was exploratory and only provided insights into factors that influenced recruitment and follow-up;
4. Testing strategies that could improve recruitment and follow-up would be particularly beneficial to improve mHealth-based studies.

10 Ideas for mHealth-based data collection

Overview of chapter

Following the chapters linked to the first, second and third objective of this thesis, this chapter addresses the final fourth objective. Three ideas where *mHealth* could potentially facilitate data collection are proposed: (i) to conduct and validate household surveys; (ii) to measure the burden of disease; and (iii) to monitor large-scale health programmes [374].

10.1 mHealth-based conduction and validation of household surveys

10.1.1 Brief introduction to household surveys

As previously described in Chapter 1, household surveys are needed to provide accurate estimates of indicators on health and coverage of health interventions that can be used to assess progress towards national and international health goals. These surveys will continue to provide information on health low- and middle-income countries in the foreseeable future. Even when health information systems improve, the need for household surveys using probability sampling will remain. Health facility-based assessments are not based on probability sampling and thus will overestimate coverage of health interventions [130]. In addition, household surveys can, in contrast to health information system reports, allow analysis by equity variables such as socio-economic position (education, income, consumption, expenditure and occupation), ethnicity, gender and geography [328].

10.1.2 Challenges of household surveys and mHealth-based solutions

Section 1.1.3 showed challenges for household surveys and how text messaging surveys could overcome some of them. While this thesis explored the application of text messaging for surveys on care-seeking for childhood diarrhoea and pneumonia, text messaging could be used for other child health indicators [94,147,159].

Also as indicated in section 1.1.3, an additional problem for assessing estimates of health and coverage of health interventions is the inaccuracy of information that is collected. As the information in surveys is reported by mothers or primary caregivers of children, the validity of the information depends on their ability to correctly recognise illness signs and symptoms and recall information [67]. In 2013, the PLOS Collection on Measuring Coverage in Maternal, Newborn and Child Health reported on the accuracy of maternal, newborn and child health intervention coverage indicators based on surveys [67,85,94,130,131,328,348,375,376]. The following paragraphs describe how *mHealth* can help with addressing some of the accuracy-related issues.

Firstly, recall of symptoms for childhood diarrhoea-related indicators and other child health indicators can be problematic. While comparison of mother's reported symptoms of dehydration corresponded reasonably well with an assessment by health workers [125], the currently used two-week recall may underestimate mild diarrhoea cases and overestimate severe cases. A shorter recall period may improve accuracy of these indicators, but also increases usage of resources [131]. Other child health coverage indicators have even longer recall periods and their accuracy is negatively affected by recall bias [376]. For example, a mother can be asked to recall initiation and duration of breastfeeding of her child up to two years ago. Validity and reliability of breastfeeding indicators has shown to decrease when the recall time is prolonged [377,378]. A text messaging survey could be conducted more frequently or in real-time and thereby significantly reduce recall bias [147].

Secondly, disease signs and symptoms have been known to be poor predictors of actual disease for childhood pneumonia [126]. The current Demographic and Health Surveys and Multiple Indicator Cluster Surveys guidelines advise against the use of these surveys to estimate pneumonia incidence and two-week point prevalence, because "suspected pneumonia" cases are often not "true pneumonia" cases, but just cough and cold cases. This was confirmed in recent studies which showed that the expected measurement error in these surveys is large. An important indicator for health programmes - the antibiotic treatment rate for childhood pneumonia - cannot be used, because this indicator is based on the inaccurate two-week point prevalence of pneumonia [94,348].

Campbell *et al.* illustrated the inaccuracy of two-week point prevalence in an example; a setting with 0.3 pneumonia episodes per child per year and an estimated sensitivity of 80% (cases of true pneumonia that are recognised) and specificity of 85% (cases of non-pneumonia that are recognised). In this setting, a cross-sectional survey of 1000 caregivers has 161 reports of "suspected pneumonia" and 18 cases of "true pneumonia". This means that the ratio of reported "suspected pneumonia" to "true pneumonia" is 8.9 (161/18) to one and a highly overestimates the two-week point prevalence. The sensitivity and specificity estimates are based on health workers' assessment, which is likely to be better than caregivers' assessment. Thus, this shows a more optimistic ratio compared to the actual ratio in household surveys. In addition, it was shown that even when sensitivity and specificity is increased to very high levels (>90%), still the ratio overestimates the number of true pneumonia cases. Therefore, in settings with relatively low pneumonia incidence, most pneumonia cases will be false positives [94].

mHealth could be used to evaluate accuracy of pneumonia-related indicators and other child health indicators [94,130,348]. For example, mobile phones could be used to validate reports on care-seeking. Caregivers' movements and attendance to health care attendance could be tracked via their mobile phones [379]. This data could then be compared with information about caregivers' care-seeking behaviour collected through household surveys.

Moreover, *mHealth* could be used to improve accuracy of indicators. For childhood pneumonia, it has been recommended that the accuracy of indicators can be improved by increasing specificity or discriminative power (discriminating between cases of pneumonia and cases of non-pneumonia). Contextual factors such as maternal recognition of symptoms, education and knowledge, influence the sensitivity and specificity of indicators and can vary substantially between different settings [94]. To improve the accuracy of indicators, data collection could be strengthened by showing digital illustrations of children with signs and symptoms of childhood illnesses that are recognised by caregivers [380]. Also caregivers could be shown videos on danger signs for which care needs to be sought, which at the same time could serve as a health education intervention to improve care-seeking behaviour.

10.2 mHealth-based measurement of the burden of disease

10.2.1 Brief introduction to burden of disease measurement

The burden of a disease in a population depends on its frequency (incidence and prevalence), severity (mortality, including rates according to age, sex, place and cause and morbidity), consequences (health, social and economic) and the people who are affected (age, gender and socio-economic position). Burden of disease measurement aims to provide data to monitor trends in health outcomes, evaluate the effectiveness of interventions, set priorities for expenditures and inform health policy [370]. There is substantial geographical variation in the causes of deaths and thus data at global, regional and national level are required [280]. In addition, measurement of risk factors that underlie disease conditions are needed to inform policies that can support health promotion and disease prevention interventions [381].

Burden of disease measurements have been taken place over the past decades [382-384]. After establishment of the MDG*s* (described in section 1.2.1), there has been an increasing interest in developing and conducting measurements of the burden of disease. These efforts are seen as crucial for the MDG*s* to be achieved, because accurate measurement is essential for monitoring progress [100,283].

Groups that conduct and disseminate burden of disease measurement specifically for child health include the Child Health Epidemiology Reference Group (consisting of independent experts and working closely with the World Health Organization and United Nation Children’s Fund) in 2001 [92,280,385-387] and the Inter Agency Group for Child Mortality Estimation (led by the World Health Organization and the United Nation Children’s Fund) in 2004 [77]. These efforts have accelerated global efforts to tackle the leading causes of child mortality and highlighted the lack of information and problems for burden of disease measurement [92].

10.2.1 Challenges of burden of disease measurement and mHealth-based solutions

Data on the burden of disease are particularly sparse from the world's least developed countries where many deaths in children worldwide occur [388]. Almost three quarters of childhood diarrhoea and pneumonia deaths occur in 15 high burden low- and middle-income countries where only limited information on the burden of these illnesses is available [95]. An important reason for these gaps is the challenge of collecting the different types of data needed for measuring the burden of disease of childhood diarrhoea and pneumonia [92,97,132,389]. In the following paragraphs, it is described how *mHealth* can help address challenges for collection of three types of data: (i) incidence of childhood illnesses; (ii) mortality in children younger than five years; and (iii) risk factors in a community.

Firstly, there is currently no widely available source of incidence estimates of childhood illnesses [97]. Reviews showed that there were very few population-based studies that could provide reliable incidence estimates on diarrhoea and pneumonia in children younger than five [92,95-97]. Longitudinal community-based surveillance studies of new cases of infections are required to provide reliable estimates of incidence, because these data are usually not found in routine health information systems [96,97,132]. These studies are scarce, because they require major commitment from researchers and funders to conduct studies over a long period of time in low- and middle-income countries and face several methodological challenges [92].

Incidence studies need to be conducted over a full calendar year, because incidence of pneumonia and diarrhoea varies during different seasons [97,132]. Also screening large numbers of children on pneumonia needs to be active with an interval of two weeks or shorter to minimise recall bias, because this bias can lead to under-estimation of incidence, particularly in large families [132]. Text messaging surveys could facilitate measurement of the incidence of childhood illnesses, because these surveys could more easily measure incidence frequently over a longer period of time and include a large number of participants.

Secondly, about one-third of 135 million births and two-thirds of 57 million deaths worldwide were unregistered and unrecorded in 2010 (which equals about 40 million births and deaths) [390,391]. In 2007, *The Lancet* published a series that highlighted this “scandal of invisibility”, because so many people around the world are born and die without being registered [392]. Estimates on causes of deaths are even more scarce; a review on causes of child mortality concluded that despite huge efforts to identify relevant data, the causes of only 2.7% of deaths in children younger than five years could be obtained from medically certified vital registration in 2010 (in 61 out of 193 analysed countries) [280]. Also in countries with large populations of children, such as China, limited published data were available to enable estimation of cause-specific burden of childhood mortality [282,388]. Therefore, many of the published data on child mortality have to be obtained through modelling. While modelling methods are advancing, the methodological and statistical challenges are still considerable [280]. Thus, more empirical data and data of higher quality are needed from low- and middle-income countries [388,393].

Mortality estimates can be obtained from vital statistics that are recorded in civil registration systems and from complementary sources, including community-based studies [394]. Civil registration systems can provide timely, complete and correct information on children’s births and deaths by age, sex and cause. However, in most low-income countries these systems are non-existent and many middle-income countries only have intermediate registration systems, such as sample registration systems in China and India [394,395]. Establishment of these systems is time and resource consuming and requires long-term commitment of countries [392]. In addition to low coverage, both registration systems deal with various threats to their validity [388,394,395]. Even in countries where coverage is good, registration can be much lower than 100% [394]. Many deaths occur in the community and are often not reported to a health care facility, because they are considered to be a religious or family matter in different cultures. Community-based studies can be used to estimate mortality and causes of these deaths and require similar designs as studies that measure incidence estimates [92]. These studies use verbal autopsy, a method in which an interviewer uses a standardised questionnaire to ask a caregiver about disease signs and symptoms of the child around the time of death [396]. However, verbal autopsy has mostly not been used on a large scale within the development of health information systems [397].

mHealth can be used for strengthening interim-solutions that could produce vital statistics, which could increase coverage of civil registration systems. Several preliminary efforts have taken place for this purpose. A pilot study has demonstrated the feasibility of use of mobile phones by birth assistants to register births and postpartum haemorrhage in Ghana [150]. The United Nations Children's Fund equipped community health workers with mobile phones to improve the registration of births in countries where civil registration is very low, such as Uganda, Senegal and Brazil. In settings where registration is higher but not integrated in all health centres, such as in remote areas of Kosovo, text messaging can be used to engage community workers in reporting children [398]. The Health Metrics Network (a global partnership hosted by the World Health Organization) is establishing standards to record pregnancies, birth and deaths with mobile phones in the field [391,399]. mHealth-based data collection can also be used to simplify verbal autopsy, which may facilitate larger-scale integration within the health information system [396,397]. The Millennium Villages Project (initiated by the Earth Institute at Columbia University and the United Nations Development Programme) used mobile phones for verbal autopsy in Sub-Saharan countries [400]. Similarly, mHealth-based verbal autopsy initiated by different universities and supported by the World Health Organization has taken place in Malawi [401].

Thirdly, there is poor understanding of the effect sizes of individual risk factors of childhood illnesses, because well-conducted studies are scarce [92,96,100,132]. Risk factors for incidence and risk factors associated with progression to severe disease when children experience pneumonia can be studied at community-level [92,100]. Risk factors are usually clustered together; for example people in poorer households often have characteristics such as undernutrition, crowding and are less likely to seek care. Therefore, assessing the effect of individual risk factors will largely overestimate the true effect size of a risk factor. Thus studies that assess the effect of multiple risk factors are needed to accurately estimate the effect of individual risk factors. These studies require large sample sizes so that participants with a variety of illness prevalences are included. Also studies need to take place in different contexts to account for differences in risk factors [92,96,100,132]. A text message survey could be used to collect community-based information on risk factors on a large scale and in varying settings [159].

10.3 mHealth-based monitoring of large-scale health programmes

10.3.1 Brief introduction to monitoring large-scale health programmes

There are several large-scale international programmes that aim to strengthen health sectors in low- and middle-income countries. In the middle of the 20^{th} century, the World Health Organization played an important role and the influence of civil society organisations (also known as nongovernmental organisations) was relatively limited. In recent years, there has been increasing involvement of different actors including governments, civil society, philanthropic trusts and the private sector [402].

A large number of global health programmes (estimated at around 100) have been initiated after the establishment of the MDGs in 2000 and have been named "Global Health Initiatives", "Global Public-Private Partnerships" and "Global Health Partnerships". These programmes aim to improve health in low- and middle-income countries by focussing on diseases such as HIV/AIDS, tuberculosis, malaria, or on specific interventions, commodities or services. They often work in different countries, link their inputs to performance, directly invest in countries and are able to generate substantial amounts of funding [403]. In 2013, global health development funds were estimated to be US$31.3 billion, which was mainly reached by greater support from the Global Fund to Fight AIDS, Tuberculosis and Malaria; the GAVI Alliance (public-private partnership previously known as "Global Alliance for Vaccines and Immunisation") and bilateral (government-to-government) support [404].

The efficacy of the interventions that these programmes deliver has often been established. Therefore, these programmes could improve health of people if they were delivered with adequate quality, but the delivery of programmes is often challenging in real-life settings [405,406]. Thus, effectively monitoring and evaluating large-scale health programmes is essential for their planning and management and to focus on the most effective interventions that can improve health [407,408].

10.3.2 Challenges of monitoring of large-scale health programs and mHealth-based solutions

Despite large investments that aim to improve health outcomes in low- and middle-income countries, few programmes have been thoroughly evaluated [407,408]. In 2004, the Evaluation Gap Working Group was initiated by the Centre for Global Development to assess why there are few evaluations of development programmes [407]. The importance of monitoring programmes was highlighted by the editors of *The Lancet* who stated that evaluation is the top priority for global health [408]. Evaluation of programmes is complex, because it involves several steps in designing and conducting the evaluation, faces bureaucratic and political challenges (for example the threat of independent evaluation that can potentially show shortcomings or lack of impact of programmes) [405,406]. The following paragraphs describe how *mHealth* could play a role when obtaining data for evaluation.

Firstly, data on programme implementation are often lacking, but are needed as large-scale health programmes often cannot deliver what they originally proposed. Unforeseen problems can inhibit delivery of interventions at sufficient quality. Thus, information on a variety of potential influencing factors is essential to inform the different steps of evaluation [405].

Data on the leading causes of morbidity and mortality are required for prospective evaluation at the start of the evaluation. Even though programmes often are meant to be focussed on important global health problems, the lack of robust country-specific data limits needs assessments [403]. As described in the previous sections, there are challenges for conducting household surveys (section 10.1) and measuring the burden of disease (section 10.2), which have resulted in gaps in the available data. The previously described mHealth-based data collection methods can be used to strengthen measurement of intervention coverage and the burden of disease.

Data on the context of interventions are important to allow scaling up of interventions and to monitor the constant change of health systems [409]. It is hard to make conclusions on effectiveness of health programmes, whether programmes show positive, negative, or no effects, because often is not known why and how these programmes work [409]. Contextual data can inform implementation of programmes and include socio-economic and demographic factors, environmental characteristics and presence of other programmes that may affect health status [405]. Poor health information systems and the short supply of trained and qualified health workers limit collection of contextual data. Supply systems on commodities are often old and inadequate [101]. Also, data collection is often perceived as time-consuming, complex, inflexible and not useful by health workers. As a result, data are frequently fragmented, inaccessible, incomplete and prone to error [66].

mHealth can facilitate collection of data on the context in which large-scale programmes take place. mHealth-based data collection could provide a solution for data fabrication by data quality checks [69,133]. A study showed that text messages were used to track stocks of medication with reasonable accuracy in Kenya [410]. Studies have also evaluated the use of text messaging for disease surveillance in Sub-Saharan countries [148,411].

Secondly, programme monitoring of outcomes is expensive, time-consuming, can be difficult to perform and often provides out-of-date and inaccurate results. Frustration has been expressed by key informants representing countries with high burdens of childhood diarrhoea and pneumonia about the inadequacy of current health information systems to support programme monitoring. The inability to timely collect, aggregate and analyse data was identified as an important barrier [101]. Timing is essential as health programmes may take place in a short time-frame. Thus, continuous data collection would be particularly beneficial for monitoring programmes [409]. Electronic data collection was proposed to overcome programme monitoring challenges and to reduce the time required to analyse and disseminate information [101]. *mHealth* could facilitate programme monitoring by allowing data to be collected in real-time [94,138].

Structured summary of chapter

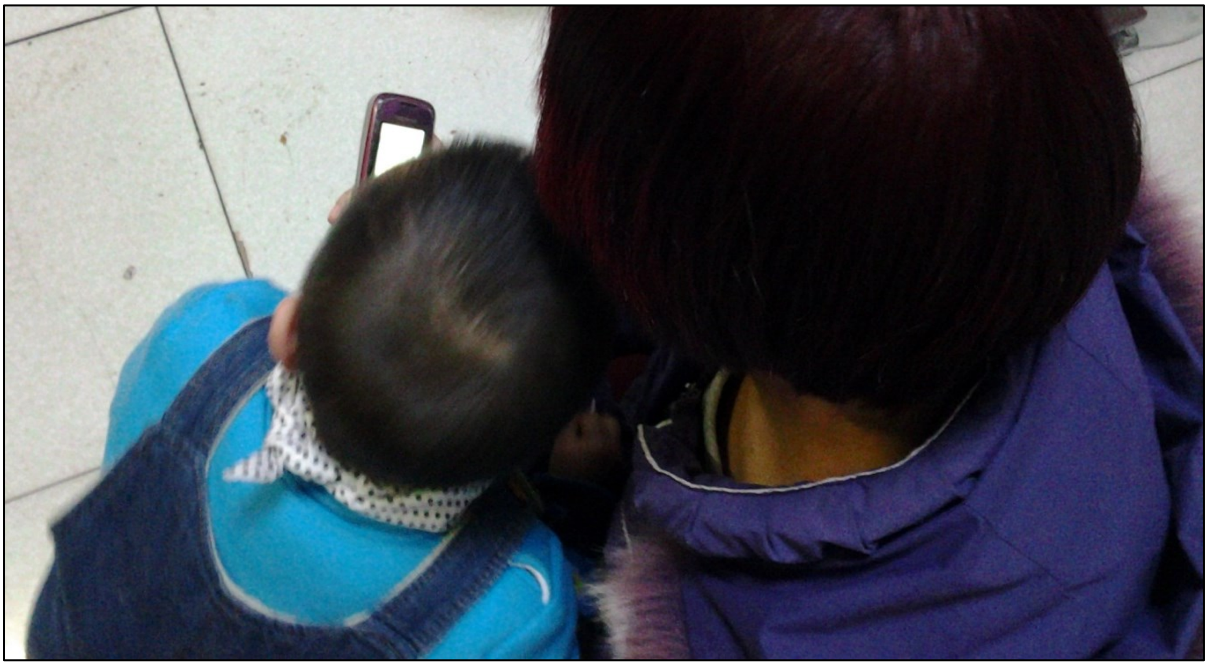
This chapter addressed the fourth objective of this thesis. In sum:

1. Household surveys are required to provide accurate estimates of health and coverage of health interventions that can be used to assess progress towards national and international health goals. However, there are limitations in both the quantity and quality of estimates. Text messaging surveys could overcome some of the challenges of current face-to-face surveys, because they could be conducted more frequently and thereby significantly reduce recall bias. Also *mHealth* could be used to evaluate and improve accuracy of child health indicators;
2. Burden of disease measurement aims to provide data to monitor trends in health outcomes, evaluate the effectiveness of interventions, set priorities for expenditures and inform health policy. However, data on the burden of disease are particularly sparse from the world's least developed countries. Text messaging surveys could facilitate measurement of the incidence of childhood illnesses, because these surveys could more easily include a large number of children and measure incidence over a longer period of time. Data collection via mobile phones in the field can be used for producing vital statistics that are used for mortality and causes of deaths estimates. Text message surveys could also be used to collect community-based information on risk factors in different settings;
3. Effectively monitoring and evaluating large-scale health programmes is essential for assessing effectiveness of these programmes, which can be used for programme planning and for focussing on the most effective interventions that can improve health. However, despite large investments aiming to improve health outcomes in low- and middle-income countries, few programmes have been thoroughly evaluated. *mHealth* could facilitate the collection of contextual data for programme implementation and monitoring programmes by allowing data to be collected in real time.

11 Overall discussion and conclusions

Overview of chapter

This chapter describes the principal findings from the thesis, as well as discussing the thesis' strengths and limitations and its recommendations for future research. This thesis explored the application of text messaging for collection of information relevant to childhood diarrhoea and pneumonia in rural China using a mixed methods approach. It made a significant contribution to both the scarce evidence-base and methodology for development and evaluation of an mHealth-based intervention. However, since this study took place in a single rural Chinese county which has high levels of both literacy and mobile phone use, the findings may not be generalizable to other contexts. Since this thesis is an example of early stage research, no firm conclusions and recommendations for practice and policy can be made regarding the potential and pitfalls of data collection by text messaging until more research is carried out in this area. This work would be valuable, because mHealth-based data collection could be used to increase the quantity and quality of child health indicators, which can improve implementation of appropriate health interventions and ultimately save children's lives.



Photograph 30 Mother and child looking at a text message

Photograph from the PhD candidate's personal collection

11.1 Principal findings of thesis

Overview of section

This thesis aimed to explore the application of mHealth-based collection of information relevant to childhood diarrhoea and pneumonia in rural China. The principal findings of the four objectives are described below.

11.1.1 The prevalence and factors influencing the usage of mobile phones by caregivers

Four themes were found in the qualitative semi-structured interview data, which were compared and complemented with the quantitative survey data.

First, quantitative data showed that a large proportion of caregivers in the county in rural China used mobile phones. However, considerably more parents used mobile phones compared to grandparents. Most caregivers and their household members owned a personal mobile phone and had not changed their mobile phone number in the past year. These findings were confirmed by the qualitative data.

Second, almost all caregivers had mobile phones that functioned for calling and text messaging at the time of the survey. Qualitative findings showed that caregivers occasionally experienced problems related to a non-functioning mobile phone, phone running out of credit, empty battery, lost mobile phone and radiation. Previously reported barriers to the usage of *mHealth*, such as costs, illiteracy, lack of electricity and sharing mobile phones, did not seem to be large barriers to usage of mobile phones in this study's setting [33,56].

Most caregivers used their mobile phones primarily for calling. Qualitative findings showed that caregivers preferred making phone calls over sending text messages because it was quicker, clearer to communicate, required less effort and was cheaper. Most surveyed mothers and fathers were able to send a text message. However, about one in four grandparents who took part in the survey and more than two thirds of grandparents who were living with survey participants were unable to send a text message.

Third, several factors influenced whether caregivers replied to text messages, including the following: (i) whether they checked their mobile phone; (ii) whether they trusted the sender of the text message; (iii) their personal emotion or feeling; (iv) the importance of replying to a text message; and (v) ease of use. Ease of use was influenced by the length of the text message response.

Fourth, there were several uses of mobile phones in health care. Almost half of households had the phone number of a village clinic and about one in four caregivers had used their mobile phone for health care during the three months prior to the survey. Of those had not used their mobile phone for health care, a very high proportion wished to use their mobile phone to receive health information. Qualitative findings showed that mobile phones were used to call doctors and family members, receive health-related text messages and browse the Internet for health information. Mobile phones were not used for health-related apps.

These findings were used to inform the development and evaluation of the text messaging survey in the second objective of this thesis. It was anticipated that many grandparents could not participate in text messaging data collection. Moreover, the following considerations were taken into account: send text message reminders; gain trust of caregivers by clearly identifying the sender of the text message; stress the importance of replying; provide information about how often the text messages are sent and at what times; ask for short text message responses; and not to ask for sensitive private information via text messages.

11.1.2 The validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia

A text messaging survey was developed by use of cognitive interviews and testing, and compared with a face-to-face survey (the reference standard) in a feasibility study using cluster randomised cross-over design.

Cognitive interview findings showed the importance of developing text messages that were clear, meaningful and could be trusted. In addition, the pilot test showed the need to check for words that were blocked by Chinese mobile telecom operators.

Almost two-thirds of participants responded to the first text message about willingness to participate. Of the participants who responded that they were willing to participate, more than half completed the text messaging survey. A significantly higher proportion of participants not responding to the first question had children with a rural *Hukou* and received a lower median number of text messages. There were more children with diarrhoea in the non-completers group compared to the completers group. As caregivers of a child with diarrhoea had to answer the largest number of questions (at least 14 questions), this indicated that the likelihood of responding decreased with an increasing number of questions. Possibly asking more than 10 questions might be too many. A large number of text messages were manually sent of which only few were in an incorrect format (researcher-related errors). Of the text message replies received, about a third were in an incorrect format (participant-related errors), but only a small proportion required follow-up. Overall, text message data were moderately to substantially equivalent to face-to-face data. The amount of information reported was fairly comparable. Both the face-to-face and text message surveys generated errors in responses that caregivers gave.

These findings indicated that text messaging surveys could deliver data that is of equal quality compared to face-to-face data. Also text messaging surveys may be most appropriate for short surveys with simple questions that require brief answers. As recruitment of caregivers was challenging and the text message response rate was insufficient for usage in household surveys, these aspects were evaluated in objective 3.

11.1.3 Factors influencing participation in mHealth-based studies

Observations of researchers and interviews with caregivers were used to explain challenges that were experienced with recruitment and follow-up of participants in the cross-over study.

In the cross-over study, only one in four potential participants could be recruited. Based on observations of researchers, there were a variety of factors influencing recruitment, related to organisation, village doctors' and caregivers' cooperativeness, such as availability of lists of names, mobile phone numbers and loudspeakers, understanding of the study, incentives and interference with work. Recommendations were made to improve recruitment, of which a number were specific to the study setting in Zhao County. Some generic recommendations were to tailor recruitment strategies to the specific context where caregivers were recruited. To improve village doctors' and caregivers' cooperativeness, more efforts should be made to inform them well by developing and testing information material.

Only one in three participants who were included in the cross-over study completed the text messaging survey. Factors influencing follow-up were based on the views of non-responders, non-completers and completers in the cross-over study. Participants had mainly negative views on their ability to use a mobile phone, problems whilst using their mobile phone, frequency of checking the mobile phone and available time. Trust was a frequently mentioned issue. These findings were consistent with the results shown for objective 1. Non-completers and completers perceived receiving the costs of text messages they send and the incentives that were provided when completing the text messaging survey as positive. Non-responders had only negative views on the perceived usefulness of the process of responding to text messages, while non-completers and completers also had positive views on these aspects. All participants had both positive and negative views on the perceived usefulness of the outcome of participation and the perceived ease of use of text messaging. Difficulties with sending text messaging were also found in the results reported for objective 1. Recommendations to improve follow-up were various and included tailoring the text messaging survey to participants' preferences and sending health information via text messages.

11.1.4 Ideas for mHealth-based data collection

Ideas for mHealth-based data collection were described. *mHealth* has potential use to: (i) conduct and validate household surveys; (ii) measure the burden of disease; and (iii) monitor large-scale health programmes.

Firstly, household surveys on different child health indicators could be conducted via text messaging [94,147,159]. Moreover, mobile devices could be used to evaluate and improve the limited accuracy for a number of child health indicators [94,130,348]. For example, data collection in household surveys could be strengthened by showing digital illustrations of children with signs and symptoms of childhood illnesses that are recognised by caregivers [380]. In addition, mobile phones could validate reports on care-seeking by monitoring caregivers' health care attendance via a mobile phone and comparing this data with similar information collected through household surveys.

Secondly, *mHealth* could be used to facilitate burden of disease measurement. There are very limited data available on the burden of childhood diseases in low- and middle-income countries [95,388]. Data are needed as appropriate health care strategies require a clear understanding of the burden of diseases [111]. Mobile devices can be used for strengthening civil registration systems that can produce vital statistics [150,391,396-398,401]. Text messaging surveys could facilitate measuring the incidence of childhood illnesses by measurements over a longer period of time. Text message surveys could also be used to collect community-based information on risk factors on a large-scale and in various settings [159].

Thirdly, *mHealth* could be used for the implementation and monitoring of large-scale health programmes. Despite large investments aiming to improve health outcomes in low- and middle-income countries, few programmes have been thoroughly evaluated and evaluation requires greater priority [407,408]. *mHealth* could facilitate implementation of programmes by easier collection of contextual data [148,410,411]. In addition, *mHealth*-based data collection could facilitate programme monitoring by allowing data to be collected in real-time [94,138].

11.2 Strengths and limitations of thesis

Specific strengths and limitations of the different parts of this thesis were explained in their relevant chapters (objective 1 in Chapter 5, objective 2 in Chapter 7 and objective 3 in Chapter 9). Instead of repeating these, the overall strengths and limitations of this thesis are described in the following paragraphs.

The thesis explored a novel research area and contributed to the scarce evidence base for mHealth-based interventions in resource-limited settings. Only a small number of studies on text messaging data collection have taken place in low and middle-income countries and no previous studies have assessed the application of text messaging for data collection on childhood illnesses. Two recent studies in rural China have already made use of the findings of this thesis [159][YL, personal communication].

The thesis made a contribution to the underdeveloped methodology concerning the development and evaluation of mHealth-based interventions. A mixed methods approach was most appropriate given the complexity of mHealth-based interventions. This allowed the work to draw on the strengths of both quantitative and qualitative approaches and to explore the research topic from different points of view. This also enabled the study to be undertaken in different phases that were used to inform, explain and validate each other. Previous studies often did not assess mobile phone usage, did not make comparisons between data collection methods, used a non-randomised design or included a small number of participants. The research in this thesis was original in combining an assessment of usage of mobile phones to explore contextual factors, comparing data collection methods and evaluating factors influencing participation. Primary research on a large number of participants (>2800) was conducted. This included the first study to use a cluster randomised cross-over design in order to assess the validity of text messaging data collection.

However, a limitation of this approach was the need to be familiar with different methodologies and the more extensive time for data collection and analysis. Therefore, sometimes a pragmatic approach had to be taken, for example a thematic analysis was used for the semi-structured interviews instead of a more thorough grounded theory analysis.

The PhD candidate co-authored 20 academic papers related to this thesis during her doctoral studies. She led the research that formed this thesis, acknowledging and referencing the efforts of others where applicable. The PhD candidate also made a substantial contribution to related research projects of the Chinese researchers and provided training in research methodology, whereby she helped build research capacity in China.

The study took place in townships of Zhao County, Hebei Province in China. Caution is needed when generalising these findings to other settings where the contextual factors are different, both within and outside China. However, the findings may be transferable to settings with similar characteristics, particularly with similar levels of literacy and mobile phone use. The findings of this thesis can be compared with findings from studies in other settings to assess transferability of the results.

The PhD candidate actively participated in the field work in China, whereby she obtained insight in the study context. She made five visits to China with a total approximate length of six months and had extensive contact with the Chinese researchers. The PhD candidate was unfamiliar with China and was not proficient in Mandarin prior to starting her PhD. However, this may have been an advantage as it allowed her to study this subject with few preconceptions. The Chinese researchers had been conducting studies for a number of years in the study site with good working relationships with the local health workers in Zhao County.

The data were collected in Mandarin and the PhD candidate relied on collaboration with the Chinese researchers to analyse and interpret the data. The risk of interpretation and language bias was minimised through continuous discussions that took place between the Chinese researchers and the PhD candidate. In addition, verification of the data was conducted by a bilingual translator. However, as with any translation, some meaning of the original language will be lost.

Since this thesis is an example of early stage research, no firm conclusions and recommendations for practice and policy can be made regarding the potential and pitfalls of data collection by text messaging until more research is carried out in this area. Several research questions remain, which are described together with possible directions for future work.

11.3 Future work

Overview of section

This section describes a number of areas for future research for mHealth-based data collection in low- and middle-income countries. Firstly, the next steps for text messaging surveys are detailed so that these surveys may potentially be used in the future. Secondly, further developing the ideas for mHealth-based data collection is described. Thirdly, the potential for smartphones to facilitate data collection is shown.

11.3.1 Next steps for text messaging-based data collection

In this thesis, a feasibility study assessing the application of text messaging data collection for a household survey on care-seeking for childhood diarrhoea and pneumonia took place in rural China. Thus, the state of evidence for text messaging data collection for this purpose is at the stage of feasibility/piloting of the Medical Research Council guidance of complex interventions [205-207]. As indicated in the background chapter, standards state that evidence for each mHealth-based intervention has to consist of at least two efficacy studies, two effectiveness studies, dissemination research and information about the intervention's costs (as described by Tomlinson *et al.* [186] and adapted by previously reported standards [198,199]). Thus, there is still much more work to be done before text messaging surveys can be implemented.

This PhD started in January 2011 and the research collaboration with the researchers in China was set up in January 2012. Thus, it took approximately two years between the initial ideas for this PhD research and the write-up of this thesis in 2014. In the next two and a half years, another efficacy study and an effectiveness study could take place. This research would have to take into account the findings of this thesis. After, a second effectiveness study and dissemination research could be conducted. The results of these studies could be used to facilitate implementation of text messaging surveys by providing information about the most optimal intervention delivery and information about costs of text messaging surveys. In the following paragraphs, issues that need to be addressed are described. When these aspects are further developed, recommendations for policy and practice and firm conclusions could be made for text messaging data collection in the next five years.

Accuracy of indicators

In this thesis, text messaging data were compared to data obtained through standard face-to-face interviews. Measuring the accuracy of these indicators is of great importance to inform implementation of appropriate health interventions, as the PLOS Collection on Measuring Coverage in Maternal, Newborn and Child Health and others previously did for face-to-face interviews [67,85,94,130,131,328,348,375,376]. The accuracy of the health indicators obtained through text messaging should also be assessed, which can be achieved by comparing data obtained through text messaging to the gold standard (direct observation at a health clinic).

In addition, only a small selection of survey questions on relevant to childhood diarrhoea and pneumonia were assessed in this thesis. Other studies on text messaging data collection in Zhao County explored the usage of text messaging for evaluation of an infant feeding intervention and to assess feeding knowledge [138], and for 24-hour dietary recall [159]. Future research needs to evaluate validity of the text messaging method for other indicators that cover antenatal care, delivery and postnatal care.

Transferability

The studies in this thesis took place in a single rural Chinese county which has high levels of both literacy and mobile phone use. The findings may not be generalizable to other settings where the contextual factors are different, both within and outside China. Future research should take place in other settings, so that the findings from different settings can be compared and transferability of the results can be assessed.

Coverage

Obtaining an accurate list of names with children and mobile phone numbers was challenging in the cross-over study. Village doctors were asked to update the list based on their records, but still the extent of inaccuracies were unknown. While this issue is relevant to surveys that use different modes of data collection, an additional problem for coverage of text messaging surveys is the requirement to obtain mobile phone numbers. A number of township hospitals were able to provide mobile phone numbers of some caregivers, but these lists were often incomplete and inaccurate. Therefore, further mobile phone numbers had to be collected from caregivers, which was time and resource consuming.

Measurement of non-coverage bias of surveys is important to assess the validity of a survey, but is difficult and expensive to measure. A frequently used procedure to assess non-coverage bias is to compare survey results with findings from other sources [129]. In order to make these comparisons, the routine health information systems need to be systematically assessed.

There are many sources of data in the routine health information system. In the Chinese research setting these include the following: records of antenatal care visits to the county Maternal and Child Health Hospital; records of antenatal care visits to township hospitals; monthly birth reports from delivery institutions to the county Maternal and Child Health Hospital; information on hospital delivery subsidies; records of child health care visits to township hospitals; and lists of names for immunization. Some of these routine health data have been made electronic as required by the Chinese government [147].

The routine health information systems could serve as a source of lists of names and mobile numbers. Thus, after assessment of health information systems, the feasibility of collecting and updating data from these systems can be explored, included the collection of names, mobile phone numbers and general demographic and socio-economic information. To collect this information, the following needs to be taken into consideration: responsible person; way of collecting data; advantages and disadvantages of different data sources; quality of data; decision on what information is included; possibility to add or reduce information; relations between different data sources; possibility to integrate different data sources; extent to which information is electronic or paper-based; inclusion of mobile phone numbers; and current mechanisms for dynamic updates [147].

A household census could be conducted in selected townships and villages to validate lists of names and mobile phone numbers collected through routine health information systems. Using household census as gold standard and comparing this with data obtained from routine health information systems could reveal the extent of the completeness and accuracy of the data. Caregivers could also be interviewed during the household census to explore the mechanism of regular updating information [147]. Furthermore, if access could be obtained to mobile phone directories [177], these numbers could be used as well for validation.

Non-response

Non-response is influenced by a number of factors; significant to mention for text messaging surveys are illiteracy and usage of mobile phones. Illiteracy is low in Zhao County and did not seem to be an issue during the study. However, in China grandparents sometimes take care of the child of their son or daughter. Many of them could not use text messages and most of the participants of the cross-over study were mothers (78.5%). This may introduce selection bias to a survey, because children who are being taken care of by grandparents who are unable to use text messages cannot be included. In China where some parents are working as migrant workers and leave their child at home, grandparents have to be included in household surveys to achieve a representative sample of children. This issue may decrease in the future as younger generations of grandparents may be more familiar with text messaging. In the meantime, continuing usage of face-to-face surveys for these caregivers may have to be used to reduce non-response bias.

In a future study, a “real” text messaging household survey (based on probability sampling procedures as described in section 1.3) could be conducted. This could provide an estimation of how many caregivers are excluded because they are unable to send text messages. These caregivers could still be included through a face-to-face survey. The recommendations for recruitment and follow-up that were found in this thesis can be used to inform this study.

Response rate

The item response rate and completion rate in the cross-over study were reasonable for a self-administered survey [140], but not sufficient according to the minimum requirements for a household survey (minimum completion rate of 90%) [67]. It was found that caregivers in rural areas were less likely to respond to the first text message question. As text messaging surveys could be particularly useful for caregivers in remote areas, this issue requires investigation. Moreover, the optimum number of questions that caregivers are willing to respond to and frequency of sending text messages needs to be further explored.

In the cross-over study was found that asking more than 10 questions not be feasible. A text message survey with a maximum of 10 simple questions requiring brief answers could be conducted to assess whether a higher response rate can be achieved. Completers seemed willing to respond to participate at least once a month. A survey could be repeatedly conducted over a longer period of time to evaluate the acceptability of frequency to participants.

There are many factors which affect the response rate of text messaging data collection. There is a large body of literature in psychology and sociology about participation in surveys and in the medical sciences on how response rates to postal, telephone and electronic surveys can be maximised [135,369]. More studies need to be conducted to test the effectiveness of these approaches on increasing response rate of text messaging surveys [YL, personal communication]. Future studies could use behavioural theories and models (section 1.5.3), such as the Technology Acceptance Model to develop interview guides [365] and test the variables of the model for mHealth-based data collection [367].

Sending health information via text messages may be particularly useful to increase the response in the Chinese research setting, because caregivers expressed a wish to receive health information text messages in different parts of this thesis. Caregivers could benefit from information on, for example, breastfeeding and complementary feeding. Also health service reminders could be sent that explain when, where, what and why health services are needed. These service reminder messages may have the potential to improve caregivers' recall of interventions that they received. In addition, text messages could also be sent to health workers to help them to deliver better care to mothers and their children [147,412]. This could be achieved by making linkages with the numerous existing health information programmes in China.

Involvement of different actors

Success of mHealth-based interventions depends on involving and addressing the needs of all actors who are involved, including healthy individuals, patients, health workers at all levels of the health care system, policy makers, governments and the industry [212]. Besides further assessment of participants' preferences, health workers' participation would be essential for text messaging surveys.

In the Chinese study setting, caregivers often have close contact with their village doctor. Therefore, it is important to understand village doctors' willingness to be involved. Previous research assessed village doctors' perceptions on recruitment of caregivers for the cross-over study [252]. Also their attitude and possible preference towards text messaging surveys needs to be assessed [147]. Furthermore, future research should also explore perceptions of other actors such as health officials, policy makers and the government.

Operational guidelines

In order to facilitate implementation of text messaging data collection, operational guidelines need to be developed and tested. Also an automated text messaging system that works in the Chinese setting needs to be developed, which could reduce the workload of researchers and further improve accuracy of sending and receiving text messages. This would also allow sending text messages quicker and at participants' preferred times. A text messaging platform would have to consist of software and staff to manage the system [147].

Cost-effectiveness

Cost-effectiveness is one of the main research priorities for *mHealth* [183]. An important advantage of text messaging over current data collection methods could be the reduced need of resources. Cost-effectiveness was not part of the outcomes of the cross-over study in this thesis, because this study was a feasibility study.

The previous text messaging data collection study found that the costs per questionnaire for the text messaging survey (¥19.7; about £1.97) were much lower than the costs for the face-to-face surveys (¥33.9; about £3.39) for all questionnaires. Costs were also lower for completed text messaging questionnaires (¥27.1; about £2.71) compared with the face-to-face questionnaires (¥34.4; about £3.44) [138]. However, an updated cost-effectiveness analysis of the text messaging method versus the face-to-face method should be done. This would be most useful when an automated text messaging system is used for a text messaging survey on a larger scale. When more information on cost-effectiveness is generated, text messaging surveys could make a stronger case for adoption.

11.3.2 Further developing ideas for mHealth-based data collection

Further work can take forward the ideas for mHealth-based data collection that were presented in Chapter 10. As was shown, some initiatives have already taken place and a limited number of studies have been conducted for some of these ideas. However, these have been insufficient to support implementation of these mHealth-based data collection methods. Much more systematic and rigorous work is required to assess the effects of these mHealth-based data collection methods on relevant outcomes. This work would have to follow the same previously described guidance for development, evaluation and implementation of complex interventions [205,207].

Research could assess the feasibility of using mobile phones to validate reports on care-seeking. A study could follow caregivers for two weeks using the Global Positioning System function of their mobile phones. After two weeks, a survey could be conducted to ask caregivers about their care-seeking behaviour in the past two weeks. The information obtained through both sources could then be compared.

To improve accuracy of survey questions, digital illustrations of children with signs and symptoms of childhood illnesses that are recognised by caregivers and danger signs could be developed. The usefulness of these materials to educate caregivers could also be assessed. Ideally, these videos should be developed in the same context as where they are used to maximise their validity [348].

More research is needed on the usage of mobile phones to assist health workers in registering pregnancies, births, and deaths could be conducted using standards that are being developed [391,399].

To facilitate collection of data on the context of large-scale health programmes, future work on using text messages to track stocks of medication and assessing effectiveness on a larger scale could be conducted [410]. Improving data quality is a research priority for disease surveillance via text messaging [411].

When these ideas for mHealth-based data collection are further developed, they can support validation of household surveys, measurement of the burden of disease and monitoring large-scale health programmes.

11.3.3 The potential smartphones offer to health data collection

Text messaging has been used over the past 20 years and is expected to remain to be the most important source for mobile messaging for some time to come [21]. Text messaging is found to be user-friendly, because of its immediacy, low costs and non-intrusiveness [17]. However, the limited capacity of text messages (restricted number of characters), language and illiteracy have been found as barriers to its usage [16].

One of the characteristics of *mHealth* is the rapid change in technologies that can be used to assist delivery of interventions. Smartphones are increasingly available in low- and middle-income countries with rapidly decreasing prices of handsets. In the rural setting of this thesis, already approximately one in three parents owned a smartphone. Furthermore, it has been predicted that Internet connectivity will grow exponentially in the next 10 years and "*everything, everywhere will be digitally connected*" [413].

With these advancements, mobile instant messaging will increase its share in mobile messaging. Mobile instant messaging is forecast to increase from 1.6 trillion messages in 2011 to 7.7 trillion in 2016 [21]. Instant messaging can overcome the challenges presented by the limited capacity of text messages. Also, instant messages can be sent for free when a smartphone is connected to the internet.

Moreover, dedicated data collection apps on smartphones can be used for surveys. App data collection was preferred over text messaging data collection, because it had a higher proportion of data entries and shorter response time [414]. In addition, the advanced computing capacity of smartphones can be used to collect more complex data than can be done with text messaging. Also, apps may be designed in a way that is convenient and user friendly for participants and researchers. For example, pictures and a tailored user interface can be used to encourage participants to respond. Apps may reduce the number of errors that occur in text messaging surveys, because an app could indicate automatically when a response is incorrect [143,144]. However, even when smartphones are more widely used, that does not mean that people are comfortable with using them (as was shown in Chapter 5). The growing complexity of technologies may also increase problems that are faced whilst using them. For example, at the moment smartphones have a much shorter battery life than simple mobile phones. Thus, research needs to assess usage of smartphones by target populations before conducting intervention studies.

11.4 Conclusions

This thesis explored the application of mHealth-based collection of information relevant to childhood diarrhoea and pneumonia in rural China using a mixed methods approach. It described both the prevalence of mobile phone usage by caregivers and the factors influencing that usage. It assessed the validity of a text messaging survey on care-seeking for childhood diarrhoea and pneumonia. Factors influencing participation in mHealth-based studies were explored. Lastly, ideas for mHealth-based data collection were suggested.

This thesis found that text messaging can be used to collect data on childhood diarrhoea and pneumonia in a rural Chinese setting with high levels of literacy and mobile phone usage. Data collected through text messages were moderately to substantially equivalent to data collected through standard face-to-face interviews. However, the response rate was too low to suggest that text messaging can be used for public health surveys. Among many factors influencing the response rate were the difficulty of obtaining trust, and the procedure’s perceived usefulness and ease of use for caregivers. It seems that text messaging would be most appropriate for short surveys with simple questions requiring brief answers. Text messaging surveys were suitable for most parents, but not for grandparents. Caution is needed when generalising these findings to other settings where the contextual factors are different, both within and outside China.

This PhD made the following direct contributions to the fields of mHealth and global health.

First, the thesis explored a novel research area and contributed to the scarce evidence base for mHealth-based interventions in resource-limited settings. Only a small number of studies on text messaging data collection have taken place in low and middle-income countries and no previous studies have assessed the application of text messaging for data collection on childhood illnesses. Two recent studies in rural China have already made use of the findings of this thesis [159][YL, personal communication].

Second, the thesis made an original contribution to the underdeveloped methodology concerning the development and evaluation of mHealth-based interventions. A mixed methods approach was most appropriate given the complexity of mHealth-based interventions. This allowed the work to draw on the strengths of both quantitative and qualitative approaches and to explore the research topic from different points of view. Previous studies often did not assess mobile phone usage, did not make comparisons between data collection methods, used a non-randomised design or included a small number of participants. The research in this thesis was original in combining an assessment of usage of mobile phones to explore contextual factors, comparing data collection methods and evaluating factors influencing participation. Primary research on a large number of participants (>2800) was conducted. This included the first study to use a cluster randomised cross-over design in order to assess the validity of text messaging data collection.

Third, the PhD candidate co-authored 20 academic papers related to this thesis during her doctoral studies. The PhD candidate led the research that formed this thesis, acknowledging and referencing the efforts of others where applicable.

Fourth, the PhD candidate helped to build research capacity in China. She provided training in research methodology and scientific writing and made substantial contributions to related research projects of the Chinese researchers.

This PhD made the following indirect contributions to the fields of mHealth and global health.

First, the findings of this thesis can be used by researchers who wish to conduct studies on text messaging data collection. As with all early stage research, this study could only provide preliminary insights. Text messaging surveys face challenges that limit their use and several questions remain, including how to improve accuracy and response rates. Further work to advance this innovative method of data collection will need to explore strategies addressing these challenges. The findings of this thesis can be compared with findings from studies in other settings to assess transferability of the results. Participants of studies in this thesis wished to receive health information, which could be used as a two-way communication tool to raise response rates. This could be achieved by making linkages with the numerous existing health information programmes in China.

Second, the methodology applied to evaluate an mHealth-based intervention in this thesis can be used by others; for example by software developers for developing tools. In addition, the spread of smartphones in low and middle-income countries may open up new possibilities for health data collection and parts of the methodology used for evaluating text messaging data collection may be transferable to evaluation of data collection using smartphones.

Third, organisations such as the World Health Organization and United Nations Children's Fund can use the findings of this thesis to use text messaging for data collection in their efforts to improve health globally. When further developed, mobile technologies can be used to conduct and validate household surveys, measure the burden of disease and monitor large-scale health programmes.

In conclusion, there is currently a lack of health information that can inform health interventions, a situation which results in preventable child deaths from childhood diarrhoea and pneumonia. This thesis contributed to addressing this problem by using text messaging as an mHealth-based data collection method that could facilitate collection of information in settings with weak health information systems. mHealth-based data collection could be used to increase the quantity and quality of child health indicators, which can improve implementation of appropriate health interventions and ultimately save children's lives.

References

1. Historical currency rates. Available from: http://www.oanda.com/currency/historical-rates/. Accessed 9 May 2014.
2. Country and Lending Groups. World Bank; 2014. Available from: http://data.worldbank.org/about/country-and-lending-groups. Accessed 9 May 2014.
3. Istepanian R, Jovanov E, Zhang YT. Introduction to the special section on M-Health: beyond seamless mobility and global wireless health-care connectivity. IEEE Trans Inf Technol Biomed. 2004;8:405-14. Medline:15615031
4. mHealth - New horizons for health through mobile technologies. World Health Organization; 2011. Available from: http://www.who.int/goe/publications/goe_mhealth_web.pdf. Accessed 9 May 2014.
5. Merson MH, Black RE, Mills AJ. Introduction. In: Merson MH, ed. Global health: diseases, programs, systems and policies. 3 ed. Burlington, MA: Jones & Bartlett Learning; 2012:xvii-xxix.
6. WHA58.28 eHealth Ninth plenary meeting, 25 May 2005 – Committee A, seventh report. 58th World Health Assembly 2005. Available from: http://www.who.int/healthacademy/media/WHA58-28-en.pdf. Accessed 9 May 2014.
7. ITU-D. Mobile-cellular subscriptions, by level of development. 2011. Available from: http://www.itu.int/ict/statistics. Accessed 9 May 2014.
8. ITU-D. The World in 2014 ICT Facts and Figures. Telecommunication Development Bureau International Telecommunication Union (ITU), Market Information and Statistics Division; 2014. Available from: http://www.itu.int/en/ITU-D/Statistics/Documents/facts/ICTFactsFigures2014-e.pdf. Accessed 9 May 2014.
9. ITU-D. The little data book on information and communication technology. 2013. Available from: http://www.itu.int/en/ITU-D/Statistics/Documents/publications/ldb/LDB_ICT_2013.pdf. Accessed 9 May 2014.

10. Guo Z, Wu M. Dancing thumbs: Mobile telephony in contemporary China. In: Zhang X, Zheng Y, eds. China's Information and Communications Technology Revolution: Social Changes and State Responses. Oxon: Routledge; 2009:34-50.
11. ITU-D. Global mobile cellular subscriptions, total and per 100 inhabitants, 2000-2010. 2011. Available from: http://www.itu.int/ict/statistics. Accessed 9 May 2014.
12. GSMA. Global mobile penetration — subscribers versus connections. 2012. Available from: https://gsmaintelligence.com/analysis/2012/10/global-mobile-penetration-subscribers-versus-connections/354/. Accessed 9 May 2014.
13. Aker JC, Mbiti IM. Mobile phones and economic development in Africa. Journal of Economic Perspectives. 2010;24:207-32. doi:10.1257/jep.24.3.207
14. Mobile phones and development: Calling an end to poverty. The Economist; 2005. Available from: http://www.economist.com/node/4157618. Accessed 9 May 2014.
15. Aker JC. Why have mobile phones succeeded where other technologies have not? 2010. Available from: http://www.cgdev.org/blog/why-have-mobile-phones-succeeded-where-other-technologies-have-not. Accessed 9 May 2014.
16. Kaplan WA. Can the ubiquitous power of mobile phones be used to improve health outcomes in developing countries? Global Health. 2006;2:9. Medline:16719925. doi:10.1186/1744-8603-2-9
17. Lacohée H, Wakeford N, Pearson I. A social history of the mobile telephone with a view of its future. BT Technology Journal. 2003;21
18. Guardian. From bricks to the iPhone: 25 years of the mobile phones. 2010. Available from: http://www.guardian.co.uk/technology/gallery/2010/feb/14/mobile-phones-gadgets-iphone#/?picture=357620329&index=1;. Accessed 9 May 2014.
19. Developing markets will drive smart phone market growth in 2013. Canalys; 2013. Available from: http://www.canalys.com/static/press_release/2013/canalys-press-release-161013-developing-markets-will-drive-smart-phone-market-growth-2013.pdf. Accessed 9 May 2014.

20. ITU-D. The World in 2010 ICT Facts and Figures. Telecommunication Development Bureau International Telecommunication Union (ITU), Market Information and Statistics Division; 2010. Available from: http://www.itu.int/ITU-D/ict/material/FactsFigures2010.pdf. Accessed 9 May 2014.

21. Clark-Dickson P. Press release: SMS will remain more popular than mobile messaging apps over next five years. 2012. Available from: http://blogs.informatandm.com/4971/press-release-sms-will-remain-more-popular-than-mobile-messaging-apps-over-next-five-years/. Accessed 9 May 2014.

22. The doctor in your pocket. Medical technology: Nearly everyone in the developed world carries a mobile phone—so why not use it to deliver health care? : The Economist; 2005. Available from: http://www.economist.com/node/4368140. Accessed 9 May 2014.

23. Mechael P. The case for mHealth in developing countries. Innovations: Technology/Governance/Globalisation. 2009;4:103-18. Medline:20093129752. doi:10.1162/itgg.2009.4.1.103

24. Kahn JG, Yang JS, Kahn JS. 'Mobile' health needs and opportunities in developing countries. Health Aff (Millwood). 2010;29:252-8. Medline:20348069. doi:10.1377/hlthaff.2009.0965

25. Tamrat T, Kachnowski S. Special delivery: an analysis of mHealth in maternal and newborn health programs and their outcomes around the world. Matern Child Health J. 2011. Medline:21688111. doi:10.1007/s10995-011-0836-3

26. Ranck J. Health information and health care: the role of technology in unlocking data and wellness – a discussion paper. United Nations Foundation & Vodafone Foundation Technology Partnership; 2011. Available from: http://www.unfoundation.org/assets/pdf/info-as-care.pdf. Accessed 9 May 2014.

27. Bloch A. The potential of mobile technologies to positively impact access to essential medicines in low and medium income countries. Washington, DC: mHealth Alliance;2010.

28. Waegemann CP. mHealth: the next generation of telemedicine? Telemed J E Health. 2010;16:23-5. Medline:20070168. doi:10.1089/tmj.2010.9990

29. Pagliari C, Sloan D, Gregor P, Sullivan F, Detmer D, Kahan JP, et al. What is eHealth (4): a scoping exercise to map the field. J Med Internet Res. 2005;7:e9. Medline:15829481. doi:10.2196/jmir.7.1.e9
30. Klasnja P, Pratt W. Healthcare in the pocket: mapping the space of mobile-phone health interventions. J Biomed Inform. 2012;45:184-98. Medline:21925288. doi:10.1016/j.jbi.2011.08.017
31. Kallander K, Tibenderana JK, Akpogheneta OJ, Strachan DL, Hill Z, ten Asbroek AH, et al. Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low- and middle-income countries: a review. J Med Internet Res. 2013;15:e17. Medline:23353680. doi:10.2196/jmir.2130
32. Black A, Car J, Pagliari C, Anandan C, Cresswell K, Bokun T. The impact of eHealth on the quality and safety of health care: a systematic overview. PLoS Med. 2011;8:e1000387. Medline:21267058. doi:10.1371/journal.pmed.1000387
33. Mechael P, Batavia N, Kaonga N, Searle S, Kwan A, Goldberger A, et al. Barriers and gaps affecting mHealth in low and middle income countries: policy white paper. Center for Global Health and Economic Development Earth Institute, Columbia University; 2010. Available from: http://cghed.ei.columbia.edu/sitefiles/file/mHealthBarriersWhitePaperFINAL.pdf. Accessed 9 May 2014.
34. mHealth in the global south landscape analysis. Vital Wave Consulting 2008. Available from: http://www.vitalwaveconsulting.com/pdf/mHealth_in_the_Global_South_Landscape_Analysis.pdf. Accessed 9 May 2014.
35. Mechael PN, Sloninsky D. Towards the development of an mHealth strategy: a literature review WHO and Millenium Villages Project; 2008. Available from: http://www.who.int/goe/mobile_health/mHealthReview_Aug09.pdf. Accessed 9 May 2014.
36. Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. Global Health: Science and Practice. 2013;1:160-71. doi:10.9745/ghsp-d-13-00031

37. Free C, Phillips G, Galli L, Watson L, Felix L, Edwards P, et al. The effectiveness of mobile-health technology-based health behaviour change or disease management interventions for health care consumers: a systematic review. PLoS Med. 2013;10:e1001362. Medline:23349621. doi:10.1371/journal.pmed.1001362
38. Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for communicating results of medical investigations. Cochrane Database Syst Rev. 2012;6:CD007456. Medline:22696369. doi:10.1002/14651858.CD007456.pub2
39. Car J, Gurol-Urganci I, de Jongh T, Vodopivec-Jamsek V, Atun R. Mobile phone messaging reminders for attendance at healthcare appointments. Cochrane Database Syst Rev. 2012;7:CD007458. Medline:22786507. doi:10.1002/14651858.CD007458.pub2
40. Guy R, Hocking J, Wand H, Stott S, Ali H, Kaldor J. How effective are short message service reminders at increasing clinic attendance? A meta-analysis and systematic review. Health services research. 2012;47:614-32. Medline:22091980. doi:10.1111/j.1475-6773.2011.01342.x
41. Horvath T, Azman H, Kennedy GE, Rutherford GW. Mobile phone text messaging for promoting adherence to antiretroviral therapy in patients with HIV infection. Cochrane Database Syst Rev. 2012;3:CD009756. Medline:22419345. doi:10.1002/14651858.cd009756
42. Nglazi MD, Bekker LG, Wood R, Hussey GD, Wiysonge CS. Mobile phone text messaging for promoting adherence to anti-tuberculosis treatment: a systematic review protocol. Systematic reviews. 2013;2:6. Medline:23324135. doi:10.1186/2046-4053-2-6
43. Fjeldsoe BS, Marshall AL, Miller YD. Behavior change interventions delivered by mobile telephone short-message service. Am J Prev Med. 2009;36:165-73. Medline:19135907. doi:10.1016/j.amepre.2008.09.040
44. Cole-Lewis H, Kershaw T. Text messaging as a tool for behavior change in disease prevention and management. Epidemiol Rev. 2010;32:56-69. Medline:20354039. doi:10.1093/epirev/mxq004

45. Vodopivec-Jamsek V, de Jongh T, Gurol-Urganci I, Atun R, Car J. Mobile phone messaging for preventive health care. Cochrane Database Syst Rev. 2012;12:CD007457. Medline:23235643. doi:10.1002/14651858.CD007457.pub2
46. Deglise C, Suggs LS, Odermatt P. Short message service (SMS) applications for disease prevention in developing countries. J Med Internet Res. 2012;14:e3. Medline:22262730. doi:10.2196/jmir.1823
47. Stephens J, Allen J. Mobile phone interventions to increase physical activity and reduce weight: a systematic review. The Journal of cardiovascular nursing. 2013;28:320-9. Medline:22635061. doi:10.1097/JCN.0b013e318250a3e7
48. Whittaker R, McRobbie H, Bullen C, Borland R, Rodgers A, Gu Y. Mobile phone-based interventions for smoking cessation. Cochrane Database Syst Rev. 2012;11:CD006611. Medline:23152238. doi:10.1002/14651858.CD006611.pub3
49. Lim MS, Hocking JS, Hellard ME, Aitken CK. SMS STI: a review of the uses of mobile phone text messaging in sexual health. Int J STD AIDS. 2008;19:287-90. Medline:18482956. doi:10.1258/ijsa.2007.007264
50. Noordam AC, Kuepper BM, Stekelenburg J, Milen A. Improvement of maternal health services through the use of mobile phones. Trop Med Int Health. 2011;16:622-6. Medline:21342374. doi:10.1111/j.1365-3156.2011.02747.x
51. de Jongh T, Gurol-Urganci I, Vodopivec-Jamsek V, Car J, Atun R. Mobile phone messaging for facilitating self-management of long-term illnesses. Cochrane Database Syst Rev. 2012;12:CD007459. Medline:23235644. doi:10.1002/14651858.CD007459.pub2
52. Joe J, Demiris G. Older adults and mobile phones for health: a review. J Biomed Inform. 2013;46:947-54. Medline:23810858. doi:10.1016/j.jbi.2013.06.008

53. Huckvale K, van Velthoven MH, Cash-Gibson L, Felix L, Car J. Self-care using apps for smartphones and other mobile device software: a systematic review of the literature using the example of diabetes mellitus. PROSPERO 2011:CRD42011001429 (protocol). 2011. Available from: http://www.crd.york.ac.uk/Prospero/display_record.asp?ID=CRD42011001708#.UzyPyfldUuc.

54. Huckvale K, Car M, Morrison C, Car J. Apps for asthma self-management: a systematic assessment of content and tools. BMC Med. 2012;10:144. Medline:23171675. doi:10.1186/1741-7015-10-144

55. Martinez-Perez B, de la Torre-Diez I, Lopez-Coronado M. Mobile health applications for the most prevalent conditions by the World Health Organization: review and analysis. J Med Internet Res. 2013;15:e120. Medline:23770578. doi:10.2196/jmir.2600

56. van Velthoven MH, Brusamento S, Majeed A, Car J. Scope and effectiveness of mobile phone messaging for HIV/AIDS care: a systematic review. Psychol Health Med. 2013;18:182-202. Medline:22788357. doi:10.1080/13548506.2012.701310

57. Braun R, Catalani C, Wimbush J, Israelski D. Community health workers and mobile technology: a systematic review of the literature. PLoS One. 2013;8:e65772. Medline:23776544 doi:10.1371/journal.pone.0065772

58. Free C, Phillips G, Watson L, Galli L, Felix L, Edwards P, et al. The effectiveness of mobile-health technologies to improve health care service delivery processes: a systematic review and meta-analysis. PLoS Med. 2013;10:e1001363. Medline:23458994. doi:10.1371/journal.pmed.1001363

59. Chatfield A, Javetski G, Fletcher A, Lesh N. CommCare Evidence Base. 2014. Available from: https://confluence.dimagi.com/display/commcarepublic/CommCare+Evidence+Base. Accessed 9 May 2014.

60. Chib A, van Velthoven MH, Car J. mHealth adoption in low-resource environments: a review of the use of mobile healthcare in developing countries. J Health Commun. 2014. Medline:24673171. doi:10.1080/10810730.2013.864735

61. Hu SS, Balluz L, Battaglia MP, Frankel MR. The impact of cell phones on public health surveillance. Bull World Health Organ. 2010;88:799. Medline:21076555. doi:10.2471/blt.10.082669

62. AbouZahr C, Boerma T. Health information systems: the foundations of public health. Bull World Health Organ. 2005;83:578-83. Medline:16184276. doi:10.1590/S0042-96862005000800010

63. Rodrigues RJ. Information systems: the key to evidence-based health practice. Bull World Health Organ. 2000;78:1344-51. Medline:11143195

64. Stansfield SK, Walsh J, Prata N, Evans T. Information to improve decision making for health. In: Jamison DT BJ, Measham AR, et al., ed. Disease Control Priorities in Developing Countries. 2nd ed. Washington, DC: World Bank; 2006.

65. Bowling A. Mode of questionnaire administration can have serious effects on data quality. J Public Health (Oxf). 2005;27:281-91. Medline:15870099. doi:10.1093/pubmed/fdi031

66. Wilkins K, Nsubuga P, Mendlein J, Mercer D, Pappaioanou M. The data for decision making project: assessment of surveillance systems in developing countries to improve access to public health information. Public Health. 2008;122:914-22. Medline:18490035. doi:10.1016/j.puhe.2007.11.002

67. Hancioglu A, Arnold F. Measuring coverage in MNCH: tracking progress in health for women and children using DHS and MICS household surveys. PLoS Med. 2013;10:e1001391. Medline:23667333. doi:10.1371/journal.pmed.1001391

68. Üstun TB, Chatterji S, Mechbal A, Murray CJL. Chapter X Quality assurance in surveys: standards, guidelines and procedures. Household Sample Surveys in Developing and Transition Countries: United Nations; 2005:199-230.

69. Tomlinson M, Solomon W, Singh Y, Doherty T, Chopra M, Ijumba P, et al. The use of mobile phones as a data collection tool: a report from a household survey in South Africa. BMC Med Inform Decis Mak. 2009;9:51. Medline:20030813. doi:10.1186/1472-6947-9-51

70. Lane SJ, Heddle NM, Arnold E, Walker I. A review of randomized controlled trials comparing the effectiveness of hand held computers with paper methods for data collection. BMC Med Inform Decis Mak. 2006;6:23. Medline:16737535. doi:10.1186/1472-6947-6-23

71. Zhang S, Wu Q, van Velthoven MH, Chen L, Car J, Rudan I, et al. Smartphone versus pen-and-paper data collection of infant feeding practices in rural China. J Med Internet Res. 2012;14:e119. Medline:22989894. doi:10.2196/jmir.2183

72. Forster D, Behrens RH, Campbell H, Byass P. Evaluation of a computerized field data collection system for health surveys. Bull World Health Organ. 1991;69:107-11. Medline:2054915

73. Aanensen DM, Huntley DM, Feil EJ, al-Own Fa, Spratt BG. EpiCollect: linking smartphones to web applications for epidemiology, ecology and community data collection. PLoS One. 2009;4:e6968. Medline:19756138. doi:10.1371/journal.pone.0006968

74. Magpi website. Available at: https://www.magpi.com/login/auth. Accessed 9 May 2014.

75. Opendatakit website. Available at: http://opendatakit.org/. Accessed 9 May 2014.

76. Blaya JA, Fraser HS, Holt B. E-health technologies show promise in developing countries. Health Aff (Millwood). 2010;29:244-51. Medline:20348068. doi:10.1377/hlthaff.2009.0894

77. The UN inter-agency group for child mortality estimation report 2013: levels and trends in child mortality. United Nation's Children's Fund/World Health Organization/World Bank; 2013. Available from: http://www.who.int/maternal_child_adolescent/documents/levels_trends_child_mortality_2013.pdf?ua=1. Accessed 9 May 2014.

78. Preamble to the constitution of the World Health Organization as adopted by the International Health Conference. World Health Organization; 1946. Available from: http://www.who.int/about/definition/en/print.html. Accessed 9 May 2014.

79. Declaration of Alma-Ata International Conference on Primary Health Care. World Health Organization; 1978. Available from: http://www.who.int/publications/almaata_declaration_en.pdf. Accessed 9 May 2014.

80. World health report - Health systems: improving performance. World Health Organization; 2000. Available from: http://www.who.int/whr/2000/en/whr00_en.pdf?ua=1. Accessed 9 May 2014.

81. United Nations Millennium Declaration. United Nations; 2000. Available from: http://www.unmillenniumproject.org/documents/ares552e.pdf. Accessed 9 May 2014.

82. Road map towards the implementation of the UN millennium declaration Report of the Secretary-General. United Nations; 2001. Available from: http://www.unmillenniumproject.org/documents/a56326.pdf. Accessed 9 May 2014.

83. Waage J, Banerji R, Campbell O, Chirwa E, Collender G, Dieltiens V, et al. The Millennium Development Goals: a cross-sectoral analysis and principles for goal setting after 2015. Lancet. 2010;376:991-1023. Medline:20833426. doi:10.1016/s0140-6736(10)61196-8

84. Claeson M, Gillespie D, Mshinda H, Troedsson H, Victora CG. Knowledge into action for child survival. Lancet. 2003;362:323-7. Medline:12892965. doi:10.1016/S0140-6736(03)13977-3

85. Requejo JH, Newby H, Bryce J. Measuring coverage in MNCH: challenges and opportunities in the selection of coverage indicators for global monitoring. PLoS Med. 2013;10:e1001416. Medline:23667336. doi:10.1371/journal.pmed.1001416

86. Bryce J, Black R, Victora C. Millennium Development Goals 4 and 5: progress and challenges. BMC Medicine. 2013;11:225. Medline:24228742 [PubMed - in process] doi:10.1186/1741-7015-11-225

87. Handbook integrated management of childhood illness. World Health Organization; 2005. Available from: http://whqlibdoc.who.int/publications/2005/9241546441.pdf. Accessed 9 May 2014.

88. Diarrhoeal disease fact sheet N°330. World Health Organization; 2013. Available from: http://www.who.int/mediacentre/factsheets/fs330/en/. Accessed 9 May 2014.

89. Pneumonia and diarrhoea: Tackling the deadliest diseases for the world's poorest children. United Nations Children's Fund; 2012. Available from: http://www.unicef.org/media/files/UNICEF_P_D_complete_0604.pdf. Accessed 9 May 2014.

90. Fischer Walker CL, Black RE. Zinc for the treatment of diarrhoea: effect on diarrhoea morbidity, mortality and incidence of future episodes. Int J Epidemiol. 2010;39 Suppl 1:i63-9. Medline:20348128. doi:10.1093/ije/dyq023

91. Pneumonia fact sheet N°331. World Health Organization; 2013. Available from: http://www.who.int/mediacentre/factsheets/fs331/en/. Accessed 9 May 2014.

92. Rudan I, O'Brien KL, Nair H, Liu L, Theodoratou E, Qazi S, et al. Epidemiology and etiology of childhood pneumonia in 2010: estimates of incidence, severe morbidity, mortality, underlying risk factors and causative pathogens for 192 countries. J Glob Health. 2013;3:10401. Medline:23826505. doi:10.7189/jogh.03.010401

93. Fischer Walker CL, Perin J, Katz J, Tielsch JM, Black RE. Diarrhea as a risk factor for acute lower respiratory tract infections among young children in low income settings. J Glob Health. 2013;3:010402. Medline:23826506. doi:10.7189/jogh.03.010402

94. Campbell H, El Arifeen S, Hazir T, O'Kelly J, Bryce J, Rudan I, et al. Measuring coverage in MNCH: challenges in monitoring the proportion of young children with pneumonia who receive antibiotic treatment. PLoS Med. 2013;10:e1001421. Medline:23667338. doi:10.1371/journal.pmed.1001421

95. Fischer Walker CL, Rudan I, Liu L, Nair H, Theodoratou E, Bhutta ZA, et al. Global burden of childhood pneumonia and diarrhoea. Lancet. 2013;381:1405-16. Medline:23582727. doi:10.1016/s0140-6736(13)60222-6

96. Rudan I, Tomaskovic L, Boschi-Pinto C, Campbell H. Global estimate of the incidence of clinical pneumonia among children under five years of age. Bull World Health Organ. 2004;82:895-903. Medline:15654403. doi:/S0042-96862004001200005

97. Fischer Walker CL, Perin J, Aryee MJ, Boschi-Pinto C, Black RE. Diarrhea incidence in low- and middle-income countries in 1990 and 2010: a systematic review. BMC Public Health. 2012;12:220. Medline:22436130. doi:10.1186/1471-2458-12-220
98. Checkley W, Buckley G, Gilman RH, Assis AM, Guerrant RL, Morris SS, et al. Multi-country analysis of the effects of diarrhoea on childhood stunting. Int J Epidemiol. 2008;37:816-30. Medline:18567626. doi:10.1093/ije/dyn099
99. Edmond K, Scott S, Korczak V, Ward C, Sanderson C, Theodoratou E, et al. Long term sequelae from childhood pneumonia; systematic review and meta-analysis. PLoS One. 2012;7:e31239. Medline:22384005. doi:10.1371/journal.pone.0031239
100. Rudan I, Boschi-Pinto C, Biloglav Z, Mulholland K, Campbell H. Epidemiology and etiology of childhood pneumonia. Bull World Health Organ. 2008;86:408-16. Medline:18545744
101. Gill CJ, Young M, Schroder K, Carvajal-Velez L, McNabb M, Aboubaker S, et al. Bottlenecks, barriers, and solutions: results from multicountry consultations focused on reduction of childhood pneumonia and diarrhoea deaths. Lancet. 2013;381:1487-98. Medline:23582720. doi:10.1016/s0140-6736(13)60314-1
102. Bhutta ZA, Das JK, Walker N, Rizvi A, Campbell H, Rudan I, et al. Interventions to address deaths from childhood pneumonia and diarrhoea equitably: what works and at what cost? Lancet. 2013;381:1417-29. Medline:23582723. doi:10.1016/s0140-6736(13)60648-0
103. Chopra M, Mason E, Borrazzo J, Campbell H, Rudan I, Liu L, et al. Ending of preventable deaths from pneumonia and diarrhoea: an achievable goal. Lancet. 2013;381:1499-506. Medline:23582721. doi:10.1016/s0140-6736(13)60319-0
104. Rudan I, Nair H, Marusic A, Campbell H. Reducing mortality from childhood pneumonia and diarrhoea: The leading priority is also the greatest opportunity. J Glob Health. 2013;3:10101. Medline:23826497. doi:10.7189/jogh.03.010101

105. Simpson E, Zwisler G, Moodley M. Survey of caregivers in Kenya to assess perceptions of zinc as a treatment for diarrhea in young children and adherence to recommended treatment behaviors. J Glob Health. 2013;3:010405. Medline:23826509. doi:10.7189/jogh.03.010405

106. Zwisler G, Simpson E, Moodley M. Treatment of diarrhea in young children: results from surveys on the perception and use of oral rehydration solutions, antibiotics, and other therapies in India and Kenya. J Glob Health. 2013;3:010403. Medline:23826507. doi:10.7189/jogh.03.010403

107. Rudan I, El Arifeen S, Black RE, Campbell H. Childhood pneumonia and diarrhoea: setting our priorities right. The Lancet infectious diseases. 2007;7:56-61. Medline:17182344. doi:10.1016/s1473-3099(06)70687-9

108. Herbert HK, Lee AC, Chandran A, Rudan I, Baqui AH. Care seeking for neonatal illness in low- and middle-income countries: a systematic review. PLoS Med. 2012;9:e1001183. Medline:22412355. doi:10.1371/journal.pmed.1001183

109. Goldman N, Pebley AR, Gragnolati M. Choices about treatment for ARI and diarrhea in rural Guatemala. Social science & medicine (1982). 2002;55:1693-712. Medline:12383456

110. Bruce N, Pope D, Arana B, Shiels C, Romero C, Klein R, et al. Determinants of care seeking for children with pneumonia and diarrhea in guatemala: implications for intervention strategies. Am J Public Health. 2014;104:647-57. Medline:24524510. doi:10.2105/ajph.2013.301658

111. Wilson SE, Ouedraogo CT, Prince L, Ouedraogo A, Hess SY, Rouamba N, et al. Caregiver recognition of childhood diarrhea, care seeking behaviors and home treatment practices in rural Burkina Faso: a cross-sectional survey. PLoS One. 2012;7:e33273. Medline:22428006. doi:10.1371/journal.pone.0033273

112. Najnin N, Bennett CM, Luby SP. Inequalities in care-seeking for febrile illness of under-five children in urban Dhaka, Bangladesh. Journal of health, population, and nutrition. 2011;29:523-31. Medline:22106759

113. Ending Preventable Child Deaths from Pneumonia and Diarrhoea by 2025. World Health Organization; 2013. Available from: http://apps.who.int/iris/bitstream/10665/79200/1/9789241505239_eng.pdf . Accessed 9 May 2014.

114. Sakisaka K, Jimba M, Hanada K. Changing poor mothers' care-seeking behaviors in response to childhood illness: findings from a cross-sectional study in Granada, Nicaragua. BMC Int Health Hum Rights. 2010;10:10. Medline:20515485. doi:10.1186/1472-698x-10-10

115. Chandran A, Herbert HK, Lee AC, Rudan I, Baqui AH. Assessment of the proportion of neonates and children in low and middle income countries with access to a healthcare facility: A systematic review. BMC Res Notes. 2011;4:536. Medline:22166258. doi:10.1186/1756-0500-4-536

116. Olaogun AA, Adebayo AA, Ayandiran OE, Olasode OA. Effects of mothers' socio-economic status on the management of febrile conditions in their under five children in a resource limited setting. BMC Int Health Hum Rights. 2006;6:1. Medline:16426450. doi:10.1186/1472-698x-6-1

117. Hertel-Fernandez AW, Giusti AE, Sotelo JM. The Chilean infant mortality decline: improvement for whom? Socioeconomic and geographic inequalities in infant mortality, 1990-2005. Bull World Health Organ. 2007;85:798-804. Medline:18038062

118. Wazny K, Zipursky A, Black R, Curtis V, Duggan C, Guerrant R, et al. Setting research priorities to reduce mortality and morbidity of childhood diarrhoeal disease in the next 15 years. PLoS Med. 2013;10:e1001446. Medline:23690756. doi:10.1371/journal.pmed.1001446

119. Rudan I, El Arifeen S, Bhutta ZA, Black RE, Brooks A, Chan KY, et al. Setting research priorities to reduce global mortality from childhood pneumonia by 2015. PLoS Med. 2011;8:e1001099. Medline:21980266. doi:10.1371/journal.pmed.1001099

120. Fontaine O, Kosek M, Bhatnagar S, Boschi-Pinto C, Chan KY, Duggan C, et al. Setting research priorities to reduce global mortality from childhood diarrhoea by 2015. PLoS Med. 2009;6:e41. Medline:19278292. doi:10.1371/journal.pmed.1000041

121. IMCI and health systems strengthening. World Health Organization; 2012. Available from: http://www.wpro.who.int/child_adolescent_health/documents/info_package7.pdf. Accessed 9 May 2014.

122. China Health and Nutrition survey website. Available at: http://www.cpc.unc.edu/projects/china. Accessed 9 May 2014.

123. Demographic and Health Surveys website. United States Agency for International Development. Available at: http://dhsprogram.com/. Accessed 9 May 2014.

124. Multiple Indicator Cluster Surveys website. United Nations Children's Fund. Available at: http://www.childinfo.org/mics.html. Accessed 9 May 2014.

125. Herman E, Cutts F, Soares A. Assessing diarrhoea-induced dehydration at the community level. The Journal of tropical medicine and hygiene. 1991;94:224-30. Medline:1880822

126. Lanata CF, Quintanilla N, Verastegui HA. Validity of a respiratory questionnaire to identify pneumonia in children in Lima, Peru. Int J Epidemiol. 1994;23:827-34. Medline:8002198

127. Yansaneh IS. Chapter XII An analysis of cost issues for surveys in developing and transition countries. Household Sample Surveys in Developing and Transition Countries: United Nations; 2005:253-66.

128. Raven JH, Chen Q, Tolhurst RJ, Garner P. Traditional beliefs and practices in the postpartum period in Fujian Province, China: a qualitative study. BMC Pregnancy Childbirth. 2007;7:8. Medline:17584930. doi:10.1186/1471-2393-7-8

129. Lepkowski J. Chapter VIII Non-observation error in household surveys in developing countries. Household Sample Surveys in Developing and Transition Countries: United Nations; 2005:149-70.

130. Bryce J, Arnold F, Blanc A, Hancioglu A, Newby H, Requejo J, et al. Measuring coverage in MNCH: new findings, new strategies, and recommendations for action. PLoS Med. 2013;10:e1001423. Medline:23667340. doi:10.1371/journal.pmed.1001423

131. Fischer Walker CL, Fontaine O, Black RE. Measuring coverage in MNCH: current indicators for measuring coverage of diarrhea treatment interventions and opportunities for improvement. PLoS Med. 2013;10:e1001385. Medline:23667330. doi:10.1371/journal.pmed.1001385

132. Lanata CF, Rudan I, Boschi-Pinto C, Tomaskovic L, Cherian T, Weber M, et al. Methodological and quality issues in epidemiological studies of acute lower respiratory infections in children in developing countries. Int J Epidemiol. 2004;33:1362-72. Medline:15166188. doi:10.1093/ije/dyh229

133. Birnbaum B, DeRenzi B, Flaxman AD, Lesh N. Automated quality control for mobile data collection. Proceedings of the 2nd ACM Symposium on Computing for Development. Atlanta, Georgia: ACM; 2012:1-10.

134. Streiner DL, Norman GR. Methods of administration. Health measurement scales: a practical guide to their development and use. 4th ed. Oxford: Oxford University Press; 2008:331-64.

135. O'Toole J, Sinclair M, Leder K. Maximising response rates in household telephone surveys. BMC Med Res Methodol. 2008;8:71. Medline:18980694. doi:10.1186/1471-2288-8-71

136. De Leeuw E, van der Zouwen J. Data quality in telephone and face-to-face surveys: a comparative meta-analysis. In: Groves R, Biemer P, Lyberg L, eds. Telephone survey methodology. New York: John Wiley and Sons; 1988:283-300.

137. Morrison DM, Leigh BC, Gillmore MR. Daily data collection: a comparison of three methods. The Journal of Sex Research. 1999;36:76-81. doi:10.1080/00224499909551970

138. Li Y, Wang W, van Velthoven MH, Chen L, Car J, Rudan I, et al. Text messaging data collection for monitoring an infant feeding intervention program in rural China: feasibility study. J Med Internet Res. 2013;15:e269. Medline:24305514. doi:10.2196/jmir.2906

139. Lee YW, Strong DM, Kahn BK, Wang RY. AIMQ: a methodology for information quality assessment. Inf. Manage. 2002;40:133-46. doi:10.1016/s0378-7206(02)00043-5

140. Arber S. Designing samples. In: Gilbert N, ed. Researching Social Life. London: SAGE Publications; 2001.

141. Kasprzyk D. Chapter IX Measurement error in household surveys: sources and measurement. Household Sample Surveys in Developing and Transition Countries: United Nations; 2005:171-98.

142. Shapiro JS, Bessette MJ, Baumlin KM, Ragin DF, Richardson LD. Automating research data collection. Academic emergency medicine : official journal of the Society for Academic Emergency Medicine. 2004;11:1223-8. Medline:15528588. doi:10.1197/j.aem.2004.08.017

143. Marcano Belisario JS, Huckvale K, Greenfield G, Car J, Gunn LH. Smartphone and tablet self management apps for asthma. Cochrane Database Syst Rev. 2013;11:Cd010013. Medline:24282112. doi:10.1002/14651858.CD010013.pub2

144. Marcano Belisario JS, Huckvale K, Saje A, Porcnik A, Morrison CP, Car J. Comparison of self administered survey questionnaire responses collected using mobile apps versus other methods. Cochrane Database Syst Rev. 2014. Medline:MR000042. doi:10.1002/14651858.MR000042

145. Smith C, Vannak U, Sokhey L, Cockroft M. Overcoming mHealth operational challenges in Cambodia. JMTM. 2013;2:20-3. doi:10.7309/jmtm.2.3.6

146. Chakraborty D, Medhi I, Cutrell E, Thies W. Man versus machine: evaluating IVR versus a live operator for phone surveys in India. Paper presented at: ACM Symposium on Computing for Development (ACM DEV)2013.

147. Zhang Y, Chen L, van Velthoven MH, Wang W, Liu L, Du X, et al. mHealth Series: Measuring maternal newborn and child health coverage by text messaging - a county-level model for China. J Glob Health. 2013;3:20402. Medline:24363920. doi:10.7189/jogh.03.020402

148. Rajatonirina S, Heraud JM, Randrianasolo L, Orelle A, Razanajatovo NH, Raoelina YN, et al. Short message service sentinel surveillance of influenza-like illness in Madagascar, 2008-2012. Bull World Health Organ. 2012;90:385-9. Medline:22589573. doi:10.2471/blt.11.097816

149. Lemay NV, Sullivan T, Jumbe B, Perry CP. Reaching remote health workers in Malawi: baseline assessment of a pilot mHealth intervention. J Health Commun. 2012;17 Suppl 1:105-17. Medline:22548604. doi:10.1080/10810730.2011.649106

150. Andreatta P, Debpuur D, Danquah A, Perosky J. Using cell phones to collect postpartum hemorrhage outcome data in rural Ghana. International Journal of Gynecology & Obstetrics. 2011;113:148-51. Medline:21420086. doi:10.1016/j.ijgo.2010.11.020

151. Alam M, Khanam T, Khan R, Raihan A, Chowdhury M. Assessing the scope for use of mobile based solution to improve maternal and child health in Bangladesh: A case study on efficiency of community health workers, automated risk assessment of patients and web based data collection. ICT4D; 2010. Available from: http://www.gg.rhul.ac.uk/ict4d/ictd2010/posters/ICTD2010%20Alam%20et%20al.pdf. Accessed 9 May 2014.

152. Svoronos T, Mjungub D, Dhadialla P, Luk R, Zue C, Jackson J, et al. CommCare: automated quality improvement to strengthen community-based health. 2010. Available from: http://d-tree.org/wp-content/uploads/2010/05/Svoronos-Medinfo-CommCare-safe-pregnancy1.pdf. Accessed 9 May 2014.

153. Kaewkungwal J, Singhasivanon P, Khamsiriwatchara A, Sawang S, Meankaew P, Wechsart A. Application of smart phone in "Better Border Healthcare Program": a module for mother and child care. BMC Med Inform Decis Mak. 2010;10:69. Medline:21047412. doi:10.1186/1472-6947-10-69

154. Mobile technology for cummunity health in Ghana. Grameen Foundation; 2012. Available from: http://www.grameenfoundation.org/sites/grameenfoundation.org/files/MOTECH-Lessons-Learned-Sept-2012.pdf.

155. Barrington J, Wereko-Brobby O, Ward P, Mwafongo W, Kungulwe S. SMS for Life: a pilot project to improve anti-malarial drug supply management in rural Tanzania using standard technology. Malar J. 2010;9:298. Medline:20979633. doi:10.1186/1475-2875-9-298

156. Yang C, Yang J, Luo X, Gong P. Use of mobile phones in an emergency reporting system for infectious disease surveillance after the Sichuan earthquake in China. Bull World Health Organ. 2009;87:619-23. Medline:19705013

157. Skinner D, Rivette U, Bloomberg C. Evaluation of use of cellphones to aid compliance with drug therapy for HIV patients.[Erratum appears in AIDS Care. 2007 Aug;19(7):953 Note: Donald, S [removed]; Ulrike, R [corrected to Rivette, U]; Charissa, B [corrected to Bloomberg, C]]. AIDS Care. 2007;19:605-7. Medline:17505920

158. Axen I, Bodin L, Kongsted A, Wedderkopp N, Jensen I, Bergstrom G. Analyzing repeated data collected by mobile phones and frequent text messages. An example of low back pain measured weekly for 18 weeks. BMC Med Res Methodol. 2012;12:105. Medline:22824413. doi:10.1186/1471-2288-12-105

159. Du X, Wang W, Velthoven MH, Chen L, Scherpbier RW, Zhang Y, et al. mHealth Series: Text messaging data collection of infant and young child feeding practice in rural China - a feasibility study. J Glob Health. 2013;3:020403. Medline:24363921. doi:10.7189/jogh.03.020403

160. L'Engle KL, Vahdat HL, Ndakidemi E, Lasway C, Zan T. Evaluating feasibility, reach and potential impact of a text message family planning information service in Tanzania. Contraception. 2013;87:251-6. Medline:22935322. doi:10.1016/j.contraception.2012.07.009

161. Macedo LG, Maher CG, Latimer J, McAuley JH. Feasibility of using short message service to collect pain outcomes in a low back pain clinical trial. Spine. 2012;37:1151-5. Medline:22146289. doi:10.1097/BRS.0b013e3182422df0

162. Suffoletto B, Callaway C, Kristan J, Kraemer K, Clark DB. Text-message-based drinking assessments and brief interventions for young adults discharged from the emergency department. Alcoholism, clinical and experimental research. 2012;36:552-60. Medline:22168137. doi:10.1111/j.1530-0277.2011.01646.x

163. Baird J, Ranney ML, Mello MJ. Comment on the paper by Suffoletto et al. entitled: Text-message-based assessments and brief intervention for young adults discharged from the emergency department. Alcoholism, clinical and experimental research. 2012;36:395-7. Medline:22236062. doi:10.1111/j.1530-0277.2011.01710.x

164. Whitford HM, Donnan PT, Symon AG, Kellett G, Monteith-Hodge E, Rauchhaus P, et al. Evaluating the reliability, validity, acceptability, and practicality of SMS text messaging as a tool to collect research data: results from the Feeding Your Baby project. J Am Med Inform Assoc. 2012;19:744-9. Medline:22539081. doi:10.1136/amiajnl-2011-000785

165. Moller M, Attermann J, Myklebust G, Wedderkopp N. Injury risk in Danish youth and senior elite handball using a new SMS text messages approach. Br J Sports Med. 2012;46:531-7. Medline:22554848. doi:10.1136/bjsports-2012-091022

166. Axen I, Bodin L, Bergstrom G, Halasz L, Lange F, Lovgren PW, et al. The use of weekly text messaging over 6 months was a feasible method for monitoring the clinical course of low back pain in patients seeking chiropractic care. J Clin Epidemiol. 2012;65:454-61. Medline:22169083. doi:10.1016/j.jclinepi.2011.07.012

167. Magee M, Isakov A, Paradise HT, Sullivan P. Mobile phones and short message service texts to collect situational awareness data during simulated public health critical events. American journal of disaster medicine. 2011;6:379-85. Medline:22338318

168. Schembre SM, Yuen J. Project TwEATs. A feasibility study testing the use of automated text messaging to monitor appetite ratings in a free-living population. Appetite. 2011;56:465-8. Medline:21251941. doi:10.1016/j.appet.2011.01.014

169. Haberer JE, Kiwanuka J, Nansera D, Wilson IB, Bangsberg DR. Challenges in using mobile phones for collection of antiretroviral therapy adherence data in a resource-limited setting. AIDS Behav. 2010;14:1294-301. Medline:20532605. doi:10.1007/s10461-010-9720-1

170. Johansen B, Wedderkopp N. Comparison between data obtained through real-time data capture by SMS and a retrospective telephone interview. Chiropr Osteopat. 2010;18:10. Medline:20500900. doi:10.1186/1746-1340-18-10

171. Lim MS, Sacks-Davis R, Aitken CK, Hocking JS, Hellard ME. Randomised controlled trial of paper, online and SMS diaries for collecting sexual behaviour information from young people. J Epidemiol Community Health. 2010;64:885-9. Medline:19767322. doi:10.1136/jech.2008.085316

172. Alfven G. SMS pain diary: a method for real-time data capture of recurrent pain in childhood. Acta Paediatr. 2010;99:1047-53. Medline:20219052. doi:10.1111/j.1651-2227.2010.01735.x

173. Kew S. Text messaging: an innovative method of data collection in medical research. BMC Res Notes. 2010;3:342. Medline:21172018. doi:10.1186/1756-0500-3-342

174. Kongsted A, Leboeuf-Yde C. The Nordic back pain subpopulation program--individual patterns of low back pain established by means of text messaging: a longitudinal pilot study. Chiropr Osteopat. 2009;17:11. Medline:19919715. doi:10.1186/1746-1340-17-11

175. Kuntsche E, Robert B. Short message service (SMS) technology in alcohol research--a feasibility study. Alcohol and alcoholism (Oxford, Oxfordshire). 2009;44:423-8. Medline:19482879. doi:10.1093/alcalc/agp033

176. Roberts A, Gorman A. Short message service for outpatient data collection. Br J Anaesth. 2009;102:436. Medline:19218377. doi:10.1093/bja/aen400

177. Bexelius C, Merk H, Sandin S, Ekman A, Nyren O, Kuhlmann-Berenzon S, et al. SMS versus telephone interviews for epidemiological data collection: feasibility study estimating influenza vaccination coverage in the Swedish population. Eur J Epidemiol. 2009;24:73-81. Medline:19082745. doi:10.1007/s10654-008-9306-7

178. Haller DM, Sanci LA, Patton GC, Sawyer SM. Text message communication in primary care research: a randomized controlled trial. Fam Pract. 2009;26:325-30. Medline:19542193. doi:10.1093/fampra/cmp040

179. Haller D, Sanci L, Sawyer S, Coffey C, Patton G. R U OK 2 TXT 4 RESEARCH?--feasibility of text message communication in primary care research. Aust Fam Physician. 2006;35:175-6. Medline:16525536

180. Anhøj J, Moldrup C. Feasibility of collecting diary data from asthma patients through mobile phones and SMS (short message service): response rate analysis and focus group evaluation from a pilot study. J Med Internet Res. 2004;6:e42. Medline:15631966. doi:10.2196/jmir.6.4.e42

181. Howitt P, Darzi A, Yang GZ, Ashrafian H, Atun R, Barlow J, et al. Technologies for global health. Lancet. 2012;380:507-35. Medline:22857974. doi:10.1016/s0140-6736(12)61127-1

182. Coiera E. Recent advances: medical informatics. BMJ. 1995;310:1381-7. Medline:7787545. doi:10.1136/bmj.310.6991.1381

183. van Heerden A, Tomlinson M, Swartz L. Point of care in your pocket: a research agenda for the field of m-health. Bull World Health Organ. 2012;90:393-4. Medline:22589575. doi:10.2471/blt.11.099788

184. Penicaud C. The State of Mobile Money Usage – How many people use mobile money globally? 2014. Available from: http://www.gsma.com/mobilefordevelopment/the-state-of-mobile-money-usage-how-many-people-use-mobile-money-globally. Accessed 9 May 2014.
185. Why does Kenya lead the world in mobile money? : The Economist; 2013. Available from: http://www.economist.com/blogs/economist-explains/2013/05/economist-explains-18. Accessed 9 May 2014.
186. Tomlinson M, Rotheram-Borus MJ, Swartz L, Tsai AC. Scaling up mHealth: where is the evidence? PLoS Med. 2013;10:e1001382. Medline:23424286. doi:10.1371/journal.pmed.1001382
187. Evaluating mHealth, adoption barriers: human behaviour insights guide. Vodafone mHealth Solutions; 2011. Available from: http://www.anthrologica.com/voda_guide.pdf. Accessed 9 May 2014.
188. Aranda-Jan CB, Mohutsiwa-Dibe N, Loukanova S. Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. BMC Public Health. 2014;14:188. Medline:24555733. doi:10.1186/1471-2458-14-188
189. van Velthoven MH, Majeed A, Car J. Text4baby – national scale up of an mHealth programme. Who benefits? J R Soc Med. 2012;105:452-3. Medline:23257962. doi:10.1258/jrsm.2012.120176
190. Nilsen W, Kumar S, Shar A, Varoquiers C, Wiley T, Riley WT, et al. Advancing the science of mHealth. J Health Commun. 2012;17 Suppl 1:5-10. Medline:22548593. doi:10.1080/10810730.2012.677394
191. Leon N, Schneider H, Daviaud E. Applying a framework for assessing the health system challenges to scaling up mHealth in South Africa. BMC Med Inform Decis Mak. 2012;12:123. Medline:23126370. doi:10.1186/1472-6947-12-123
192. Lemaine J. Scaling up mobile health; elements necessary for the succesful scale up of mHealth in developing countries. 2011. Available from: http://www.k4health.org/sites/default/files/ADA_mHealth%20White%20Paper.pdf. Accessed 9 May 2014.

193. Pop-Eleches C, Thirumurthy H, Habyarimana JP, Zivin JG, Goldstein MP, de Walque D, et al. Mobile phone technologies improve adherence to antiretroviral treatment in a resource-limited setting: a randomized controlled trial of text message reminders. AIDS (London, England). 2011;25:825-34. Medline:21252632. doi:10.1097/QAD.0b013e32834380c1

194. Leslie I, Sherrington S, Dicks D, Gray N, Chang T-T. Mobile communications for medical care - a study of current and future heatlhcare and health promotion applications, and their use in China and elsewhere. University of Cambridge; 2011. Available from: http://www.csap.cam.ac.uk/media/uploads/files/1/mobile-communications-for-medical-care.pdf. Accessed 9 May 2014.

195. Vodafone. The role of mobile phones in increasing accesibility and efficiency in healthcare. 2006. Available from: http://www.vodafone.com/content/dam/vodafone/about/public_policy/policy_papers/public_policy_series_4.pdf. Accessed 9 May 2014.

196. The bigger picture for e-health. Bull World Health Organ. 2012;90:330-1. Medline:22589565. doi:10.2471/blt.12.040512

197. Green paper on mobile Health ("mHealth") {SWD(2014) 135 final}. European Commission; 2014. Available from: https://ec.europa.eu/digital-agenda/en/news/green-paper-mobile-health-mhealth. Accessed 9 May 2014.

198. Flay BR, Biglan A, Boruch RF, Castro FG, Gottfredson D, Kellam S, et al. Standards of evidence: criteria for efficacy, effectiveness and dissemination. Prevention science : the official journal of the Society for Prevention Research. 2005;6:151-75. Medline:16365954

199. Olds DL, Sadler L, Kitzman H. Programs for parents of infants and toddlers: recent evidence from randomized trials. Journal of child psychology and psychiatry, and allied disciplines. 2007;48:355-91. Medline:17355402. doi:10.1111/j.1469-7610.2006.01702.x

200. Lester RT, Ritvo P, Mills EJ, Kariri A, Karanja S, Chung MH, et al. Effects of a mobile phone short message service on antiretroviral treatment adherence in Kenya (WelTel Kenya1): a randomised trial. Lancet. 2010;376:1838-45. Medline:21071074. doi:10.1016/s0140-6736(10)61997-6

201. Newell A. A mobile phone text message and Trichomonas vaginalis. Sex Transm Infect. 2001;77:225. Medline:11402245

202. Atun R, Sittampalam R, Mohan A. Uses and benefits of SMS in healthcare delivery Imperial College London 2005. Available from: http://www.sermos.nl/filesystem/downloads/imperial_college%20schotland.pdf. Accessed 9 May 2014.

203. Patrick K, Griswold WG, Raab F, Intille SS. Health and the mobile phone. Am J Prev Med. 2008;35:177-81. Medline:18550322. doi:10.1016/j.amepre.2008.05.001

204. Krishna S, Boren SA, Balas EA. Healthcare via cell phones: a systematic review. Telemed J E Health. 2009;15:231-40. Medline:19382860. doi:10.1089/tmj.2008.0099

205. Campbell NC, Murray E, Darbyshire J, Emery J, Farmer A, Griffiths F, et al. Designing and evaluating complex interventions to improve health care. BMJ. 2007;334:455-9. Medline:17332585. doi:10.1136/bmj.39108.379965.BE

206. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. BMJ. 2008;337:a1655. Medline:18824488. doi:10.1136/bmj.a1655

207. Developing and evaluating complex interventions: new guidance. Medical Research Council; 2008. Available from: http://www.mrc.ac.uk/documents/pdf/complex-interventions-guidance/. Accessed 9 May 2014.

208. Greenhalgh T, Russell J. Why do evaluations of eHealth programs fail? An alternative set of guiding principles. PLoS Med. 2010;7:e1000360. Medline:21072245. doi:10.1371/journal.pmed.1000360

209. Whittaker R. Issues in mHealth: findings from key informant interviews. J Med Internet Res. 2012;14:e129. Medline:23032424. doi:10.2196/jmir.1989

210. Keeton C. Measuring the impact of e-health. Bull World Health Organ. 2012;90:326-7. Medline:22589563. doi:10.2471/blt.12.020512

211. Fiordelli M, Diviani N, Schulz PJ. Mapping mHealth research: a decade of evolution. J Med Internet Res. 2013;15:e95. Medline:23697600. doi:10.2196/jmir.2430

212. Call to action on global eHealth evaluation The Bellagio eHealth Evaluation Group; 2011. Available from: https://sites.google.com/site/jhumhealth/BELLAGIO.pdf?attredirects=1. Accessed 9 May 2014.

213. Riley WT, Rivera DE, Atienza AA, Nilsen W, Allison SM, Mermelstein R. Health behavior models in the age of mobile interventions: are our theories up to the task? Transl Behav Med. 2011;1:53-71. Medline:21796270. doi:10.1007/s13142-011-0021-7

214. Strauss A, Corbin J. Basics of qualitative research: techniques and procedures for developing grounded theory. 3rd ed. Thousand Oaks, California, USA: Sage Publications; 2008. 379

215. Backman K, Kyngas HA. Challenges of the grounded theory approach to a novice researcher. Nursing & health sciences. 1999;1:147-53. Medline:10894637

216. Fishbein M, Ajzen I. Belief, attitude, intention and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley; 1975.

217. Huckvale K, Car J. Implementation of mobile health tools. JAMA. 2014;311:1447-8. Medline:24715083. doi:10.1001/jama.2014.1106

218. Capital Institute of Pediatrics website. Available at: http://www.shouer.com.cn/en/web/index.aspx. Accessed 9 May 2014.

219. Wu Q, van Velthoven MH, Chen L, Car J, Rudan D, Saftic V, et al. Improving the intake of nutritious food in children aged 6-23 months in Wuyi County, China -- a multi-method approach. Croat Med J. 2013;54:157-70. Medline:23630143. doi:10.3325/cmj.2013.54.157

220. Chen L, Dai Y, Zhang Y, Wu Q, Rudan D, Saftic V, et al. A comparison between antenatal care quality in public and private sector in rural Hebei, China. Croat Med J. 2013;54:146-56. Medline:23630142. doi:10.3325/cmj.2013.54.146

221. Chen L, Wu Q, van Velthoven MH, Zhang Y, Zhang S, Li Y, et al. Coverage, quality of and barriers to postnatal care in rural Hebei, China: a mixed method study. BMC Pregnancy Childbirth. 2014;14:31. Medline:24438644. doi:10.1186/1471-2393-14-31

222. Zhang Y, Wu Q, van Velthoven MH, Chen L, Car J, Li Y, et al. Care-seeking and quality of care for outpatient sick children in rural Hebei, China: a cross-sectional study. Croat Med J. 2013;54:541-9. Medline:24382848. doi:10.3325/cmj.2013.54.541

223. van Velthoven MH, Li Y, Wang W, Du X, Wu Q, Chen L, et al. mHealth Series: mHealth project in Zhao County, rural China - Description of objectives, field site and methods. J Glob Health. 2013;3:020401. Medline:24363919. doi:10.7189/jogh.03.020401

224. Coons SJ, Gwaltney CJ, Hays RD, Lundy JJ, Sloan JA, Revicki DA, et al. Recommendations on evidence needed to support measurement equivalence between electronic and paper-based patient-reported outcome (PRO) measures: ISPOR ePRO Good Research Practices Task Force report. Value Health. 2009;12:419-29. Medline:19900250. doi:10.1111/j.1524-4733.2008.00470.x

225. Creswell JW. Quantitative methods. Research design: qualitative, quantitative and mixed methods approaches. Vol 3. Thousand Oaks, California: SAGE Publications; 2009:145-72.

226. Pope C, Mays N. Reaching the parts other methods cannot reach: an introduction to qualitative methods in health and health services research. BMJ. 1995;311:42-5. Medline:7613329

227. Malterud K. The art and science of clinical knowledge: evidence beyond measures and numbers. Lancet. 2001;358:397-400. Medline:11502338. doi:10.1016/s0140-6736(01)05548-9

228. Greenhalgh T, Taylor R. Papers that go beyond numbers (qualitative research). BMJ. 1997;315:740-3. Medline:9314762

229. Creswell JW. The selection of a research design. Research design: qualitative, quantitative and mixed methods approaches. Vol 3. Thousand Oaks, California: SAGE Publications; 2009:3-21.

230. Malterud K. Qualitative research: standards, challenges, and guidelines. Lancet. 2001;358:483-8. Medline:11513933. doi:10.1016/s0140-6736(01)05627-6

231. Mays N, Pope C. Rigour and qualitative research. BMJ. 1995;311:109-12. Medline:7613363

232. Creswell JW. Mixed methods procedures. Research design: qualitative, quantitative and mixed methods approaches. Vol 3. Thousand Oaks, California: SAGE Publications; 2009:203-25.

233. Lingard L, Albert M, Levinson W. Grounded theory, mixed methods, and action research. BMJ. 2008;337:a567. Medline:18687728

234. Stange KC. In this issue: multimethod research. Ann Fam Med 2004;2:2-3. doi:10.1370/afm.110
235. Jick TD. Mixing qualitative and quantitative methods: triangulation in action. Administrative Science Quarterly. 1979;24:602-11. doi:10.2307/2392366
236. Protheroe J, Bower P, Chew-Graham C. The use of mixed methodology in evaluating complex interventions: identifying patient factors that moderate the effects of a decision aid. Family Practice. 2007;24:594-600. doi:10.1093/fampra/cmm066
237. Creswell JW, Plano Clark VL. The nature of mixed methods research. Designing and conducting mixed methods research. Thousand Oaks, CA: Sage; 2007:5.
238. Teddlie C, Tashakkori A. Overview of contempory issues in mixed methods research. Handbook of Mixed Methods in Social & Behavioral Research. Vol 2: Sage; 2010:1-41.
239. Wisdom JP, Cavaleri MA, Onwuegbuzie AJ, Green CA. Methodological reporting in qualitative, quantitative, and mixed methods health services research articles. Health services research. 2012;47:721-45. Medline:22092040. doi:10.1111/j.1475-6773.2011.01344.x
240. Johnson RB, Onwuegbuzie AJ, A. TL. Toward a Definition of Mixed Methods Research Journal of Mixed Methods Research 2007;1:112-33. doi:10.1177/1558689806298224
241. Guba EG. The alternative paradigm dialog. In: Guba EG, ed. The paradigm dialog. Newbury Park, CA: Sage; 1990:17.
242. Baum F. Researching public health: behind the qualitative-quantitative methodological debate. Social science & medicine (1982). 1995;40:459-68. Medline:7725120
243. Ozawa S, Pongpirul K. 10 best resources on ... mixed methods research in health systems. Health Policy Plan. 2013. Medline:23564372. doi:10.1093/heapol/czt019
244. Morrow M, Nguyen QA, Caruana S, Biggs BA, Doan NH, Nong TT. Pathways to malaria persistence in remote central Vietnam: a mixed-method study of health care and the community. BMC Public Health. 2009;9:85. Medline:19309519. doi:10.1186/1471-2458-9-85

245. Njeru MK, Blystad A, Shayo EH, Nyamongo IK, Fylkesnes K. Practicing provider-initiated HIV testing in high prevalence settings: consent concerns and missed preventive opportunities. BMC Health Serv Res. 2011;11:87. Medline:21507273. doi:10.1186/1472-6963-11-87

246. Ranson MK, Jayaswal R, Mills AJ. Strategies for coping with the costs of inpatient care: a mixed methods study of urban and rural poor in Vadodara District, Gujarat, India. Health Policy Plan. 2012;27:326-38. Medline:21653545. doi:10.1093/heapol/czr044

247. Long Q, Li Y, Wang Y, Yue Y, Tang C, Tang S, et al. Barriers to accessing TB diagnosis for rural-to-urban migrants with chronic cough in Chongqing, China: a mixed methods study. BMC Health Serv Res. 2008;8:202. Medline:18828929. doi:10.1186/1472-6963-8-202

248. Kelley K, Clark B, Brown V, Sitzia J. Good practice in the conduct and reporting of survey research. International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua. 2003;15:261-6. Medline:12803354

249. Britten N. Qualitative interviews in medical research. BMJ. 1995;311:251-3. Medline:7627048

250. Patton MQ. Qualitative interviewing. Qualitative research and evaluation methods. Vol 3. Thousand Oaks, California: Sage; 2002:339-80.

251. Willis G. Cognitive Interviewing, A “How To” Guide 1999. Available from: http://www.dfpp.univr.it/documenti/OccorrenzaIns/matdid/matdid823948.pdf. Accessed 9 May 2014.

252. van Velthoven MH, Li Y, Wang W, Du X, Chen L, Wu Q, et al. mHealth Series: Factors influencing sample size calculations for mHealth-based studies - A mixed methods study in rural China. J Glob Health. 2013;3:020404. Medline:24363922. doi:10.7189/jogh.03.020404

253. Patton MQ. Fieldwork strategies and observation methods. Qualitative research and evaluation methods. Vol 3. Thousand Oaks, California: Sage; 2002:259-338.

254. Mays N, Pope C. Qualitative research: observational methods in health care settings. BMJ. 1995;311:182-4. Medline:7613435

255. People's Republic of China public administration country profile. United Nations; 2006. Available from: http://unpan1.un.org/intradoc/groups/public/documents/un/unpan023305.pdf. Accessed 9 May 2014.
256. China profile: Timeline. BBC. Available from: http://www.bbc.co.uk/news/world-asia-pacific-13017882. Accessed 9 May 2014.
257. Report for selected countries and subjects. International Monetary Fund; 2013. Available from: http://www.imf.org/external/pubs/ft/weo/2013/01/weodata/weorept.aspx?sy=1980&ey=2018&sort=country&ds=.&br=1&pr1.x=40&pr1.y=0&c=924&s=NGDP_RPCH%2CPPPPC&grp=0&a=. Accessed 9 May 2014.
258. China overview. World Bank. Available from: http://www.worldbank.org/en/country/china/overview. Accessed 9 May 2014.
259. Hofman B. How urbanization can help the poor. China Daily; 2014. Available from: http://www.chinadaily.com.cn/opinion/2014-04/17/content_17439811.htm. Accessed 9 May 2014.
260. Chen J, Chen S, Landry PF. Migration, environmental hazards, and health outcomes in China. Social Science & Medicine. 2013;80:85-95. doi:10.1016/j.socscimed.2012.12.002
261. China: Building the dream. The Economist; 2014. Available from: http://www.economist.com/news/special-report/21600797-2030-chinese-cities-will-be-home-about-1-billion-people-getting-urban-china-work. Accessed 9 May 2014.
262. The impact of Chinese migration: We like to move it move it. The Economist; 2012. Available from: http://www.economist.com/node/21548277. Accessed 9 May 2014.
263. World Statistics Pocketbook Country Profile: China. United Nations; 2013. Available from: http://unstats.un.org/unsd/pocketbook/PDF/2013/China.pdf.

264. The household (Hukou) registration regulations of the People's Republic of China (Chinese, 中华人民共和国户口登记条例) Available from: http://www.npc.gov.cn/wxzl/gongbao/2000-12/10/content_5004332.htm. Accessed 9 May 2014.
265. The rural-urban divide: Ending apartheid. The Economist; 2014. Available from: http://www.economist.com/news/special-report/21600798-chinas-reforms-work-its-citizens-have-be-made-more-equal-ending-apartheid. Accessed 9 May 2014.
266. China formally eases one-child policy. BBC; 2013. Available from: http://www.bbc.co.uk/news/world-asia-china-25533339. Accessed 9 May 2014.
267. T'ung PC, Pollard DE. T'ung and Pollard's colloquial Chinese: Taylor & Francis/Routledge Ltd; 1982. 1-322
268. Fallows D. Dreaming in Chinese: lessons in life, love and Mandarin: Bloomsbury Publishing; 2012. 1-208
269. Pinyin celebrates 50th birthday. Xinhua News Agency; 2008. Available from: http://www.china.org.cn/english/news/242463.htm. Accessed 9 May 2014.
270. ISO 7098:1982 Documentation -- Romanization of Chinese. 1982. Available from: http://www.iso.org/iso/iso_catalogue/catalogue_ics/catalogue_detail_ics.htm?csnumber=13682. Accessed 9 May 2014.
271. Towards better health for people in China. Lancet. 2013;381:1959. Medline:23746880. doi:10.1016/s0140-6736(13)61183-6
272. Dong Z, Phillips MR. Evolution of China's health-care system. Lancet. 2008;372:1715-6. Medline:18930524. doi:10.1016/s0140-6736(08)61351-3
273. Hipgrave D. Communicable disease control in China: From Mao to now. J Glob Health. 2011;1:224-38. Medline:23198121
274. Barber SL, Huang B, Santoso B, Laing R, Paris V, Wu C. The reform of the essential medicines system in China: a comprehensive approach to universal coverage. J Glob Health. 2013;3:010303. Medline:23826503. doi:10.7189/jogh.03.010303
275. Yip WC, Hsiao WC, Chen W, Hu S, Ma J, Maynard A. Early appraisal of China's huge and complex health-care reforms. Lancet. 2012;379:833-42. Medline:22386036. doi:10.1016/s0140-6736(11)61880-1

276. Kleinman A. Patients and healers in the context of culture: An exploration of the borderland between anthropology, medicine, and psychiatry: University of California Press; 1981.

277. Scrimshaw SC. Culture, Behaviour, and Health. In: Merson MH, ed. Global health: diseases, programs, systems and policies. 3 ed. Burlington, MA: Jones & Bartlett Learning; 2012:43-74.

278. Tang JL, Liu BY, Ma KW. Traditional Chinese medicine. Lancet. 2008;372:1938-40. Medline:18930523. doi:10.1016/s0140-6736(08)61354-9

279. Rongrong H, Hiroshi K. Shanghuo Syndrome in Traditional Chinese Medicine. World Science and Technology. 2008;10:37-41. doi:10.1016/S1876-3553(09)60024-7

280. Liu L, Johnson HL, Cousens S, Perin J, Scott S, Lawn JE, et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. Lancet. 2012;379:2151-61. Medline:22579125. doi:10.1016/s0140-6736(12)60560-1

281. Feng XL, Theodoratou E, Liu L, Chan KY, Hipgrave D, Scherpbier R, et al. Social, economic, political and health system and program determinants of child mortality reduction in China between 1990 and 2006: A systematic analysis. J Glob Health. 2012;2:010405. Medline:23198134. doi:10.7189/jogh.02.010405

282. Rudan I, Chan KY, Zhang JS, Theodoratou E, Feng XL, Salomon JA, et al. Causes of deaths in children younger than 5 years in China in 2008. Lancet. 2010;375:1083-9. Medline:20346815. doi:10.1016/s0140-6736(10)60060-8

283. Bryce J, Daelmans B, Dwivedi A, Fauveau V, Lawn JE, Mason E, et al. Countdown to 2015 for maternal, newborn, and child survival: the 2008 report on tracking coverage of interventions. Lancet. 2008;371:1247-58. Medline:18406859. doi:10.1016/s0140-6736(08)60559-0

284. Report on women and children's health development in China. Ministry of Health of the People’s Republic of China 2011. Available from: http://unpan1.un.org/intradoc/groups/public/documents/apcity/unpan051019.pdf. Accessed 9 May 2014.

285. Banister J. Shortage of girls in China today. Journal of Population Research. 2004;21:19-45. doi:10.1007/BF03032209

286. Gupta MD, Chung W, Shuzhuo L. Evidence for an Incipient Decline in Numbers of Missing Girls in China and India. Population and Development Review. 2009;35:401-16. doi:10.1111/j.1728-4457.2009.00285.x

287. Luo J, Peng X, Zong R, Yao K, Hu R, Du Q, et al. The status of care and nutrition of 774 left-behind children in rural areas in China. Public health reports (Washington, D.C. : 1974). 2008;123:382-9. Medline:19006981

288. Mobithinking. Global mobile statistics 2014 Part A: Mobile subscribers; handset market share; mobile operators. 2014. Available from: http://mobithinking.com/mobile-marketing-tools/latest-mobile-stats/a. Accessed 9 May 2014.

289. Sui L. China overtakes United States as world's largest smartphone market in Q3 2011. Strategy Analytics; 2011. Available from: http://www.strategyanalytics.com/default.aspx?mod=reportabstractviewer&a0=6871.

290. Operations report for the telecommunication industry (Chinese, 2013 年通信运营业统计公报). 2013. Available from: http://www.miit.gov.cn/n11293472/n11293832/n11294132/n12858447/15861120.html. Accessed 9 May 2014.

291. Tencent QQ concurrent users exceeded 200 million (Chinese). QQ; 2014. Available from: http://tech.qq.com/a/20140412/000129.htm. Accessed 9 May 2014.

292. QQ (instant messaging program) website. Available at: http://www.qq.com/. Accessed 9 May 2014.

293. QQ International (instant messaging program) website. Available at: http://www.imqq.com/. Accessed 9 May 2014.

294. Chen ZW, Fang LZ, Chen LY, Dai HL. Comparison of an SMS text messaging and phone reminder to improve attendance at a health promotion center: a randomized controlled trial. J Zhejiang Univ Sci B. 2008;9:34-8. Medline:18196610. doi:10.1631/jzus.B071464

295. Tai Z, Sun T. The rumouring of SARS during the 2003 epidemic in China. Sociol Health Illn. 2011;33:677-93. Medline:21592140. doi:10.1111/j.1467-9566.2011.01329.x

296. Corpman DW. Mobile health in china: a review of research and programs in medical care, health education, and public health. J Health Commun. 2013;18:1345-67. Medline:23915211. doi:10.1080/10810730.2013.778370
297. Russon MA. China Arrests 1,500 People for Sending Spam Text Messages from Fake Mobile Base Stations. 2014. Available from: http://www.ibtimes.co.uk/china-arrests-1500-people-sending-spam-text-messages-fake-mobile-base-stations-1442099. Accessed 9 May 2014.
298. Lafraniere S. China to scan text messages to spot 'unhealthy content'. 2010. Available from: http://www.nytimes.com/2010/01/20/world/20text.html?_r=0. Accessed 9 May 2014.
299. China employs two million microblog monitors state media say. BBC; 2013. Available from: http://www.bbc.co.uk/news/world-asia-china-24396957.
300. Jing Z. Behind the great firewall of China. 2012. Available from: http://www.ted.com/talks/michael_anti_behind_the_great_firewall_of_china/transcript. Accessed 9 May 2014.
301. Beijing's air pollution: Blackest day. The Economist; 2013. Available from: http://www.economist.com/blogs/analects/2013/01/beijings-air-pollution. Accessed 9 May 2014.
302. Air quality guidelines - global update 2005. World Health Organization; 2005. Available from: http://www.who.int/phe/health_topics/outdoorair/outdoorair_aqg/en/. Accessed 9 May 2014.
303. Beijing US embassy air pollution: real-time Air Quality Index (AQI). Available at: http://aqicn.org/city/beijing/us-embassy/. Accessed 9 May 2014.
304. Statistical Communiqué of the Hebei Province on the 2010 Economic and Social Development. Shijiazhuang: Hebei Provincial Bureau of Statistics;2010.
305. Zhao County information. Available from: http://www.zhaoxian.gov.cn. Accessed 9 May 2014.
306. Zhaozhou Township information. Available from: http://www.zhaozhouchina.com/en/info/zhao-county.html. Accessed 9 May 2014.

307. Statistical Communiqué of the People's Republic of China on the 2010 National Economic and Social Development: Beijing National Bureau of Statistics of China;2010.

308. Weiyuan C. China's village doctors take great strides. Bull World Health Organ. 2008;86:914-5. Medline:19142288

309. Zurovac D, Sudoi RK, Akhwale WS, Ndiritu M, Hamer DH, Rowe AK, et al. The effect of mobile phone text-message reminders on Kenyan health workers' adherence to malaria treatment guidelines: a cluster randomised trial. Lancet. 2011;378:795-803. Medline:21820166. doi:10.1016/s0140-6736(11)60783-6

310. Odeny TA, Bailey RC, Bukusi EA, Simoni JM, Tapia KA, Yuhas K, et al. Text messaging to improve attendance at post-operative clinic visits after adult male circumcision for HIV prevention: a randomized controlled trial. PLoS One. 2012;7:e43832. Medline:22957034. doi:10.1371/journal.pone.0043832

311. Zurovac D, Larson BA, Sudoi RK, Snow RW. Costs and cost-effectiveness of a mobile phone text-message reminder programmes to improve health workers' adherence to malaria guidelines in Kenya. PLoS One. 2012;7:e52045. Medline:23272206. doi:10.1371/journal.pone.0052045

312. Wesolowski A, Eagle N, Noor AM, Snow RW, Buckee CO. Heterogeneous mobile phone ownership and usage patterns in Kenya. PLoS One. 2012;7:e35319. Medline:22558140. doi:10.1371/journal.pone.0035319

313. Zurovac D, Otieno G, Kigen S, Mbithi AM, Muturi A, Snow RW, et al. Ownership and use of mobile phones among health workers, caregivers of sick children and adult patients in Kenya: cross-sectional national survey. Global Health. 2013;9:20. Medline:23672301. doi:10.1186/1744-8603-9-20

314. Lei X, Liu Q, Wang H, Tang X, Li L, Wang Y. Is the short messaging service feasible to improve adherence to tuberculosis care? A cross-sectional study. Trans R Soc Trop Med Hyg. 2013;107:666-8. Medline:23918285. doi:10.1093/trstmh/trt070

315. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Med. 2007;4:e296. Medline:17941714. doi:10.1371/journal.pmed.0040296

316. Tong A, Sainsbury P, Craig J. Consolidated criteria for reporting qualitative research (COREQ): a 32-item checklist for interviews and focus groups. International journal for quality in health care : journal of the International Society for Quality in Health Care / ISQua. 2007;19:349-57. Medline:17872937. doi:10.1093/intqhc/mzm042
317. Braun V, Clarke V. Using thematic analysis in psychology. Qualitative Research in Psychology. 2006;3:77-101. doi:10.1191/1478088706qp063oa
318. NCRM. How many qualitative interviews is enough? 2012. Available from: http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf. Accessed 9 May 2014.
319. Smith HJ, Chen J, Liu X. Language and rigour in qualitative research: problems and principles in analyzing data collected in Mandarin. BMC Med Res Methodol. 2008;8:44. Medline:18616812. doi:10.1186/1471-2288-8-44
320. SPSS for Windows version 16.0. Chicago: SPSS Inc; 2007.
321. SAS version 9.2. Marlow, UK: SAS Institute Inc; 2008.
322. MAXQDA software for qualitative data analysis. Berlin, Germany: VERBI Software - Consult - Sozialforschung GmbH; 1989-2013.
323. Chen HY, Boore JR. Translation and back-translation in qualitative nursing research: methodological review. J Clin Nurs. 2010;19:234-9. Medline:19886874. doi:10.1111/j.1365-2702.2009.02896.x
324. Xiao Xun Tong (school information program) website (Chinese, 家校沟通平台). Available at: http://www.xxt.cn/gsjs/yw_xx.jsp. Accessed 9 May 2014.
325. Oreglia E, Kaye JJ. A gift from the city: mobile phones in rural China. Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work. Seattle, Washington, USA: ACM; 2012:137-46.
326. Hughes LD, Done J, Young A. Not 2 old 2 TXT: there is potential to use email and SMS text message healthcare reminders for rheumatology patients up to 65 years old. Health Informatics Journal. 2011;17:266-76. Medline:22193827. doi:10.1177/1460458211422019
327. What are the health risks associated with mobile phones and their base stations? : World Health Organization; 2013. Available from: http://www.who.int/features/qa/30/en/. Accessed 9 May 2014.

328. Barros AJ, Victora CG. Measuring coverage in MNCH: determining and interpreting inequalities in coverage of maternal, newborn, and child health interventions. PLoS Med. 2013;10:e1001390. Medline:23667332. doi:10.1371/journal.pmed.1001390

329. Kottner J, Audige L, Brorson S, Donner A, Gajewski BJ, Hrobjartsson A, et al. Guidelines for Reporting Reliability and Agreement Studies (GRRAS) were proposed. J Clin Epidemiol. 2011;64:96-106. Medline:21130355. doi:10.1016/j.jclinepi.2010.03.002

330. CommConnect. Dimagi. Available from: http://www.dimagi.com/commconnect/. Accessed 9 May 2014.

331. Frontlinesms website. Available at http://www.frontlinesms.com/. Accessed 9 May 2014.

332. E: Protocol for Identifying and Validating Local Terms. IMCI adaptation guid: A guide to identifying necessary adaptations of clinical policies and guidelines, and to adapting the charts and modules for the WHO/UNICEF course. Geneva: World Health Organization, Department of Child and Adolescent Health and Development; 2002.

333. Microsoft Excel 2010.

334. Bland JM, Altman DG. Measuring agreement in method comparison studies. Stat Methods Med Res. 1999;8:135-60. Medline:10501650

335. de Vet HC, Terwee CB, Knol DL, Bouter LM. When to use agreement versus reliability measures. J Clin Epidemiol. 2006;59:1033-9. Medline:16980142. doi:10.1016/j.jclinepi.2005.10.015

336. Cohen J. A coefficient of agreement for nominal scales. Educational and Psychological Measurement. 1960;20:37-46

337. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33:159-74. Medline:843571

338. Fleiss JL, Levin B, Paik MC. The measurement of interrater agreement. Statistical methods for rates and proportions. 3rd ed. Hoboken: John Wiley & Sons; 2003:598-626.

339. Cohen J. Weighted kappa: nominal scale agreement with provision for scaled disagreement or partial credit. Psychological Bulletin. 1968;70:213-20

340. Cicchetti D, Allison T. A new procedure for assessing reliability of scoring eeg sleep recordings. American Journal EEG Technology. 1971;11:101-9

341. Fleiss JL, Cohen J. The equivalence of weighted kappa and the intraclass correlation coefficient as measure of reliability. Educational and Psychological Measurement. 1973;33:613-9

342. Schuster C. A note on the interpretation of weighted kappa and its relation to other rater agreement statistics for metric scales. Educational and Psychological Measurement. 2004;64:243-53

343. Brenner H, Kliebsch U. Dependence of weighted kappa coefficients on the number of categories. Epidemiology. 1996;7:199-202. Medline:8834562

344. Vanbelle S, Albert A. A note on the linearly weighted kappa coefficient for ordinal scales. Statistical Methodology. 2009;6:157-63. doi:10.1016/j.stamet.2008.06.001

345. Graham P, Jackson R. The analysis of ordinal agreement data: beyond weighted kappa. J Clin Epidemiol. 1993;46:1055-62. Medline:8263578

346. Sim J, Wright CC. The kappa statistic in reliability studies: use, interpretation, and sample size requirements. Phys Ther. 2005;85:257-68. Medline:15733050

347. Schnall R, Okoniewski A, Tiase V, Low A, Rodriguez M, Kaplan S. Using text messaging to assess adolescents' health information needs: an ecological momentary assessment. J Med Internet Res. 2013;15:e54. Medline:23467200. doi:10.2196/jmir.2395

348. Hazir T, Begum K, El Arifeen S, Khan AM, Huque MH, Kazmi N, et al. Measuring coverage in MNCH: a prospective validation study in pakistan and bangladesh on measuring correct treatment of childhood pneumonia. PLoS Med. 2013;10:e1001422. Medline:23667339. doi:10.1371/journal.pmed.1001422

349. Hahn S, Puffer S, Torgerson DJ, Watson J. Methodological bias in cluster randomised trials. BMC Med Res Methodol. 2005;5:10. Medline:15743523. doi:10.1186/1471-2288-5-10

350. Fewtrell MS, Kennedy K, Singhal A, Martin RM, Ness A, Hadders-Algra M, et al. How much loss to follow-up is acceptable in long-term randomised trials and prospective studies? Arch Dis Child. 2008;93:458-61. Medline:18495909. doi:10.1136/adc.2007.127316

351. Sully BG, Julious SA, Nicholl J. A reinvestigation of recruitment to randomised, controlled, multicenter trials: a review of trials funded by two UK funding agencies. Trials. 2013;14:166. Medline:23758961. doi:10.1186/1745-6215-14-166

352. Christensen H, Mackinnon A. The law of attrition revisited. J Med Internet Res. 2006;8:e20; author reply e1. Medline:17032636. doi:10.2196/jmir.8.3.e20

353. Davis FD. Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly. 1989;13:319-40. doi:10.2307/249008

354. King WR, He J. A meta-analysis of the technology acceptance model. Information & Management. 2006;43:740-55. doi:10.1016/j.im.2006.05.003

355. Kaasinen E. User acceptance of mobile services - value, ease of use, trust and ease of adoption. VTT Information Technology, Espoo. 151 s, VTT Publications 566; 2005.

356. Venkatesh V, Morris MG, Gordon BD, Davis FD. User Acceptance of Information Technology: toward a unified view. MIS Quarterly. 2003;27:425-78. doi:10.2307/30036540

357. Gagnon MP, Orruno E, Asua J, Abdeljelil AB, Emparanza J. Using a modified technology acceptance model to evaluate healthcare professionals' adoption of a new telemonitoring system. Telemed J E Health. 2012;18:54-9. Medline:22082108. doi:10.1089/tmj.2011.0066

358. Venkatesh V, Davis FD. A theoretical extension of the Technology Acceptance Model: four longitudinal field studies. Management Science. 2000;46:186-204. doi:10.2307/2634758

359. Venkatesh V, Morris MG. Why don't men ever stop to ask for directions? Gender, social influence, and their role in Technology Acceptance and usage behavior. MIS Quarterly. 2000;24:115-39. doi:10.2307/3250981

360. Tung FC, Chang SC, Chou CM. An extension of trust and TAM model with IDT in the adoption of the electronic logistics information system in HIS in the medical industry. Int J Med Inform. 2008;77:324-35. Medline:17644029. doi:10.1016/j.ijmedinf.2007.06.006

361. Straub D, Keil M, Brenner W. Testing the technology acceptance model across cultures: A three country study. Information & Management. 1997;33:1-11. doi:10.1016/S0378-7206(97)00026-8

362. Treweek S, Lockhart P, Pitkethly M, Cook JA, Kjeldstrom M, Johansen M, et al. Methods to improve recruitment to randomised controlled trials: Cochrane systematic review and meta-analysis. BMJ Open. 2013;3. Medline:23396504. doi:10.1136/bmjopen-2012-002360

363. Holden RJ, Karsh BT. The technology acceptance model: its past and its future in health care. J Biomed Inform. 2010;43:159-72. Medline:19615467. doi:10.1016/j.jbi.2009.07.002

364. van Heerden A, Norris S, Tollman S, Richter L, Rotheram-Borus MJ. Collecting Maternal Health Information From HIV-Positive Pregnant Women Using Mobile Phone-Assisted Face-to-Face Interviews in Southern Africa. J Med Internet Res. 2013;15:e116. Medline:23748182. doi:10.2196/jmir.2207

365. Day M, Demiris G, Oliver DP, Courtney K, Hensel B. Exploring underutilization of videophones in hospice settings. Telemed J E Health. 2007;13:25-31. Medline:17309351. doi:10.1089/tmj.2006.0023

366. Kuo MC, Lu YC, Chang P. A newborn baby care support app and system for mHealth. Nurs Inform. 2012;2012:228. Medline:24199091

367. Lim S, Xue L, Yen CC, Chang L, Chan HC, Tai BC, et al. A study on Singaporean women's acceptance of using mobile phones to seek health information. Int J Med Inform. 2011;80:e189-202. Medline:21956003. doi:10.1016/j.ijmedinf.2011.08.007

368. Jian WS, Syed-Abdul S, Sood SP, Lee P, Hsu MH, Ho CH, et al. Factors influencing consumer adoption of USB-based Personal Health Records in Taiwan. BMC Health Serv Res. 2012;12:277. Medline:22925029. doi:10.1186/1472-6963-12-277

369. Edwards PJ, Roberts I, Clarke MJ, Diguiseppi C, Wentz R, Kwan I, et al. Methods to increase response to postal and electronic questionnaires. Cochrane Database Syst Rev. 2009:Mr000008. Medline:19588449. doi:10.1002/14651858.MR000008.pub4

370. Booker CL, Harding S, Benzeval M. A systematic review of the effect of retention methods in population-based cohort studies. BMC Public Health. 2011;11:249. Medline:21504610. doi:10.1186/1471-2458-11-249

371. Singer E, Ye C. The use and effects of incentives in surveys. The ANNALS of the American Academy of Political and Social Science. 2013;645:112-41. doi:10.1177/0002716212458082

372. Carr ECJ, Worth A. The use of the telephone interview for research. Nursing Times Research. 2001;6:511-24. Medline:12013519. doi:10.1177/136140960100600107

373. Musselwhite K, Cuff L, McGregor L, King KM. The telephone interview is an effective method of data collection in clinical nursing research: a discussion paper. Int J Nurs Stud. 2007;44:1064-70. Medline:16844128. doi:10.1016/j.ijnurstu.2006.05.014

374. van Velthoven MH, Car J, Zhang Y, Marusic A. mHealth series: New ideas for mHealth data collection implementation in low- and middle-income countries. J Glob Health. 2013;3:020101. Medline:24363911. doi:10.7189/jogh.03.020101

375. Liu L, Li M, Yang L, Ju L, Tan B, Walker N, et al. Measuring coverage in MNCH: a validation study linking population survey derived coverage to maternal, newborn, and child health care records in rural China. PLoS One. 2013;8:e60762. Medline:23667429. doi:10.1371/journal.pone.0060762

376. Moran AC, Kerber K, Sitrin D, Guenther T, Morrissey CS, Newby H, et al. Measuring coverage in MNCH: indicators for global tracking of newborn care. PLoS Med. 2013;10:e1001415. Medline:23667335. doi:10.1371/journal.pmed.1001415

377. Li R, Scanlon KS, Serdula MK. The validity and reliability of maternal recall of breastfeeding practice. Nutrition reviews. 2005;63:103-10. Medline:15869124

378. Bland RM, Rollins NC, Solarsh G, Van den Broeck J, Coovadia HM. Maternal recall of exclusive breast feeding duration. Arch Dis Child. 2003;88:778-83. Medline:12937095

379. Gonzalez MC, Hidalgo CA, Barabasi AL. Understanding individual human mobility patterns. Nature. 2008;453:779-82. Medline:18528393. doi:10.1038/nature06958

380. Brock TP, Smith SR. Using digital videos displayed on personal digital assistants (PDAs) to enhance patient education in clinical settings. Int J Med Inform. 2007;76:829-35. Medline:17113345. doi:10.1016/j.ijmedinf.2006.09.024

381. Hyder A, Puvanachandra P, Morrow RH. Measures of health and disease in populations. In: Merson MH, ed. Global health: diseases, programs, systems and policies. 3 ed. Burlington, MA: Jones & Bartlett Learning; 2012:1-42.

382. Cockburn WC, Assaad F. Some observations on the communicable diseases as public health problems. Bull World Health Organ. 1973;49:1-12. Medline:4545151

383. Investing in health: the world development report. World Bank; 1993. Available from: http://elibrary.worldbank.org/doi/book/10.1596/0-1952-0890-0. Accessed 9 May 2014.

384. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380:2095-128. Medline:23245604. doi:10.1016/S0140-6736(12)61728-0

385. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet. 2003;361:2226-34. Medline:12842379. doi:10.1016/s0140-6736(03)13779-8

386. Bryce J, Boschi-Pinto C, Shibuya K, Black RE. WHO estimates of the causes of death in children. Lancet. 2005;365:1147-52. Medline:15794969. doi:10.1016/s0140-6736(05)71877-8

387. Black RE, Cousens S, Johnson HL, Lawn JE, Rudan I, Bassani DG, et al. Global, regional, and national causes of child mortality in 2008: a systematic analysis. Lancet. 2010;375:1969-87. Medline:20466419. doi:10.1016/s0140-6736(10)60549-1

388. Rudan I, Lawn J, Cousens S, Rowe AK, Boschi-Pinto C, Tomaskovic L, et al. Gaps in policy-relevant information on burden of disease in children: a systematic review. Lancet. 2005;365:2031-40. Medline:15950717. doi:10.1016/s0140-6736(05)66697-4

389. Schmidt WP, Arnold BF, Boisson S, Genser B, Luby SP, Barreto ML, et al. Epidemiological methods in diarrhoea studies--an update. Int J Epidemiol. 2011;40:1678-92. Medline:22268237

390. World population prospects: the 2012 revision. United Nations; 2012. Available from: http://esa.un.org/wpp/unpp/panel_indicators.htm. Accessed 9 May 2014.

391. MOVE-IT for the MDGs Health Metrics Network. Health Metrics Network and World Health Organization; 2010. Available at: http://www.who.int/healthmetrics/MOVEIT_final_web_single_page.pdf Accessed 9 May 2014.

392. Setel PW, Macfarlane SB, Szreter S, Mikkelsen L, Jha P, Stout S, et al. A scandal of invisibility: making everyone count by counting everyone. Lancet. 2007;370:1569-77. doi:10.1016/S0140-6736(07)61307-5

393. AbouZahr C, Cleland J, Coullare F, Macfarlane SB, Notzon FC, Setel P, et al. The way forward. Lancet. 2007;370:1791-9. doi:10.1016/S0140-6736(07)61310-5

394. Setel PW, Sankoh O, Rao C, Velkoff VA, Mathers C, Gonghuan Y, et al. Sample registration of vital events with verbal autopsy: a renewed commitment to measuring and monitoring vital statistics. Bull World Health Organ. 2005;83:611-7. Medline:16184280. doi:/S0042-96862005000800015

395. Yang G, Hu J, Rao KQ, Ma J, Rao C, Lopez AD. Mortality registration and surveillance in China: History, current situation and challenges. Popul Health Metr. 2005;3:3. Medline:15769298. doi:10.1186/1478-7954-3-3

396. Verbal autopsy standards: The 2012 WHO verbal autopsy instrument, Release Candidate 1. World Health Organization; 2012. Available from: http://www.who.int/healthinfo/statistics/WHO_VA_2012_RC1_Instrument.pdf. Accessed 9 May 2014.

397. Setel PW. Verbal autopsy and global mortality statistics: if not now, then when? Popul Health Metr. 2011;9:20. Medline:21794100. doi:10.1186/1478-7954-9-20

398. Increasing child birth registration. United Nations Children's Fund; 2012. Available from: http://unicefinnovation.org/challenges/increasing-child-birth-registration. Accessed 9 May 2014.

399. Monitoring of vital events: Standards and tools. Health Metrics Network. Available from: http://www.who.int/healthmetrics/move_it/en/index3.html. Accessed 9 May 2014.

400. The MVP introduces enhanced mobile technology to reduce child and maternal mortality. Millenium Villages Project; 2010. Available from: http://millenniumvillages.org/field-notes/the-mvp-introduces-enhanced-mobile-technology-to-reduce-child-and-maternal-mortality/. Accessed 9 May 2014.
401. Phone app offers 'verbal autopsies' to improve death records. BBC; 2013. Available from: http://www.bbc.co.uk/news/health-24164824. Accessed 9 May 2014.
402. Walt G, Buse K, Harmer A. Cooperation in global health. In: Merson MH, ed. Global health: diseases, programs, systems and policies. 3 ed. Burlington, MA: Jones & Bartlett Learning; 2012:853-84.
403. Samb B, Evans T, Dybul M, Atun R, Moatti JP, Nishtar S, et al. An assessment of interactions between global health initiatives and country health systems. Lancet. 2009;373:2137-69. Medline:19541040. doi:10.1016/s0140-6736(09)60919-3
404. Dieleman JL, Graves CM, Templin T, Johnson E, Baral R, Leach-Kemon K, et al. Global health development assistance remained steady in 2013 but did not align with recipients' disease burden. Health Affairs. 2014. doi:10.1377/hlthaff.2013.1432
405. Victora CG, Walker D, Johns B, Bryce J. Evaluations of large-scale health programs. In: Merson MH, ed. Global Health: diseases, programs, systems and policies. 3 ed. Burlington, MA: Jones & Bartlett Learning; 2012:815-52.
406. Victora CG, Black RE, Boerma JT, Bryce J. Measuring impact in the Millennium Development Goal era and beyond: a new approach to large-scale effectiveness evaluations. Lancet. 2011;377:85-95
407. When will we ever learn? Improving lives through impact evaluation. Washington, DC: Evaluation Gap Working Group, Center for Global Development;2006.
408. Evaluation: the top priority for global health. Lancet. 2010;375:526. Medline:20079530. doi:10.1016/s0140-6736(10)60056-6
409. Svoronos T, Mate KS. Evaluating large-scale health programmes at a district level in resource-limited countries. Bull World Health Organ. 2011;89:831-7. Medline:22084529. doi:10.2471/blt.11.088138

410. Githinji S, Kigen S, Memusi D, Nyandigisi A, Mbithi AM, Wamari A, et al. Reducing stock-outs of life saving malaria commodities using mobile phone text-messaging: SMS for life study in Kenya. PLoS One. 2013;8:e54066. Medline:23349786. doi:10.1371/journal.pone.0054066

411. Githinji S, Kigen S, Memusi D, Nyandigisi A, Wamari A, Muturi A, et al. Using mobile phone text messaging for malaria surveillance in rural Kenya. Malar J. 2014;13:107. Medline:24642130. doi:10.1186/1475-2875-13-107

412. Chen L, Wang W, Du X, Rao X, van Velthoven M, Yang R, et al. Effectiveness of a smart phone app on improving immunization of children in rural Sichuan Province, China: study protocol for a paired cluster randomized controlled trial. BMC Public Health. 2014;14:262. Medline:24645829. doi:10.1186/1471-2458-14-262

413. Digital everything….everywhere. Thomson Reuters predicts what the world will be like in 2025 Thomson Reuters; 2014. Available from: http://sciencewatch.com/articles/digital-everything-everywhere. Accessed 1 July 2014.

414. Ainsworth J, Palmier-Claus JE, Machin M, Barrowclough C, Dunn G, Rogers A, et al. A comparison of two delivery modalities of a mobile phone-based assessment for serious mental illness: native smartphone application vs text-messaging only implementations. J Med Internet Res. 2013;15:e60. Medline:23563184. doi:10.2196/jmir.2328

415. Creative Commons Attribution 4.0 International License (CC BY 4.0). Available from: http://creativecommons.org/licenses/by/4.0/. Accessed 9 May 2014.

Appendices

Overview

The appendices contain:

Appendix A Copyright permission;

Appendix B Ethical approval;

Appendix C Questionnaires;

Appendix D Consent and information forms;

Appendix E Development of face-to-face and text message questionnaires;

Appendix F Local terminology study;

Appendix G Additional tables for cross-over study;

Appendix H Additional tables for researchers' observations;

Appendix I Other published papers.

Appendix A Copyright permission

This thesis contains adapted versions of four articles published in the *Journal of Global Health* [147,223,252,374], which is licensed under a *Creative Commons Attribution 4.0 International License* [415].

This means that anyone is free to:

- ***"Share** — copy and redistribute the material in any medium or format*
- ***Adapt** — remix, transform, and build upon the material for any purpose, even commercially.*

The licensor cannot revoke these freedoms as long as you follow the license terms."

Under the following terms:

- *"**Attribution** — You must give **appropriate credit**, provide a link to the license, and **indicate if changes were made**. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.*
- ***No additional restrictions** — You may not apply legal terms or **technological measures** that legally restrict others from doing anything the license permits."*

With the following notices:

- *"You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable **exception or limitation**.*

- *No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as **publicity, privacy, or moral rights** may limit how you use the material."*

Appendix B Ethical approval

Overview

This appendix provides a copy of Imperial College Research Ethics Committee approval and a copy and translation of Ethics Review Committee of Capital Institute of Pediatrics approval.

Copy of Imperial College Research Ethics Committee approval

Imperial College London

Imperial College Research Ethics Committee

Imperial College London
Room 5L10D, 5th Floor, Lab Block
Charing Cross Hospital
Fulham Palace Road
London
W6 8RF

Tel: +44 (0)203 331 0208 Fax: +44 (0) 203 311 0203

researchethicscommittee@imperial.ac.uk

21 February 2013

Dr Josip Car
Director of the Global eHealth Unit
Imperial College London
3rd Floor
Reynolds Building
Charing Cross Campus
St Dunstans Road
London
W6 8RP

Dear Dr Car,

Study Title: Mobile phone text messaging for collecting data on care-seeking for childhoos diarrhoea and pneumonia in China; an acceptability and feasibility study

ICREC reference: ICREC_13_2_1

The above study was approved by your HoD on 07 January 2013 and by the Joint Research Office on the 21 February 2013.

Under the Imperial College Research Ethics Committee process, a study that has been reviewed by the Joint Research Office and Head of Division/Department (or Principal), where no significant ethical issues have been identified in the protocol or ethics application, can be approved without requiring it to go to full committee.

This approval is conditional of the fact that a signature box for the researcher (individual obtaining consent) is added to the consent form before the research begins.

Documents
The documents reviewed were:

- ICREC Application form V1.2 21/01/13
- Chinese Ethics Approval (SHERLL2013009)
- Consent and Information Form V1.2 21/01/13
- Consent and Information Form V1.2 21/01/13 (Chinese version)
- Sponsorship and Insurance Registration Form
- Semi-structured Interview Guide V1.1 04/01/13
- Protocol V1.1 04/01/13
- Cognitive Interview Guide V1.1 04/01/13
- WHO Newborn and Childhealth Survey
- Survey Questionnaire V1.1 04/01/13

Yours sincerely,

Gary Roper,
Head of Regulatory Compliance,
Imperial College London

Copy Ethics Review Committee of Capital Institute of Pediatrics approval

首都儿科研究所伦理委员会伦理审查批件

伦理审查编号　SHERLL2013009

审查会议日期	2013 年 1 月 18 日
审查会议地点	首都儿科研究所科研楼 310 会议室
临床研究项目	**应用手机短信收集农村儿童常见病就诊情况的可行性研究**
审查文件	☑ 临床研究方案及相关资料　☑ 向受试者提供知情同意书 ☑ 伦理审查申请报告　☑ 研究人员的简历
临床研究单位	首都儿科研究所　儿童早期综合发展研究室
主要研究者	张延峰　副研究员
伦理审查方式	会议审查
会议审查到会委员	杨健、张君莉、牟京辉、王凯戎、庞秀兰、孙吉萍、马继东
审查意见	1、根据国际医学科学组织委员会颁布的《人体生物医学研究国际指南》和《赫尔辛基宣言》的伦理原则，经本伦理委员会审查，同意 **"应用手机短信收集农村儿童常见病就诊情况的可行性研究"** 的研究。 2、完成临床研究，请提交结题报告。 3、暂停\提前终止\完成临床研究，请及时通知伦理委员会。 4、如伦理委员会审查批件时效时不能完成所有的临床研究（包括统计分析），请于本批件失效前 1 个月提交跟踪审查。 5、如发生严重不良反应事件以及影响研究风险受益比的非预期不良事件，应及时报告本伦理委员会。如临床研究方案、知情同意书作任何修改，主要研究者更换，应及时通知伦理委员会，重新审查，获得批准后执行。 6、发现影响受试者参加研究意愿的违反方案情况应及时报告。
本批件有效期	2013 年 1 月 18 日　至 2016 年 1 月 17 日
联系电话	85628191
主任委员签字	杨健印记
	伦理委员会　（盖章）首都儿科研究所伦理委员会

English translated version of Ethics Review Committee of the Capital Institute of Pediatrics approval

No. SHERLL 2013009

Date of the meeting	January 18th 2013
Place of the meeting	Room 310, Research Building, Capital Institute of Pediatrics, Beijing, China
Title of the research	Project on mobile phone text messaging for collecting data on care-seeking for childhood diarrhoea and pneumonia in Zhao County
Review document	Research protocol and related material Informed consent form Ethics review application form Resume of researchers
Research department	Department of Integrated Early Childhood Development, Capital Institute of Pediatrics, Beijing, China
Principle investigator	Associate research fellow Yanfeng Zhang
Type of ethics review	Meeting
Committee members present during the meeting	Jian Yang, Junli Zhang, Jinghui Mu, Kairong Wang, Xiulan Pang, Jiping Sun, Jidong Ma
Comments	1. According to the International Ethical Guidelines for Biomedical Research Involving Human Subjects released by the Council for International Organizations of Medical Sciences (CIOMS), and the principles of the Declaration of Helsinki, we grant approval for the project entitled 'Mobile phone text messaging for collecting data on care-seeking for childhood diarrhoea and pneumonia in Zhao County'. 2. When the research is completed, please hand in the report for the entire research project. 3. If the research is suspended or stopped before completion, please inform the ethics review committee as soon as possible. 4. If the research cannot be completed (including the statistical analysis part) within the period of validity, please apply for ongoing project review one month ahead of the expiry date. 5. If severe adverse effects or unexpected adverse effects that influence the risk-benefit ratio of the study occur, please report to the ethics committee immediately. If the study protocol, informed consent or principle investigator has to be changed, please inform the ethics review committee to re-examine the documents. The research can only continue with renewed ethics approval. 6. If any deviation from the protocol influences the willingness of participants to take part in the research, please report immediately.
Period of validity	Jan 18th 2013 - Jan 17th 2016
Contact number	85628191
Signature of the chief the ethics review committee	
	The Ethics Review Committee of Capital Institute of Pediatrics

Appendix C Questionnaires

Overview

This appendix provides the following questionnaires: the survey questionnaires on demographics and mobile phone usage (objective 1); topic guides for semi-structured interviews (objective 1); guide for cognitive interviews (objective 2); cross-over study questionnaires on demographics and mobile phone usage (objective 2); questionnaire about reasons for differences in responses (objective 2); questionnaires on participation in the cross-over study (objective 3).

English translated version of survey questionnaire on demographics and mobile phone usage (objective 1)

Question nr	Question	Answer options	Referral to other questions
Identification (ID)			
ID1a	The name (code) of the township	_________	
ID1b	The name (code) of the village	_________	
ID1c	The ID of the child	_________	
ID2	The name (code) of the interviewee	_________	
ID3	Relationship to the child	1.Mother 2.Father 3.Grandfather/Grandmother 8.Other____	
ID4	Who is the primary caregiver for this child?	1.Mother 2.Father 3.Grandfather/Grandmother 8.Other____	
ID5	The name of the child *(whose age is 6-23 months)*		
ID6	Gender of the child	1.Male 2.Female	
ID7	Date of birth of the child *(solar calendar; yyyy/mm/dd)*	________	
ID8	Weight at birth	________g 8888=Do not know	
ID9	Length at birth	________cm 88=Do not know	
ID10	How many pregnancies has the mother of the child had, up to and including this child?	8=Do not know	
ID10a	How many children has the mother had before this child? *(fill in "7" if there are more than 7 children)*	___________ 8=Do not know	
ID10b	Is the child a twin/triplet etc.?	1.No 2.Twin 3.Triplet or more 8.Do not know	
ID11	What was the method of delivery for this child?	1.Vaginal delivery 2.Delivery with instrumental assistance 3.Caesarean section 8.Do not know	
ID12	Gestation period for this child in weeks *(round down to nearest week)*	________________ 88.Do not know	
ID13	Type of Hukou *(household register)*	1.Urban 2.Rural	
ID14	Investigator ID	______________	
ID15	Date of the investigation *(solar calendar; yyyy/mm/dd)*	______________	

Mobile phone (MP) usage			
MP1	Do you use a mobile phone?	1.Yes 2.No	If MP1=2 go to MP17
MP2	What is the brand and type of the mobile phone you use?	____________________ 8.Do not know	
MP3	Is the mobile phone you use a smartphone? *(demonstrate a smartphone, based on Android, Symbian or iOS system)*	1.Yes 2.No 8.Do not know	
MP4	What is the usual location of the mobile phone you use, when you leave the house?	1.Carry the phone with me 2.Leave the phone in the house 3.Someone else carries the phone 8.Other____	
MP5	Do you primarily use a mobile phone for making calls or sending text messages?	1.Making calls 2.Sending text messages 3.Both in equal measure 8.Other____	
MP5a	Do you primarily send text messages or use QQ?	1.QQ 2.Text messages 3.Both in equal measure 4.Cannot use neither 5.Other____ 8.Do not know	
MP6	How many phone calls do you make in an average week?	___________________ 88=Do not know 99=Cannot do it	
MP7	How many phone calls do you receive in an average week?	___________________ 88= Do not know 99=Cannot do it	
MP8	How many text messages do you sent in an average week?	___________________ 88=Do not know 99=Cannot do it	
MP9	How many text messages do you receive in an average week?	___________________ 88=Do not know 99=Cannot do it	
MP10	How much is your average mobile phone bill in one month?	___________________ 888=Do not know	
MP11	How often did you change your mobile phone number in the last year?	1.Never 2.Once 3.Twice 4.Three times 5.Four times or more 8.Do not remember	
MP12	Is your mobile phone currently functioning correctly i.e. can it be used for making a phone call and sending a text message? *(including a mobile phone without sufficient credit)*	1.The phone can be used to make a call and send a text message 2.The phone can be used to make a call but cannot send a text message 3.The phone can be used to send a text message, but cannot make a call 4.The phone can neither send a text message nor make a phone call 5.Other____	

MP13	Do you or anyone in your household have the telephone number of the following *(including mobile)*:		
	1.County hospital or above *(including county hospital, county children's hospital, private hospital)*	1.Yes 2.No 8.Do not know	
	2.Township hospital	1.Yes 2.No 8.Do not know	
	3.Village clinic	1.Yes 2.No 8.Do not know	
MP14	How often have you used your mobile phone to receive information about your own health or your child's health in the past 3 months? *(including text message and calls)*	1.Never 2.Once 3.Twice 4.Three times 5.More than three times	If MP14=1, go to MP15 If MP14=2,3,4 or 5, go to MP16
MP15	Would you like to use your mobile phone to receive health information?	1.Yes 2.No 3.Other____	
MP16	Where do you usually buy your mobile phone?	1.In the village 2.In the town 3.In the county 4.In the city 5.Other____ 8.Do not know	
MP17	Does anyone else in your household use a mobile phone?	1.Yes 2.No, only I have a mobile phone 3.No, nobody in our household has got a mobile phone 8.Do not know	If MP17=3, go to QQ1
MP18a	Regarding the child's mother: Does she use a mobile phone?	1.Yes 2.No 8.Do not know	If MP18a=2 or 8, go to MP19a
MP18b	Who owns the mobile phone?	1=Herself 2=Father 3=Grandmother 4=Grandfather 5=Other____	If MP18b=2,3, 4,5 go to MP18d1
MP18c	Mobile phone number	____________________	
MP18d1	Does she know how to make a phone call with a mobile phone?	1.Yes 2.No 8.Do not know	
MP18d2	Does she know how to send a text message?	1.Yes 2.No 8.Do not know	
MP19a	Regarding the child's father: Does he use a mobile phone?	1.Yes 2.No 8.Do not know	If MP19a=2 or 8, go to MP20a
MP19b	Who owns the mobile phone?	1=Mother 2=Himself 3=Grandmother 4=Grandfather 5=Other____	If MP19b=1, 3, 4, or 5 then go to MP19d1
MP19c	Mobile phone number	____________________	
MP19d1	Does he know how to make a phone call with a mobile phone?	1.Yes 2.No 8.Do not know	

MP19d2	Does he know how to send a text message?	1.Yes 2.No 8.Do not know	
MP20a	Regarding the grandmother: Does she use a mobile phone?	1.Yes 2.No 8.Do not know	If MP20a=2 or 8, go to MP21a
MP20b	Who owns the mobile phone?	1=Mother 2=Father 3=Herself 4=Grandfather 5=Other____	If MP20b=1, 2, 4, or 5 then go to MP20d1
MP20c	Mobile phone number	____________________	
MP20d1	Does she know how to make a phone call with a mobile phone?	1.Yes 2.No 8.Do not know	
MP20d2	Does she know how to send a text message?	1.Yes 2.No 8.Do not know	
MP21a	Regarding the grandfather: Does he use a mobile phone?	1.Yes 2.No 8.Do not know	If MP21a=2 or 8, go to MP22a
MP21b	Who owns the mobile phone?	1=Mother 2=Father 3=Grandmother 4=Himself 5=Other____	If MP21b=1, 2, 3, or 5 go to MP21d1
MP21c	Mobile phone number	____________________	
MP21d1	Does he know how to make a phone call with a mobile phone?	1.Yes 2.No 8.Do not know	
MP21d2	Does he know how to send a text message?	1.Yes 2.No 8.Do not know	
MP22a	Are there other adult household members who have interacted frequently with the child?	1.Yes 2.No 8.Do not know	If MP22a=2 or 8, go to QQ1
MP22b	How does the child refer to him/her?	____________________	
MP22c	Does she/he use a mobile phone?	1.Yes 2.No 8.Do not know	If MP22c=2 or 8, go to QQ1
MP22d	Who owns the mobile phone?	1=Mother 2=Father 3=Grandmother 4=Grandfather 5=Him/herself 6=Other____	If MP22d=1, 2, 3, 4 or 6 go to MP22f1
MP22e	Mobile phone number	____________________	
MP22f1	Does she/he know how to make a phone call with a mobile phone?	1.Yes 2.No 8.Do not know	
MP22f2	Does she/he know how to send a text message?	1.Yes 2.No 8.Do not know	

Use of Internet (QQ)		
QQ1a	Do you use your computer in your household to access the Internet?	1.Yes 2.No 8.Do not know
QQ2	Do you use your mobile phone to access the Internet?	1.Yes 2.No 3.Do not have a mobile phone 8.Do not know
Household (HH)		
HH4a	Is it possible to collect information about the mother?	1.Yes 2.No, remarried 3.No, lost 4.No, passed away
HH4	What is the age of the mother?	____________________years 88=Do not know
HH6	What is the mother's education level?	1.No education 2.Primary school 3.Junior high school 4.Senior high school/technical school 5.Vocational/technical secondary school 6.College 7.University or above 8.Do not know
HH7	How many years of education has the mother had?	____________________years
HH8	What is the mother's occupation?	1.Housework 2.Head of an enterprise, organisation or business unit 3.Technical 4.Receptionist, clerk, secretary 5.Commercial, business and service industry 6.Owner of individual business 7.Farmer engaged in non-agricultural industry 8.Industrial workers (factory production worker or transporter, mining, construction) with non-agricultural *Hukou* 9. Agriculture, forestry, or fishing water conservation 10.Military 11.Other_____ 88.Do not know
HH10a	Is it possible to collect information about the father?	1.Yes 2.No, remarried 3.No, lost 4.No, passed away
HH10	What is the age of the father?	____________________years 88=Do not know

HH12	What is the father's education level?	1.No education 2.Primary school 3.Junior high school 4.Senior high school/technical school 5.Vocational/technical secondary school 6.College 7.University or above 8.Do not know
HH12a	How many years of education has the father had?	____________________years
HH13	What is the father's occupation?	1.Housework 2.Head of an enterprise, organisation or business unit 3.Technical 4.Receptionist, clerk, secretary 5.Commercial, business and service industry 6.Owner of individual business 7.Farmer engaged in non-agricultural industry 8.Industrial workers (factory production worker or transporter, mining, construction) with non-agricultural Hukou 9. Agriculture, forestry, or fishing water conservation 10.Military 11.Other____ 88.Do not know
HH16a	What is the age of the primary caregiver? *Only ask if the caregiver is not the mother or the father.*	____________________years
HH16b	What is the caregiver's education level?	1.No education 2.Primary school 3.Junior high school 4.Senior high school/technical school 5.Vocational/technical secondary school 6.College 7.University or above 8.Do not know
HH16c	How many years' of education does the caregiver have?	____________________years

HH16d	What is the caregiver's occupation?	1.Housework 2.Head of an enterprise, organisation or business unit 3.Technical 4.Receptionist, clerk, secretary 5.Commercial, business and service industry 6.Owner of individual business 7.Farmer engaged in non-agricultural industry 8.Industrial workers (factory production worker or transporter, mining, construction) with non-agricultural *Hukou* 9. Agriculture, forestry, or fishing water conservation 10.Military 11.Other____ 88.Do not know
HH20	Family net income in the last year *(after subtracting cost of production)*	________¥ 888888=Do not know
HH21	Family living expenses in the last year *(living expenses include food, clothing, daily consumable, transport, communication, mortgage/rent, household bills, education, cultural entertainment, hospital bills etc.)*	________¥ 888888=Do not know

Topic guides for semi-structured interviews (objective 1)

Topic guide 1 (first round of interviews)

Research questions

1. How do people use a mobile phone?
2. What is people's experience with seeking information for their child's health via their mobile phone?

GENERAL SECTION

To start off, I would like to find out a little about you and your family:

1. What do you usually do during the day?
2. Can you please describe your family members and their relationship to you?
3. Who will take care of the child when he or she is ill?

SECTION 1

We will continue to talk about your mobile phone use:

4. Can you show me your mobile phone? *(if participant cannot show the mobile phone ask what sort of mobile phone it is)* Do you use any other mobile phones?
5. Where do you keep your mobile phone?
6. Why do you use a mobile phone?
7. Which functions of the mobile phone do you use?
8. Which do you prefer: sending text messages or making phone calls? Why?
9. Sometimes people have problems with using their mobile phone. For example a phone stops working, someone deletes a text message accidently by pressing the wrong button, or someone realises that there is not enough credit on the phone. Have you ever seen something like this happening?
10. How much money do you spend on using your mobile phone?
11. How long have you used a mobile phone?
12. How often do you change your mobile phone number? Why?
13. Did you purchase this mobile phone? If not, who purchased the mobile phone? On what occasion did he or she give you the mobile phone?
14. Can you tell me about other people in your household using a mobile phone?

Before I ask you more questions, I just want to briefly sum what you told me about using your mobile phone. You said……………., is that right?

SECTION 2

I would now like to ask you a bit about seeking information or advice when your child has a health problem:

15. Who do you first ask for help when your child has a health problem?
16. Have you sought any information about your child's health from a doctor working in a village clinic or township hospital in the past year? Please tell me about the most recent time you sought information about your child's health.
17. Have you contacted a doctor working in a village clinic or township hospital by a mobile phone in the past year? Please tell me about your most recent contact with a health worker via your mobile phone.
18. Do you use health-related applications on your mobile phone? If so, please tell me more about this.
19. Would you be interested in participating in follow-up research? *(if so, please record contact details carefully)*

Before we end this interview, I just want to briefly sum what you told me about seeking health information. You said……………., is that right?

Thank you very much for taking part <u>(stress confidentiality and anonymity again).</u>

Topic guide 2 (second round of interviews)

Research questions

1. Which factors influence whether people respond to text messages?
2. What is people's experience with seeking information for their child's health via their mobile phone?

SECTION 1

We will talk about your mobile phone use:

1. When did you use a mobile phone for the first time?
2. Why do you use a mobile phone?
3. Which functions of the mobile phone do you use?
4. Which function do you like best? Why?
5. Now I would like to talk more about mobile phone text messaging. How long does it normally take for you to notice receiving a text message?
6. When you notice you have received a text message, when will you respond to it?
7. What kind of messages do you respond to? What kind of messages do you ignore? Why?
8. Have you ever received information or questions via mobile phone text messages? If so, please tell me more about this.

Before I ask you more questions, I just want to briefly sum what you told me about using your mobile phone and text messaging. You said……………., is that right?

SECTION 2

I would now like to ask you a bit about seeking information or advice when your child has a health problem:

9. Who do you first ask for help when your child has a health problem?
10. Have you sought any information about your child's health from a doctor working in a village clinic or township hospital in the past year? Please tell me about the most recent time you sought information about your child's health.
11. Have you contacted a doctor working in a village clinic or township hospital by a mobile phone in the past year? Please tell me about your most recent contact with a health worker via your mobile phone.
12. Do you use health-related applications on your mobile phone? If so, please tell me more about this.
13. Have you sought any health information on the Internet? If so, please tell me more about this.
14. Would you be interested in participating in follow-up research? *(if so, please record contact details carefully)*

Before we end this interview, I just want to briefly sum what you told me about seeking health information. You said………………, is that right?

Thank you very much for taking part <u>(stress confidentiality and anonymity again).</u>

Guide for cognitive interviews (objective 2)

Research questions

1. Do people understand the meaning of the information in text message format?
2. Do people understand how to respond to the text messages?
3. What do people prefer: receiving the information in one text message or in two separate text messages?

Introduction

- Explain that we will try out sending text messages with questions about the health of the child of the participant to see if the questions and answers are clear to the participant;
- Explain that we are testing the questions of the survey with people who take care of young children like the participant;
- Explain that you will ask the survey questions and that the participant should answer them, just like a regular survey;
- However, explain that your goal is here to get a better idea of how the questions are working. Explain that the participant should think aloud when they answer the survey questions, they should tell you everything that they are thinking about the questions when they are answering them;
- Explain that sometimes you will ask more questions about the terms or phrases in the questions and what the participant thinks a question is asking about. Also, say that you will be taking notes;
- Explain that the participant should keep in mind that you really want to hear all opinions and reactions. He or she should not hesitate to speak up whenever something seems unclear, is hard to answer, or does not seem to apply to them;
- Tell the participant that you estimate that the interview will last about 30 minutes;
- Ask the participant if he or she has any questions before you start.

Procedures

Example question 1: Diarrhoea is the passage of 3 or more loose or liquid stools per day. Has (NAME) had diarrhoea in the last 2 weeks (from… till ……)? Text us the number of your answer: 1.Yes, 2.No, 8.Do not know"

Sent the text message to the participant and ask the following:

1. Please explain to me in your own words what the health information, "*diarrhoea is the passage of 3 or more loose or liquid stools per day"*, means to you.
2. Please explain to me in your own words what the question means to you.
3. Please explain to me in your own words what the answer options mean to you.

Ask the participant to respond to the text message and ask the following:

4. Please think aloud when you reply to the message and tell me how you come to your answer.
5. What is your experience with replying to the message?
6. If you would write this (the information, question and answers) yourself, how would you write it in your own words?
7. Would you prefer this information to be in one text messages or in separate text messages? Why?

Repeat this procedure for all the survey questions

English translated version of cross-over study questionnaire on demographics and mobile phone usage (objective 2)

Nr	Question	Answer options
Identification (ID)		
ID1a	The name (code) of the village	________
ID1c	The ID of the child	________
ID2	The name (code) of the interviewee	________
ID3	Relationship to the child	1.Mother 2.Father 3.Grandfather 4.Grandmother 5.Other____
ID3a	What is your mobile phone number?	_________________
ID.4	Is each family member one of the main caregivers? *Read selections one by one and record all of them.*	
ID.4.1	The mother?	1.Yes 2.No
ID.4.2	The father?	1.Yes 2.No
ID.4.3	The grandmother?	1.Yes 2.No
ID4.4	The grandfather?	1.Yes 2.No
ID4.5	Anyone else?	1.Yes 2.No
ID5	The name of the youngest child	______________
ID6	Gender of the child	1.Male 2.Female
ID7	Date of birth for the child *(solar calendar; yyyy/mm/dd)*	______________
ID10a	How many children has the mother had before this child? *(fill in "7" if there are more than 7 children)*	______________ 8=Do not know
ID10b	Is the child a twin/triplet etc.?	1.No 2.Twin 3.Triplet or more 8.Do not know
ID13	Type of Hukou *(household register)*	1.Urban 2.Rural 8.Do not know
ID14	Investigator ID	______________
ID15	Date of the investigation	______________

Mobile phone (MP) usage		
MP3	Is the mobile phone you use a smartphone? *(demonstrate a smartphone, based on Android, Symbian or iOS system)*	1.Yes 2.No 8.Do not know
MP5	Do you primarily use a mobile phone for making calls or sending text messages?	1.Making calls 2.Sending text messages 3.Both in equal measure 8.Other_____
MP5a	Do you usually primarily send text messages or use QQ?	1.QQ 2.Text messages 3.Both in equal measure 4.Use neither 5.Other_____ 8.Do not know
MP6	How many phone calls do you make in an average week?	____________________ 888=Do not know 999=Cannot do it
MP7	How many phone calls do you receive in an average week?	____________________ 888=Do not know 999=Cannot do it
MP8	How many text messages do you sent in an average week?	____________________ 888=Do not know 999=Cannot do it
MP9	How many text messages do you receive in an average week?	____________________ 888=Do not know 999=Cannot do it
MP13	Do you or anyone in your household have the telephone number of the following *(including mobile number).*	*Read selections one by one and record all of them.*
MP13.1	County hospital or above *(including county hospital, county children's hospital, private hospital)*	1.Yes 2.No 8.Do not know
MP13.2	Township hospital	1.Yes 2.No 8.Do not know
MP13.3	Village clinic	1.Yes 2.No 8.Do not know
MP14	How many times have you used your mobile phone to receive information about your own health or your child's health in the past 3 months? *(including text message and telephone) If MP14=1, go to MP15* *If MP14=2,3,4 or 5, go to HH4*	1.Never 2.Once 3.Twice 4.Three times 5.More than three times
MP15	Would you like to use your mobile phone to receive health information?	1.Yes 2.No 3.Other_____

Household (HH)		
HH4	What is the age of the mother?	____________________years
HH6	What is the mother's education level?	1.No education 2.Primary school 3.Junior high school 4.Senior high school/technical school 5.Vocational/technical secondary school 6.College 7.University or above 8.Do not know
HH7	How many years of education has the mother had?	____________________years
HH8	What is the mother's occupation?	1.Housework 2.Head of an enterprise, organisation or business unit 3.Technical 4.Receptionist, clerk, secretary 5.Commercial, business and service industry 6.Owner of individual business 7.Farmer engaged in non-agricultural industry 8.Industrial workers (factory production worker or transporter, mining, construction) with non-agricultural Hukou 9. Agriculture, forestry, or fishing water conservation 10.Military 11.Other_____ 88.Do not know
HH10	What is the age of the father?	____________________years
HH12	What is the father's education level?	1.No education 2.Primary school 3.Junior high school 4.Senior high school/technical school 5.Vocational/technical secondary school 6.College 7.University or above 8.Do not know
HH12a	How many years of education has the father had?	____________________years
HH13	What is the father's occupation?	1.Housework 2.Head of an enterprise, organisation or business unit 3.Technical 4.Receptionist, clerk, secretary 5.Commercial, business and service industry 6.Owner of individual business 7.Farmer engaged in non-agricultural industry 8.Industrial workers (factory production worker or transporter, mining, construction) with non-agricultural Hukou 9. Agriculture, forestry, or fishing water conservation 10.Military 11.Other_____ 88.Do not know

HH20	Family net income in the last year *(after subtracting cost of production)*	________¥ 888888=Do not know
HH21	Family living expenses in the last year *(living expenses include food, clothing, daily consumable, transport, communication, mortgage/rent, household bills, education, cultural entertainment, hospital bills etc.)*	________¥ 888888=Do not know

Questionnaire for interviews about reasons for differences in responses (objective 2)

Ask for all the questions for which the answer given face-to-face is different from the answer given via text messaging:

1. Can you think back in time, think about the moment you received the text message question about (*insert here what the question was about*). You answered this question by replying to us via text message. Can you tell me everything you remember about your experience and thoughts when you received the message and how you replied to it?
2. You just answered the same question to me face-to-face. Can you tell me everything about your thoughts about coming to your answer and replying to the question?
3. Why do you think the answer you gave for this question via text message is different from the response you gave face-to-face? (misunderstood text message question, misunderstood face-to-face question, changed mind, put wrong answer in text message, gave no response to text message question, other____)

Questionnaires for interviews with caregivers participating in the cross-over study (objective 3)

1. Completers

Questions:

1. How did you find replying to text messages questions about whether your child was ill in the past 2 weeks?

2. You have participated in the survey about your child's health both face-to-face and via text messaging.
   a. Which method of answering questions about your child's health do you prefer? (face-to-face, text message, other____)
   b. Why? What makes you say that?

3. Timing:
   a. What is your preferred time for receiving text messages? (time)
   b. Were the times (*state the times here*) that the messages were sent to you acceptable? (yes or no and why)

4. Reminders:
   a. Did you receive any reminders? (yes, no, not sure)
   b. How many? (number)
   c. How did you feel about the number of reminders you received? (ok with the number of reminders received, received too many reminders, would have liked more reminders, other____)

5. You received ¥1 for your text message fees and ¥5 for completing the survey.
   a. How did you feel about the amount of money for the text message fees, which is ¥1? (was enough, was not enough, was too much, other___) Why? What makes you say that?
   b. How did you feel about the amount of money for completing the survey, which is ¥5? (was enough, was not enough, was too much, other___) Why? What makes you say that?

c. You received a small gift (towel) for participating in the face-to-face survey. What is your preference: receiving ¥5 mobile phone credit, a gift, or health information for a survey? (¥5 mobile phone credit, small gift, health information, other___) Why? What makes you say that?

6. How many messages with questions about your child's health are you willing to answer at most on one day? (1-2, 3-4, 5-6, 7-8, >8)

7. How many messages with questions about your child's health are you willing to answer in total per survey? (1-2, 3-4, 5-6, 7-8, >8)

8. If we ask about your child's health regularly, how often would you accept this? (once a month, once every two months, once every three months, once every 6 months, once a year)

9. Do you have any other comments? (yes________,no)

2. Non-completers

Questions:

1. You responded to (*insert number of text messages which were responded to*) text message questions from us. You did not reply to the (*insert the number and question of text message which was not responded to*) text message question.
    a. Did you receive this question via a text message? (yes, no, not sure)
    b. Did you receive text message reminders? (yes, no, not sure)
    c. If no or not sure, why do you think you did not receive any messages? (changed the mobile phone number, mobile phone was broken, other____)

2. Why did you stop responding to the text messages questions? (did not bring the phone, phone was powered off, did not have enough credit, did not have time, did not know how to reply, forgot to reply, did not find it useful, did not trust the message, afraid of charging fees, afraid of advertising messages, other____)

3. How did you find responding to the text message(s)?

4. You have participated in the survey about your child's health face-to-face and via text messaging.
    a. Which method of answering questions about your child's health do you prefer? (face-to-face, text message, other____)
    b. Why? What makes you say that?

5. What would need to change for you, so that you would respond to all text message survey questions about your child's health?

6. You received ¥1 for your text message fees.
   a. How did you feel about the amount of money for the text message fees, which is ¥1? (was enough, was not enough, was too much, other____)
   Why? What makes you say that?
   b. You would have received ¥5 for completing the survey. How do you feel about the amount of money for completing the survey, which is ¥5? (was enough, was not enough, was too much, other____)
   Why? What makes you say that?
   c. You received a small gift (towel) for participating in the face-to-face survey. What is your preference: receiving ¥5 mobile phone credit, a gift, or health information for a survey? (¥5 mobile phone credit, small gift, health information, other____)
   Why? What makes you say that?

7. Do you have any other comments? (yes____,no)

3. Non-responders

Questions:

1. Receiving messages:
    a. Did you receive a text message from us? (yes, no, not sure)
    b. Did you receive any reminder messages? (yes, no, not sure) If no or not sure, why do you think you did not receive any messages? (changed mobile phone number, mobile phone was broken, replied but did not receive a reply from us, other____)

2. Why did you not respond to the text messages questions about whether your child was ill in the past two weeks? (did not bring the phone, phone was powered off, did not have enough credit, did not have time, did not know how to reply, forgot to reply, did not find it useful, did not trust the message, afraid of charging fees, afraid of advertising messages, other____)

3. What would need to change for you, so that you would respond to text message survey questions about your child's health?

4. Do you have any other comments? (yes____,no)

Appendix D Consent and information forms

Overview

This appendix provides English translated and Mandarin consent and information forms.

English translated version of consent and information form

Capital Institute of Pediatrics Informed Consent Form

This informed consent form is for people who take care of children under five of age who we are inviting to participate in research. The research is about using text messaging to collect information about care-seeking for common child diseases such as diarrhoea and pneumonia.

- Principle Investigators: Yanfeng Zhang from Capital Institute of Pediatrics, Josip Car from Imperial College London
- Co-investigators: Ye Li, Wei Wang, Qiong Wu from Capital Institute of Pediatrics, Igor Rudan from University of Edinburgh, Michelle Helena van Velthoven from Imperial College London
- Organisations: Capital Institute of Pediatrics, Zhao County's Maternal, Newborn and Child Health hospital, Imperial College London
- Project: Mobile phone text messaging for collecting data on care-seeking for childhood diarrhoea and pneumonia in Zhao County
- Part of project: research comparing face-to-face and mobile phone text messaging questions

This Statement of Consent consists of two parts:
- Part 1: Information sheet: to share information about the study with you
- Part 2: Certificate of Consent: to record your signature as agreement to participate in the study

You will be given a copy of the full Informed Consent Form.

<u>Part 1: Information Sheet</u>

Introduction
My name is................. working for the Capital Institute of Pediatrics. We are doing research on the use of text messaging to collect information about care-seeking for childhood diarrhoea and pneumonia. I am going to give you information and invite you to be part of this research. You can take the time you need to decide if you want to take part. There may be some words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can ask them to me.

Purpose of the research
Diseases such as diarrhoea and pneumonia can make children very ill. It is important to know how many children are ill and what parents do when their child is ill. This information can help us to improve health care which can improve child's health. Currently, this information is collected by researchers going to people's homes and asking questions, but this is time-consuming and costly. We want to see if we can collect this information by mobile phone text messaging and if that would be a more effective method. We believe that you can help us with this research by participating.

Type of Research
You will be interviewed face-to-face on about 15 questions, and the interview will take about 15 minutes. You will receive the same questions via text messages and you will be asked to respond to those questions by sending a text message back to us.

Participant selection
You are invited to take part in this research because we feel that all people who take care of a child up to five years of age who use a mobile phone can contribute to this research.

Voluntary Participation
Your participation is completely voluntary; you can choose to participate or decide not to participate. If you choose not to participate you will still receive all the health services as you usually do and nothing will change.

Procedures
We will ask you questions about whether your child has been ill in the past two weeks. We will ask those questions two times: face-to-face and via text messages.
Only with your permission, we may take a couple of photographs from you and your child during the research. The photographs will be of situations relevant to the research such as when you are using a mobile phone or when you are being interviewed. The photographs will be used for the purpose of the current study and may be included in academic publications or other material such as presentations or articles. If your photograph is used, this will be confidential and faces will be covered on the photographs. We will ask you to sign a separate consent form for the photographs. You can tell us if you do not want us to take photographs and then you will still be to participate in the research.

Risks and discomforts
We will ask you about your child's illness, but we will not directly provide you with health information. You should go to a health worker as you normally do, if you have any concerns about your child's health. There is a risk that you may feel uncomfortable answering some of the questions. For example we ask you questions about whether you sought care for your ill child. We ask these questions just to inform our research, we do not use the information you give us to assess your ability of taking care of your child. However, we do not wish you to feel uncomfortable. You do not have to answer any question or take part in the research if you feel the questions are too personal or if answering them makes you uncomfortable.

Benefits
You will not get any direct benefits from participating in this research, but the information you provide can help us to develop a better text messaging data collection method. This new method may give us more information about childhood diseases and ultimately can improve health care and child's health.

Incentive
We will not pay you to take part in the research, but we will give you a small good for your time and text messages you sent.

Confidentiality
All the information you give is confidential. Your name or other identifiable information will never be given to others without your permission and will not be visible in anything we write. Any information about you will have a number on it instead of your name. Only the researchers will know what your number is and we will lock that information up in a secured computer. It will not be shared with anyone except our research team.

Sharing of the results
We will provide you the knowledge of the research if you are interested in this. Also we will write articles and present the results to share the knowledge we get from this research.

Right to Refuse or Withdraw
If you do not want to participate in this research, you have right to refuse or withdraw at any time. You will still receive all the health services as you usually do if you decide to refuse or withdraw.

Who to contact
If you have any questions now or later, you can contact any of the following: Ye Li, Capital Institute of Pediatrics, No. 2, Yabao road, Chaoyang district, Beijing, 100020, TEL: 010-85695565

This proposal has been reviewed and approved by the ethic committee of Capital Institute of Pediatrics, whose task it is to make sure that research participants are protected from harm.

PART II: Consent form
Research consent

1. I have been invited to participate in research about using *mobile phone text messages to collect information on care-seeking for childhood diarrhoea and pneumonia*.

2. I know that I will answer questions about my child's health face-to-face and receive the same questions via text messages and reply to those text messages.

3. I understand that my participation is voluntary and that I have the right to withdraw from the research at any time without in any way affecting either my child's or my own health care.

4. I have been informed that the risks are minimal and may include feeling uncomfortable to talk about personal information. I am aware that there may be no benefit to either myself or my child personally.

5. I will only be reimbursed with a small gift for my time and for the text messages I sent.

6. I have been provided with the name, address and telephone number of a researcher who can be easily contacted.

7. I have read the information above. I have had the opportunity to ask questions about it and any questions that I have asked have been answered to my satisfaction.

8. I consent voluntarily as a participant in this research.

Print name of parent or caregiver___________________________________
Signature of parent or caregiver ____________________________________
Date (year/month/day)____

Print name researcher (individual obtaining consent)____________________
Signature of researcher ____
Date (year/month/day)____

Photographs consent

I consent voluntarily to photographs being taken of me and my child during the research. The photographs will be of situations relevant to the research such as when I am using a mobile phone or when I am being interviewed. I know that the photographs will be used for the purpose of the current study and may be included in academic publications or other material such as presentations or articles. If my photograph is used, I know this will be confidential and that faces will be covered on the photographs.

Print Name of parent or caregiver_______________________________
Signature of parent or caregiver ________________________________
Date (year/month/day)_______________________________________

Print name researcher (individual obtaining consent)_________________
Signature of researcher _______________________________________
Date (year/month/day)____

Mandarin version of consent and information form

首都儿科研究所
知情同意书

本知情同意书用于参加本研究的 5 岁以下儿童的家长或养育人。本研究是利用手机短信收集儿童肺炎和腹泻等常见疾病的就诊情况。

- 项目负责人：首都儿科研究所张延峰， 伦敦帝国理工学院约瑟普•卡尔（Josip Car)
- 研究人员：首都儿科研究所李烨、王玮、吴琼，爱丁堡大学伊戈尔•鲁丹（Igor Rudan)，伦敦帝国理工学院米歇尔•海伦娜•凡•菲多芬 (Michelle Helena van Velthoven)
- 研究机构：首都儿科研究所、伦敦帝国理工学院、赵县妇幼保健院
- 项目名称： 通过手机短信收集儿童肺炎和腹泻就诊情况的研究
- 项目单元：面对面与手机短信问卷对比研究

这份知情同意书包括两个部分：

- 信息部分，介绍相关信息
- 同意证明，了解情况后自愿参加者签字

您将得到一份完整的知情同意书副本。

第一部分：信息页

介绍

我叫__________________，来自首都儿科研究所。我们正在开展手机短信收集儿童肺炎和腹泻就诊情况的调查。我将向您介绍情况，并邀请您参加本次调查。您可以花一些时间决定是否参加。如果在介绍这些信息时，有些内容您不熟悉，可以随时向我提问，我非常乐于解答。如果之后还有不清楚的地方，也可以询问我。

研究目的

肺炎和腹泻等疾病对孩子的健康有很大危害。了解患病情况以及孩子生病后父母的处理方式非常重要。这些信息可以帮助我们提高卫生服务水平、并改善儿童健康状况。目前，这些信息都是通过研究人员入户询问得到，但这种方式需要大量的时间和财力。我们想知道通过手机短信了解这些情况的可行性和有效性。我们相信您的参与能够帮助我们完成这个研究。

研究类型

本次调查将会对您进行面对面访谈，访谈过程中您需要回答大约 15 个问题，持续 15 分钟左右。您会通过短信收到相同的问题并请您通过短信回答这些问题。

调查对象的选择

由于您正在养育 5 岁以下的孩子并且可以使用手机，可以为我们提供帮助，所以请您参加。

自愿原则

本着自愿的原则，您可以接受，也可以拒绝这次调查。如果您拒绝参加这个调查，对您和孩子就诊、保健等服务没有任何影响。

过程

我们将问您一些问题，了解您孩子过去两周内是否生过病。相同的问题我们会通过面对面和短信询问两次。

如果您允许，我们想在调查过程中为您和您的孩子拍几张相关照片。这些照片都是跟调查相关的，会在你用手机的时候或者采访你的时候为你拍照。这些照片可能会用于我们的研究，也可能会收入学术出版物或其他材料像研究介绍或文章。如果使用了您的照片，我们会保密，并在照片中遮盖住您的相貌。我们希望您在一张单独的表示您同意拍照的知情同意书上签字。如果您不想希望照这几张照片您可以告诉我们，这样您还可以参与这个调查。

风险和不适

我们会问到您孩子生病的情况，但我们不会直接给您健康指导。如您在孩子疾病方面有问题请您咨询大夫。

风险是可能有些问题您不方便回答，像问到您孩子生病有没有去治疗等问题。我们询问这些问题只是为了我们之后的研究，不是用您提供的信息来评价您照顾孩子的能力。我们不会想让您为难，如果您认为某些问题涉及隐私或者不方便回答，您有权拒绝回答一些问题或者拒绝参加这项研究。

受益

这次问答不会让您直接受益。但是，您提供的信息可以帮助我们建立更完善的手机短信信息收集方式。这种新方式可以为我们提供更多儿童疾病的相关信息，并有助于改善卫生服务水平及儿童健康状况。

财物奖励

我们不会付费请您参加本研究，但会送您一件小礼物，以补偿占用您的时间和您的短信费用。

保密原则

您提供的信息都是保密的。没有您的允许，名字以及其他身份信息都不会给别人，并且我们记录的东西不会让其他人看到。您的所有信息都会编码保存，只有研究人员知道您的编码。所有资料会保存在一个安全的电脑上。只有项目组的人员可以阅读这些资料，不会给其他人。

分享结果

如果您对我们的研究感兴趣，我们可以告诉您研究的结果。我们还会发表文章，展示研究成果。

拒绝或者退出的权利

如果您不愿意参加调查，您有权随时拒绝或者退出这个研究，并且这样做不会影响您和孩子接受的卫生服务。

联系人

如果您现在或之后有任何问题，可以联系项目组：

李烨，首都儿科研究所，北京朝阳区雅宝路 2 号，100020。电话：010-85695565

本调查的方案通过了首都儿科研究所伦理委员会的审查，确保参与研究的人不会受到伤害。

第二部分：知情同意证明
同意参与研究

1. 我受邀参加"通过手机短信收集儿童肺炎和腹泻就诊情况"的研究。

2. 我知道我将面对面回答一些关于孩子疾病方面的问题，并通过短信接收这些问题并回复。

3. 我知道我的参加是自愿的，我随时有权退出。退出调查不会以任何方式影响到我和孩子享受的保健服务。

4. 我已经被告知风险很小，可能仅会在谈论个人情况时会有些不便。我知道我跟我的孩子不会直接获益。

5. 我会得到一个小礼物以补偿占用我的时间和回复短信的费用。

6. 我已经得到项目联系人的姓名、地址以及电话。

7. 我阅读了以上信息。我说出了不明白的地方，得到了满意的回答。

8. 我自愿参加本研究。

父母或养育人的姓名（印刷体）：________

父母或养育人的签名：______________________________

日期（年月日）：______________

拍照知情同意书

我同意在研究过程中为我和孩子拍几张照片。这些照片都是跟调查相关的，会在我用手机的时候或者采访我的时候为我拍照。这些照片可能会用于我们的研究，也可能会收入学术出版物或其他材料像研究介绍或文章。如果使用了您的照片，我们会保密，并在照片中遮盖住您的相貌。

父母或养育人的姓名（印刷体）：______________

父母或养育人的签名：________________________________

日期（年月日）：_____________________

Appendix E Development of face-to-face and text message questionnaires

Overview

This appendix describes how the relevant questions from the World Health Organization Maternal, Newborn and Child Health Household survey were adapted to the local context in Zhao County and converted into text message questions; this process is illustrated in a flow diagram in seven steps (Figure 7).

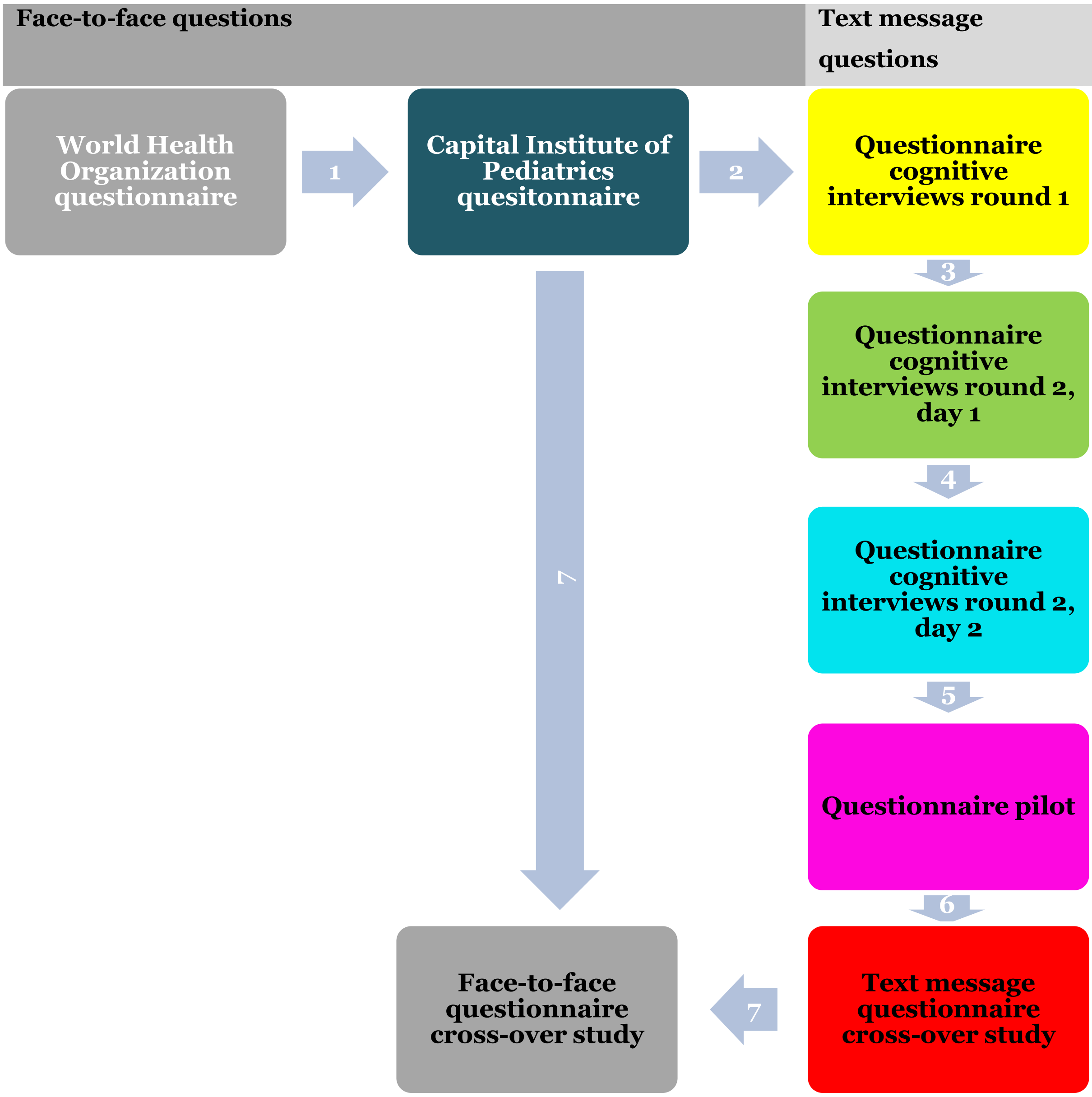


Figure 7 Flow diagram of question development

Step 1: Local adaptation of face-to-face questions

The questionnaire modules on diarrhoea and cough and fever were adapted to include local terms (Appendix F Local terminology study). In addition, the following changes and additions were made to the survey based on experiences with conducting the survey in China since 2010 (Table 39):

- For a number of questions, caregivers were asked to recall signs and symptoms that the child had in the past two weeks. For clarification, an extra phrase was added, "*please think back from two weeks ago till today*", to help caregivers recall this information;
- For question *DI.3.a.* (drinking during diarrhoea), the answer option "*much less or none*" was split into "*none*" and "*much less*" and the answer option "*about the same or somewhat less*" was split into "*about the same*" and "*somewhat less*", because caregivers indicated that there was a difference between these options. In addition, "*illness*" was changed into "*diarrhoea*" to clarify for which illness drinking behaviour was asked;
- For question *DI.3.b* (eating during diarrhoea), the answer options "*much less*" and "*none*" were merged into "*much less or none*", because caregivers indicated that this was the same;
- Question *DI.4.* "*Did you seek advice or treatment for the diarrhoea outside the home?*" was changed into "*Did you seek advice or treatment for the diarrhoea?*". Also, in the first answer option "*outside the home*" was added, because caregivers felt this was clearer;
- For question *DI.4.a* "*Why didn't you seek advice?*", answer option six "*not allowed to go*" was changed into "*not necessary*", because no caregivers said that they were not allowed to go, but some said that it was not necessary to go;
- For question *DI.4.b* "*Where did you seek care?*", the answer options were made specific to Zhao County. Similar changes were made in the cough and fever module questions.

Step 2: Conversion of face-to-face survey questions into text message questions

The face-to-face survey questions were converted from the World Health Organization Maternal, Newborn and Child Health Household survey into a text messaging questionnaire. The PhD candidate led this process with guidance of the Chinese researchers (YZ, LC, QW, YL and WW), a child health expert (IR) and mHealth expert (JC). The following changes were made to the text messages that were used for the first cognitive interview round (Table 40; first column):

- An introduction text message was added to introduce the survey and health information was added to clarify the meaning of the questions;
- Question *DI.3.* (drinking during diarrhoea) had three questions in the face-to-face interview, which were merged in the text messages survey to decrease the number of text messages. For the face-to-face interviews, this question was asked in three parts, but this could be merged and asked caregivers to identify all the liquids their child drunk in one question;
- For question *CO.2* (illness caused by cough), in the face-to-face survey question *CO.2.a* (fast or difficult breathing) was not asked when the answer to *CO.2* was "*no*". However, it was decided to let caregivers answer question *CO.2.a* when the answer to *CO.2* was "*no*" to be able to ask this question to more caregivers;
- In question *DI.4.b*, "*seek care*" was changed into "*seek advice or treatment*" for consistency with previous questions in the survey.

The text messages were translated by YL and checked by WW. The translations were compared and discussed with the PhD candidate. The final translation was checked by the bilingual translator.

Step 3, 4 and 5: Text message questions for cognitive interviews

The converted survey questions were assessed using cognitive interviews to check if the interpretation of the survey questions was similar to different caregivers. The PhD candidate trained YL in interview techniques. YL asked caregivers to participate in the interviews and conducted the interviews.

The aim of the interviews was to better understand: (i) caregivers' understanding of the meaning of questions in text message format; (ii) caregivers' understanding of how to respond to the questions; and (iii) whether information should be sent in one or two text messages. The interview guide included questions abound the meaning and understanding of the questions (Appendix C Questionnaires) and was tested in November 2012.

YL sent text messages to caregivers during the interview and asked caregivers to respond straight away. Text messages that had information and a question were randomly sent in one or two text messages and caregivers were asked which way they preferred.

Caregivers were asked to describe in their own words what the information, questions and answer options meant, and to rephrase the content in their own words. The answers of caregivers were written on a standardised sheet including caregiver's understanding of the content, rephrased content in their own words, reply to the text message, experiences and feelings, and notes.

An interview approach similar to the semi-structured interviews was used (described in Chapter 4). The interviewer specifically probed on the changes that were made in the questions during different cognitive interview rounds.

It was planned to interview 5 to 10 caregivers per round of interviews. In the first cognitive interview round, eight caregivers were interviewed during five days. After the interviews, YL and the PhD candidate analysed the results and discussed the changes that had to be made with the rest of the study team (Table 41).

In the second round, eight caregivers were interviewed on two days. On the first day, four caregivers were interviewed with the revised questions from the first cognitive interview round. The findings of the interviews were discussed, changes were made in the text messages and reasons for making the changes were written down (Table 42).

On the second day, another four caregivers were interviewed about the revised questions from the first day. The interviews were ended when it was felt that the text messages were understandable and when no new issues came up during the interviews. The text messages were revised based on the findings and discussions within the research team (Table 43).

Photograph 31 Cognitive interview

Photograph from the PhD candidate's personal collection

Step 6: Text message questions for pilot

The text messages that were revised after the cognitive interviews rounds were sent to a sample of 217 caregivers from Shahedian Township in Zhao County. The aim of the pilot was to test the procedure of sending text messages. Of those 217 caregivers who the text messages were sent to, 88 responded, 86 agreed to participate and 24 completed the survey. Five caregivers had a child with diarrhoea and 10 caregivers had a child with fever or cough.

Additional issues were found that had to be addressed and changes in the text messages were made accordingly (Table 44). In addition, two important considerations had to be taken into account.

Firstly, no caregivers (out of five caregivers who had a child with diarrhoea) responded to the second diarrhoea question (about blood in diarrhoea); also not after a reminder text message was sent. When YL called caregivers, they all said that they had not received the second diarrhoea question. It was found that the text messages were not sent, because the second diarrhoea question contained the word “blood”, which blocked sending out text messages with the text messaging system. This issue was not found earlier during the cognitive interviews, because then a mobile phone was used to send text messages. YL asked the major telecommunication operators in China (China Mobile, China Telecom and China Unicom) for their lists of words that blocked sending out text messages. These words were checked and no additional words in the text messages that would block sending out text messages were found.

Secondly, the text messaging system could not sent some of the text messages in one text message, because they were too long, despite that YL carefully checked that the information in the text messages was less than 65 Chinese characters. Minor changes were made to those text messages to make the information fit into one text message.

Step 7: Text message questions and face-to-face questions for cross-over study

Adjustments based on findings from the pilot were made and the final questions for the face-to-face and text message surveys were developed. Between the pilot and the cross-over study, it was not possible to interview caregivers face-to-face. Therefore, YL interviewed caregivers through phone calls. The adjustments were tested by sending text messages with an adjustment to four caregivers. Then YL called caregivers to ask about the meaning of the question, and caregivers' experiences and feelings when responding to the text messages.

It was intended to use the face-to-face questions that were used in Zhao County for previous surveys. However, as modifications were made to the text message questions, also minor modifications to the face-to-face questions had to be made to maximise similarity between the face-to-face and text messaging survey. These changes were only made for consistency and did not change the meaning of the questions (Table 39; right column).

Table 39 Overview of questions during development of face-to-face questionnaire

World Health Organization questionnaire	Capital Institute of Pediatrics questionnaire	Cross-over study questionnaire
DI.2. Has (*name*) had diarrhoea in the last 2 weeks? 1.Yes 2.No 8.Do not know	DI.1. Has (*name*) had diarrhoea in the last 2 weeks (please think back from two weeks ago till today)? 1.Yes 2.No 8.Do not know	DI.1. Has (*name*)* had diarrhoea in the last 2 weeks (please think back from two weeks ago till today, emphasise right date‡)? Diarrhoea is the passage of 3 or more loose or watery stools, compared to usual, per day. 1.Yes 2.No 8.Do not know
DI.3. Did (*name*) have blood in the stools? 1.Yes 2.No 8.Do not know	DI.2. Did (*name*) have blood in the stools? 1.Yes 2.No 8.Do not know	DI.2. Did (*name*)* have blood in the stools? *(explain that the blood should be caused by diarrhoea)* 1.Yes 2.No 8.Do not know
DI.4. During this last episode of diarrhoea, did (*name*) drink any of the following: *Read each item aloud and record response before proceeding to the next.* A fluid made from a packet called [*Local ORS name*]? 1. Yes 2. No	DI.3. During this last episode of diarrhoea, did (*name*) drink any of the following: *Read each item aloud and record response before proceeding to the next.* 1.A fluid made from a packet called ORS? 1.Yes 2.No 8.Do not know	DI.3. During this last episode of diarrhoea, did (*name*)* drink any of the following: *Read each item aloud and record response before proceeding to the next.* 1.A fluid made from a packet called ORS? *(explain ORS is drug for diarrhoea treatment)* 1.Yes 2.No 8.Do not know
A recommended homemade fluid [recommended fluid]? 1. Yes 2. No	2. A recommended homemade fluid [tap water, mineral water, rice water or soup]? 1.Yes 2.No 8.Do not know	2.One of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? 1.Yes 2.No 8.Do not know
Other homemade fluids [SSS or other not recommended]? 1. Yes 2. No	3.Other homemade fluids [tea or drinks]? 1.Yes 2.No 8.Do not know	3.Other fluids such as tea, drinks, water with honey or any sugary drinks? 1.Yes 2.No 8.Do not know
DI.5. During (*name's*) illness, did he/she drink much less, about the same, or more than usual? *If less probe*: Was he/she offered much less than usual to drink or somewhat less? 1.Much less or none 2.About the same or somewhat less 3.More 8.Do not know	DI.3.a During (*name's*) diarrhoea, did he/she drink much less, about the same, or more than usual? *If less probe*: Was he/she offered much less than usual to drink or somewhat less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 8.Do not know	DI.3.a During (*name's*)* diarrhoea, did he/she drink much less, about the same, more than usual or none? *If less probe*: Was he/she offered much less than usual to drink or somewhat less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 8.Do not know

DI.6. When (*name*) had diarrhea, did he/she eat less, about the same, or more food than usual? *If less probe*: Much less or a little less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 6.Child never received solid or semi-solid foods 8.Do not know	DI.3b. When (*name*) had diarrhoea, did he/she eat less, about the same, or more food than usual? *If less probe*: Much less or a little less? 1.Much less or none 2.Somewhat less 3.About the same 4.More 5.Child never received solid or semi-solid foods 8.Do not know	DI.3.b When (*name*)* had diarrhoea, did he/she eat less, about the same, more food than usual or none? *If less probe*: Much less or a little less? 1.None 2.Much less 3.Somewhat less 4.About the same 5.More 6.Child never received solid or semi-solid foods 8.Do not know
DI.7. Did you seek advice or treatment for the diarrhoea outside the home? 1.Yes 2.No 8.Do not know	DI.4. Did you seek advice or treatment for the diarrhoea? 1.Yes, seek advice or treatment outside home 2.No, managed at home 8.Do not know	DI.4. During this last episode of diarrhoea in (*name*)*, did you seek advice or treatment for the diarrhoea outside the home? *(explain that this means asking anyone who is not a family member living with them)* 1.Yes, outside the home 2.No, managed at home 8.Do not know
DI.8. Why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not allowed to go, harmful traditional healer etc. 07.Religious beliefs 08.Other: specify __________ 88.Do not know	DI.4.a. Why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify __________ 88.Do not know	DI.4.a. During this last episode of diarrhoea in (*name*)*, why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify __________ 88.Do not know

DI.9. Where did you seek care? *Record all sources mentioned.* *Prompt: "Anywhere else?"* Public health sector 1.Yes 2.No Hospital 1.Yes. 2.No Health center/dispensary1.Yes. 2.No Outreach/mobile clinic 1.Yes. 2.No Other public 1.Yes. 2.No Specify:__________ Private health sector 1.Yes 2.No Hospital 1.Yes. 2.No Private dispensary/health center 1.Yes 2.No Pharmacy 1.Yes 2.No Other private 1.Yes. 2.No Specify: _________ Community 1.Yes 2.No Community health worker 1.Yes. 2.No Traditional healer/Traditional birth attendant 1.Yes. 2.No Other: 1.Yes 2.No Specify: _________	DI.4.b Where did you seek care? *Record all sources mentioned.* *Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1. Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: _______ 1.Yes 2.No Specify: __________	DI.4.b. Where did you seek care when (*name*)[*] had diarrhoea? *Record all sources mentioned.* *Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1. Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: _______ 1.Yes 2.No Specify: _______
CO.3. Has (*name*) been ill with a fever at any time in the last 2 weeks, that is, since (DAY OF THE WEEK) of the week before last? 1.Yes 2.No 8.Do not know	CO.1. Has (*name*) been ill with a fever at any time in the last 2 weeks (please think back from two weeks ago till today)? 1.Yes 2.No 8.Do not know	CO.1. Has (*name*)[*] been ill with a fever at any time in the last 2 weeks, (please think back from two weeks ago till today, emphasise right date[‡])? 1.Yes 2.No 8.Do not know
CO.4. Has (*name*) had an illness with a cough at any time in the last 2 weeks, that is, since (*day of the week*) of the week before last? 1.Yes 2.No 8.Do not know	CO.2. Has (*name*) had an illness with a cough at any time in the last 2 weeks (please think back from two weeks ago till today)? 1.Yes 2.No 8.Do not know	CO.2. Has (*name*)[*] had an illness with a cough at any time in the last 2 weeks (please think back from two weeks ago till today, emphasise right date[‡])? 1.Yes 2.No 8.Do not know

CO.5. When (*name*) had an illness with a cough, did he/she breathe faster than usual with short, fast breaths or have difficulty breathing? 1.Yes 2.No 8.Do not know	CO.2.a When (*name*) had an illness with a cough, did he/she breathe faster than usual with short, fast breaths or have difficulty breathing? 1.Yes 2.No 8.Do not know	CO.2.a Did (*name*)* breathe faster than usual with short, fast breaths or have difficulty breathing *(local terms)* in the last 2 weeks (please think back from two weeks ago till today, emphasise right date‡)? 1.Yes 2.No 8.Do not know
CO.6. Were the symptoms due to a problem in the chest or a blocked nose? 1.Problem in the chest 2.Blocked nose 3.Both 4.Other, specify: _____ 8.Do not know	CO.2.b Were the symptoms due to a problem in the chest or a blocked nose? 1.Problem in the chest 2.Blocked nose 3.Both 4.Other, specify: _____ 8.Do not know	CO.2.b Were the symptoms due to a problem in the chest or a blocked nose? 1.Problem in the chest 2.Blocked nose 3.Both 4.Other, specify: _____ 8.Do not know
CO.7 Did you seek advice or treatment for the fever/cough outside the home? 1.Yes 2.No 8.Do not know	CO.4.a Did you seek advice or treatment for the fever/cough? 1.Yes, seek advice or treatment outside home 2.No, managed at home 8.Do not know	CO.4.a During this last episode of fever or cough in (*name*)*, did you seek advice or treatment for the fever/cough outside the home? *(explain that this means asking anyone who is not a household family member living with them)* 1.Yes 2.No 8.Do not know
CO.8. Why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not allowed to go, harmful traditional healer etc. 07.Religious beliefs 08.Other: specify __________ 88.Do not know	CO.4. Why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify __________ 88.Do not know	CO.4. During this last episode of fever or cough in (*name*)*, why didn't you seek advice? *Only one answer allowed.* 01.Mild disease/did not need outside help 02.Geographical access (too far from facility) 03.Costs (had to pay for visit or transportation) 04.Facility closed/staff not available 05.Poor quality of care at facility 06.Not necessary 07.Religious beliefs 08.Other: specify ______ 88.Do not know

CO.09. Where did you seek advice or treatment? *Record all sources mentioned. Prompt: "Anywhere else?"* Public health sector 1.Yes 2.No Hospital 1.Yes. 2.No Health center/dispensary1.Yes. 2.No Outreach/mobile clinic 1.Yes. 2.No Other public 1.Yes. 2.No Specify:_________ Private health sector 1.Yes 2.No Hospital 1.Yes. 2.No Private dispensary/health center 1.Yes 2.No Pharmacy 1.Yes 2.No Other private 1.Yes. 2.No Specify: ________________ Community 1.Yes 2.No Community health worker 1.Yes. 2.No Traditional healer/Traditional birth attendant 1.Yes. 2.No Other: 1.Yes 2.No Specify: _________	CO.4.a Where did you seek advice or treatment? *Record all sources mentioned. Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1. Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: ________ 1.Yes 2.No Specify: ___________	CO.4.a Where did you seek advice or treatment when (*name*)* had fever or cough? *Record all sources mentioned. Prompt: "Anywhere else?"* 1.Relative or friend 11.Own family 1.Yes 2.No 12.Friends or neighbours 1.Yes 2.No 2.Health facility 21.County level hospital or above (excluding MCH hospital) 1.Yes 2.No 22.County level MCH hospital 1.Yes 2.No 23.Community health centre 1.Yes 2.No 24.Township hospital 1.Yes 2.No 25.Community health station 1.Yes 2.No 26.Village clinic 1.Yes 2.No 3.Private health facility 31.Private hospital 1.Yes 2.No 32.Private clinic 1. Yes. 2.No 33.Pharmacy 1.Yes 2.No 4.Community 41.Midwife 1.Yes 2.No 42.Staff for family planning 1.Yes 2.No 5.Other: 1.Yes 2.No Specify: ___

*For the face-to-face questions, the smartphone programme could insert the name of the child automatically for each question.

Table 40 Overview of questions during development of text message questionnaire

Nr	Cognitive interviews round 1, changes* marked	Cognitive interviews round 2, day 1 changes* marked	Cognitive interviews round 2, day 2, changes* marked	Pilot, changes* in marked	Cross-over study, changes* marked
1	1.Hello, this is Maternal and Child Health Hospital and the *Capital Institute of Pediatrics*. We want to ask you questions about your child's health via mobile phone text messages. Your information can help us improving health services. Are you willing to answer those questions? Text us the number of your answer: 1.Yes 2.No	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving health services. [*Zhao County's Maternal and Child Health Hospital message*]	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*]	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*]	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*]
2		You do not have to pay extra fees and you will be paid back for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*]	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*]	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*]	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*]

3				How does your child call you (the relationship between you and your child)? Please respond: mother/father/grandmother/grandfather/other.....(please specify) [*Zhao County's Maternal and Child Health Hospital message*]	How does your child call you (the relationship between you and your child)? Please respond: mother/father/grandmother/grandfather/other.....(please specify) [*Zhao County's Maternal and Child Health Hospital message*]
4	2.Diarrhoea is the passage of 3 or more loose or watery stools per day. Has your child had diarrhoea in the last 2 weeks (day till day)? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Diarrhoea is the passage of 3 or more loose or watery stools per day. Has your youngest child had diarrhoea in the last 2 weeks (*day* till *day*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*]	Diarrhoea is the passage of 3 or more loose or watery stools per day. Has your youngest child had diarrhoea in the last 2 weeks (*day* till *day*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*]	Diarrhoea is the passage of 3 or more loose or watery stools per day. Has your youngest child had diarrhoea in the last 2 weeks (*month*/*day* till *day*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*]	Diarrhoea is the passage of 3 or more loose or watery stools, compared to usual, per day. Has your youngest child[†] had diarrhoea in the last 2 weeks (from *month*/*day* till *today*[§])? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*]
5	3.Did your child have blood in the stools? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*]

6	4.During this last episode of diarrhoea, did your child drink any of the following: 1.a fluid made from a packet called ORS 2.a recommended homemade fluid such as tap water, mineral water or soup 3.other homemade fluids such as tea or drinks. Please text the all the numbers (1, 2, 3) related to the fluid(s) you gave your child.	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug which is a mixture of clean water, salt and sugar)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*]
7		During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*]

8		During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea, drinks, water with honey or any sugary drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*]
9	5.During your child's diarrhoea, did he/she drink much less, about the same, or more of any liquid than usual? Text us the number of your answer: 1.None 2.Much less 2.Little less 3.About the same 4.More 8.Do not know	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	During your youngest child's diarrhoea, how much did he/she drink compared to usual (anything the child can drink, including breast milk or formula)? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]

10	6.When your child had diarrhoea, did he/she eat less, about the same, or more food than usual? Text us the number of your answer: 1.Much less or none 2.Little less 3.About the same 4.More 5.Child never received solid or semi-solid foods 8.Do not know	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child ever been introduced to foods such as rice, noodles, manto, meat, eggs, vegetables, fruits (excluding breast milk or formula)? Please respond: child received foods before/child never received foods before [*Zhao County's Maternal and Child Health Hospital message*] *For children who have been introduced to complementary foods sent:* When your youngest child had diarrhoea, how much did he/she eat (including all foods, excluding breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*]

11	7.Did you seek advice or treatment for the diarrhoea outside the home? Text us the number of your answer: 1.Yes, outside the home 2.No, at home 8.Do not know	Did you seek advice or treatment when your youngest child had diarrhoea outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*]
12	8.Why did you not you seek advice or treatment for the diarrhoea outside the home?	Why did you not seek advice when your youngest child had diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]
13	9.Where did you seek advice or treatment?	Where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]

				After response, prompt: "Did you go anywhere else during the last episode of diarrhoea in your youngest child? Please respond by telling us all the places you want to. [*Zhao County's Maternal and Child Health Hospital message*]"	*After response, prompt:* "Did you go anywhere else during the last episode of diarrhoea in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]"
14	10.Children have fever when they have a high temperature equal to or above 37.5 degrees of Celsius. Has your child had fever at any time in the last 2 weeks (from day till day)? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Has your youngest child had fever at any time in the last 2 weeks (*day* till *day*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had fever at any time in the last 2 weeks (*day* till *day*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had fever at any time in the last 2 weeks (*month*/*day* till *day*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had fever at any time in the last 2 weeks (from *month/day* till *today*[§])? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*]
15	11.Has your child had cough caused by illness at any time in the last 2 weeks (from day till day)? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Has your youngest child had cough caused by illness at any time in the last 2 weeks (*day* till *day*)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had cough caused by illness at any time in the last 2 weeks (*day* till *day*)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had cough caused by illness at any time in the last 2 weeks (*month* /*day* till *day*)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*]	Has your youngest child had cough caused by illness at any time in the last 2 weeks (from *month/day* till *today*[§])? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*]

16	12.Count the number of breaths your child has in one minute. When your child is younger than 1 year, fast breathing is when your child has more than 50 breaths in one minute. When your child is older than 1 year, fast breathing is when your child has more than 40 breaths in one minute. Did your child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (from day till day)? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (day till day)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (*day* till *day*)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (*month*/*day* till *day*)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*]	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (from *month/day* till *today*§)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*]
17	13.Were the fast breathing or difficult breathing due to a problem in the chest or a blocked nose? Text us the number of your answer: 1.Problem in the chest 2.Blocked nose 3.Both problem in the chest and blocked nose 4.Other reason 8.Do not know	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*]	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*]	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*]	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*]

18	14. Did you seek advice or treatment for fever or cough outside the home? Text us the number of your answer: 1.Yes 2.No 8.Do not know	Did you seek advice or treatment for fever or cough outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home. [*Zhao County's Maternal and Child Health Hospital message*]
19	15.Why did you not seek advice for the fever or cough?	Why did you not seek advice for the fever or cough outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, why did you not seek advice outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, why did you not seek advice outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]	During this last episode of fever or cough in your youngest child, why did you not seek advice outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*]
20	16.Where did you seek advice or treatment for the fever or cough?	Where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	Where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]

			After response, prompt: Did you go anywhere else during the last episode of fever and cough in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]	*After response, prompt:* Did you go anywhere else during the last episode of fever and cough in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*]
21	This is the end of the survey. Thank you very much for participating! You will receive the reimbursement for your text messages and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*]	This is the end of the survey. Thank you very much for participating! You will receive the reimbursement for your text messages and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*]	This is the end of the survey. Thank you very much for participating! You will receive ¥0.1 per text message and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*]	This is the end of the survey. Thank you very much for participating! You will receive ¥0.1 per text message and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*]

*For the text message questions, the questions for each phase (=one column) were the text messages that were used for that phase. The coloured changes were the changes that were made in the previous phase. The reasons for the changes are specified in tables below; the changes were made based on what caregivers said during interviews and on discussions in the research team. During the interviews, extra attention was paid to the highlighted changes to ensure that they did not alter the meaning of the original questions and that they improved clarity, so that caregivers could understand the questions.

†It was technically not possible to insert the name of the child. This would have been preferable, because it could prevent confusion about which child was meant in the question (when the caregiver had more than one child). In addition, it could have made the text messages more personal. Therefore, the child was identified in the text messaging survey by the words "*your youngest child*", because when a caregiver had two children under five, it was meant to ask about the youngest child.

‡For the text message questions, after trying different formats for the time, it was found that the format (from *month/day* till *today*) was the clearest and shortest in Chinese characters. For the face-to-face questions, this format was technically not possible. Therefore, in the face-to-face survey, for "in the last 2 weeks (please think back from two weeks ago till today, emphasise right date)" was asked.

§For the cross-over study, "today" was changed into "yesterday" in group 1, because the face-to-face survey took place the day before the text messaging survey and it was meant to ask for information in the same period.

Table 41 Text messages with changes marked, based on cognitive interviews round 1

Nr	Text messages in English and Mandarin with marked changes	Changes	Explanation for change based on findings
All	See text messages below	See below	It was aimed to design text messages that were clear, meaningful and could be trusted, because caregivers indicated in the cognitive interviews that these were important themes for them. Where possible, this was kept in mind when making changes in the text messages.
All	See text messages below	Combine information where possible in 1 text message/65 Chinese characters	It was decided to combine questions and answer options together in one text message to reduce the number of text messages when possible. Caregivers were asked about their preference for receiving text messages that contained much information together or separately. During the first round of cognitive interviews, this was randomly tested sending the text messages together and separately. Caregivers did not have a consistent preference for one or the other. However, one caregiver said to be focused on the first part of the text message and did not read the second part of the text message when it was very long. Also, if text messages that contained more than 65 Chinese characters (one text message) were sent, text messages were split into separate text messages. Sometimes it happened that the second part of the text message was delayed and this confused caregivers. It was possible to do this for all the questions, apart from the first question that asked whether caregivers were willing to participate (see text message 1 below). Caregivers considered this information important for being reminded about the survey and this information could not be shortened to make it fit into one text message.

All	See text messages below	Provide additional information to clarify the meaning of text message survey questions, but remove complicated information on disease signs and symptoms	It was decided to add information to clarify the meaning of questions. In the text messaging survey it was not possible to directly clarify the meaning of the question as was done in the face-to-face survey. Therefore, information was added. However, this could not explain everything, because adding too much information on certain topics (such as fever and fast and difficult breathing) confused caregivers.
All	See text messages below	Adding local terms	The local terms were added for diarrhoea, blood in stools, cough, fever and fast and difficult breathing based on the local terminology study.
All	See text messages below	Provide survey answer options in text messages	It was decided to provide caregivers the answer options in the text message survey. In the face-to-face survey, the answer options were not given to caregivers; the interviewer asked the question, listened to the caregiver's response and selected the most appropriate answer. If the answer options were not given to caregivers in the text message survey, they could respond with any answer and it was time-consuming to categorise their answers and to follow-up ambiguous answers.
All	See text messages below	"Return" between question and answer options	It was decided to start the answer options on a new line where possible. One caregiver said that it was clearer to read the answer options when they started on a new line.
All	See text messages below "~~Do not know/~~"	Omit answer option "do not know"	It was decided to not give caregivers the option "do not know", because this may have encouraged caregivers to choose this option. The answer "do not know" was not desirable as it was a missing value. Therefore, the data was only coded as "do not know" when the caregiver wrote this in the text message.

All	See text messages below	Respond by Chinese characters, instead of responding by numbers	It was decided to provide the answer options in Chinese characters for each question. The first reason for this was that during the cognitive interviews several caregivers ignored a request to respond by numbers. Caregivers said that it was easier to respond by Chinese characters with a Chinese mobile phone, because caregivers had to change the setting in their mobile phone to insert numbers. The second reason was that when using the text messaging system, the responses were not automatically categorised. Therefore, it may not have been directly clear to which question a caregiver gave a response if the answers were all the same. By asking caregivers to respond with the answer in Chinese characters, it was clearer for which question they gave an answer. For example for the question "Are you willing to respond to those questions?"' The answer was not just "yes", but "I am willing" or "I am not willing. Thereby, the answer could be distinguished from answers to another question like: "Did your child have diarrhoea?", because answers were: "have diarrhoea" (this means yes) or "do not have" (this means no). In Mandarin, there is no fixed "yes" or "no"; the answer depends on the question asked. When saying "yes", people will confirm what is asked. When saying "no", this can either be "no" (bù) or "do not have" (méi yǒu).
All	See text messages below	Omit text message number in the text message	It was decided to omit the text message number in the text messages. During pilot cognitive interviews, caregivers said that they liked to see which question number they received, because then they knew how many questions they had answered. Numbers were added in the first cognitive interview round, but then caregivers said that this was sometimes confusing. Adding numbers was also prone to error and time-consuming, because the number of the question depended on the question algorithm and the text message researcher had to insert this manually.

All	See text messages below	Small changes in Chinese characters to fit the information into 65 Chinese characters	Sometimes Chinese characters had to be changed to make the information fit in 65 characters. This was done by YL and checked by WW.
All	See the green marking in the text messages below "[*Zhao County's Maternal and Child Health Hospital message*]【县妇幼短信】"	Add "[*Zhao County's Maternal and Child Health Hospital message*]"	It was decided to add a "label" to each text message that said "Zhao County's Maternal and Child Health Hospital". The text message software company asked to do this, so that they could ensure that the text messages were successfully sent out. Also, it was thought that the label gave the text messages more trustworthiness. Caregivers said that they wanted to know who sent the text messages. They were familiar with Zhao County's Maternal and Child Health Hospital and therefore it was expected that caregivers recognised the label and trusted the text messages.
All	See the green marking in the text messages below "Youngest", "最小的"	Add "youngest" before "child" in all text messages	It was decided to add "youngest" before "child" in all text messages, because families could have more than one child younger than five years.

1	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving health services. [*Zhao County's Maternal and Child Health Hospital message*] 您好，我们是赵县妇幼，想了解您家里最小的那个孩子健康有关情况。您的回复对我们很重要，可以改进卫生保健服务。【县妇幼短信】	Omit "and the Capital Institute of Pediatrics"	It was decided to omit that the questions were sent by the Capital Institute of Pediatrics in Beijing, because most caregivers were not familiar with the Capital Institute of Pediatrics in Beijing. The previous sentence said "Hello, this is Maternal and Child Health Hospital and the Capital Institute of Pediatrics." While this information was given to the caregivers, they may have forgotten about this by the time they received the text message.
		Add "Zhao County's"	It was decided to add "Zhao County's" before "Maternal and Child Health Hospital" to clarify which hospital was meant. All caregivers were familiar with Zhao County's Maternal and Child Health Hospital.
		Separate introduction (1) and question about willingness to participate (2)	It was decided to combine questions and answer options together in one text message to reduce the number of text messages when possible. It was not possible to do this for the first question that asked about whether caregivers were willing to participate. The previously used text message said: "Hello, this is Maternal and Child Health Hospital and the Capital Institute of Pediatrics. We want to ask you questions about your child's health via mobile phone text messages. Your information can help us improving health services. Are you willing to answer those questions? Text us the number of your answer: 1.Yes 2.No". However, this information was insufficient and more information had to be added, which could not fit in one text message.
		Omit "mobile phone text messaging"	It was decided to change "We want to ask you questions about your child's health via mobile phone text messages.", into simply "We want to ask you questions about your youngest child's health.", because it was obvious that this was via mobile phone text messaging and these words could be deleted to shorten the text message.
		Add that caregiver's response is meaningful and important	It was decided to add that the caregiver's response was meaningful to motive caregivers to respond.

2	You do not have to pay extra fees and you will be paid back for replying to messages. In addition, if you answer all the questions, you will receive 5 ¥ extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*] 回短信无额外费用，并将得话费补偿。答完所有问题还将得 5 元话费。2 周内充到您手机。您愿意回答吗？ 请回复：愿意/不愿意【县妇幼短信】	Add information on paying back expenses for text message fees and receiving an incentive for completing the survey	It was decided to add information about paying back text message fees, because one caregiver worried about the costs of ¥0.1 per text message. Also, it was decided to give caregivers a small incentive of ¥5 for completing the survey; that was similar to the towel given for the face-to-face interview, which was also worth ¥5.
		Add "within 2 weeks"	The phrase "within 2 weeks" was added, because it was thought that it should be clear when the money was given.
3	*Text message 3 was added at a later stage*	NA	NA
4	Diarrhoea is the passage of 3 or more loose or liquid stools per day. Has your youngest child had diarrhoea in the last 2 weeks (from *day* till *day*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*] 拉肚子/拉稀指稀便或水样便一天三次或以上。您家最小的孩子过去两周内（*从...到...*）拉肚子/拉稀了吗？ 请回复：拉了/没拉【县妇幼短信】	Information and question together	See changes "Combine information where possible in 1 text message/65 Chinese characters" above.
5	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子有过因拉肚子/拉稀导致的大便里边带血吗？ 请回复：带血/不带血【县妇幼短信】	Add information to clarify meaning of question	It was decided to add the information "(caused by diarrhoea)" to clarify the meaning of the question. For this question the World Health Organization Maternal, Newborn and Child Health Household survey stated that only blood associated with diarrhoea was meant. Other causes of blood in stools, such as constipation, were not meant. It was thought about adding "(not including blood caused by constipation)", but as this may have confused caregivers. Therefore, this phrase was not used.

6	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug which is a mixture of clean water, salt and sugar)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*] 您最小的孩子最近一次拉肚子/拉稀期间，喝了口服补液盐吗(糖、盐与水混合的药)？ 请回复：喝了口服补液盐/没喝口服补液盐【县妇幼短信】	Separate question in three text messages	It was decided to separate the question about drinking during diarrhoea into three questions, as specified in the World Health Organization Maternal, Newborn and Child Health Household survey handbook. It was considered to combine these three questions in one text message to reduce the number of text messages that had to be sent. However, caregivers did not understand the questions correct during the cognitive interviews. It was realised that the meaning of the question changed by combining the three questions in one text message. Therefore, the three questions were asked in three separate text messages.
		Clarify the meaning of ORS	It was decided to clarify the meaning of ORS, because caregivers said that they did not knew what ORS was.
7	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近一次拉肚子/拉稀期间，是否喝了以下任一种液体：母乳、配方奶粉、白开水、矿泉、水、米汤、菜汤？ 请回：喝过这些/都没喝过【县妇幼短信】	New text message	See text message 6.
		Omit "recommended"	It was decided to omit the word "recommended" to not confuse caregivers. Caregivers asked why it said "recommended". One caregiver did not knew which drinks were recommended, but thought that this meant that other homemade fluids such as tea and drinks were less good, because they were not recommended.
		Add breast milk and formula	The list of locally recommended fluids was completed by adding breast milk and formula.
8	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子最近一次拉肚子/拉稀期间，是否喝了其他液体，如茶水或饮料等？ 请回复：喝过其他液体/没喝其他液体【县妇幼短信】	New text message	See text message 6.
		Omit "homemade"	It was decided to omit the word "homemade", because this was not necessary for understanding the question and omitting it reduced the number of Chinese characters in the text message.

9	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，喝的液体量（汤水、母乳和配方奶）比平常怎样？请回：一点没喝/少得多/少些/一样/多些【县妇幼短信】	Rephrase question	It was decided to rephrase this question; information in the question was moved to the answer options. Caregivers said the previous question was unclear, because the answer options (less, about the same, or more) were in the question: "During your child's diarrhoea, did he/she drink much less, about the same, or more of any liquid than usual?". The answer options were omitted in the question and replaced by "how much compared to usual".
		Add "liquids, breast milk, or formula" between brackets	It was decided to add the information "liquids, breast milk or formula" between brackets to clarify the meaning of the question. The World Health Organization Maternal, Newborn and Child Health Household survey handbook specified that drinking included all liquids.
10	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, excluding breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，吃固体、半固体、母乳和配方奶的量比平常怎样？请回：没吃/少很多/少些/一样/多些/？【县妇幼短信】	Rephrase question	It was decided to rephrase this question; information in the question was moved to the answer options. Caregivers said that the previous question was unclear, because the answer options (less, about the same, or more) were in the question: "During your child's diarrhoea, did he/she eat much less, about the same, or more of any liquid than usual?". The answer options were omitted in the question and replaced by "how much compared to usual".
		Separate the answer options "none" and "much less"	It was decided to split the answer options "none" and "much less" to be consistent with the World Health Organization handbook.
		Remove the answer option "never received solid or semi-solid foods"	It was decided to remove the answer option "never received solid or semi-solid foods", because this could be confused with "none".
		Add information to clarify question meaning	It was decided to add "(including solid and semi-solid foods, breast milk and formula)", which was specified in the World Health Organization Maternal, Newborn and Child Health Household survey handbook.

11	Did you seek advice or treatment when your youngest child had diarrhoea outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子拉肚子/拉稀时，向家里以外的人寻求过指导或治疗了吗(问家里人不算)？ 请回复：寻求过 /没有寻求 【县妇幼短信】	Add information to clarify question meaning	It was decided to add extra information between brackets, because caregivers often only thought about going to a doctor for seeking advice or treatment (this question meant to ask about seeking advice to anyone outside the family, also neighbours or friends).
12	Why did you not seek advice when your youngest child had diarrhoea outside the home? Please respond by giving us one reason, the most important one [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子拉肚子/拉稀时您为什么没有到家庭外寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】	Add "Please respond by giving us one reason, the most important one"	It was decided to add "please respond by giving us one reason, the most important one", because caregivers may otherwise have given many reasons for why they did not seek advice outside the home. The World Health Organization Maternal, Newborn and Child Health Household survey guidelines specified to record only the most important reason. In Mandarin "one" had to be added to make this clear.
13	Where did you seek advice or treatment when your youngest child had diarrhoea? Please respond by telling us all the places you went to [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子拉肚子/拉稀时你到哪里寻求指导和治疗？ 请回复去的所有地方。【县妇幼短信】	Add "Please respond by telling us all the places you went to"	It was decided to add "please respond by telling us all the places you went to", because caregivers may only have given one answer and the World Health Organization handbook specified to list all the places caregivers went to.
14	Has your youngest child had fever at any time in the last 2 weeks (from *day* till *day*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内 （*从…到…*）有过发烧吗？ 请回复：发烧了/没发烧【县妇幼短信】	Delete information	It was decided to omit the information on fever, because this was confusing for caregivers. All caregivers knew what fever was, but they found the information about the temperature degree confusing. Caregivers said that they did not measure the body temperature of their child. Some had incorrect ideas about what the temperature of fever was. One caregiver said that it should be when the temperature of the child was higher than 36.5 degrees (normal temperature according to this caregiver).

15	Has your youngest child had cough caused by illness at any time in the last 2 weeks (from *day* till *day*)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（*从...到...*）有过因为生病引起咳嗽吗？ 请回复：有过生病引起的咳嗽/没有过生病引起的咳嗽【县妇幼短信】	No change	One caregiver responded that the child had cough because of Shanghuo, which is a belief from Traditional Chinese Medicine (see section 3.2.6). While most Chinese people know this term, there is no clear consensus what it means. There is no equivalent term for Shanghuo in Western Medicine, but a translation could be "being under the weather". It was decided not to change anything, because if a caregiver mentioned that cough was caused by Shanghuo, this was likely to be less serious than a common cough.
16	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (from *day* till *day*)? Please respond: child had/ child didn't have [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子 2 周内有过呼吸比平时快而短，或者有喘不上气/憋得慌吗？（从...到...） 请回复：有过/没有【县妇幼短信】	Omit information about fast and difficult breathing	It was decided to omit the information about fast and difficult breathing, because caregivers found the information on counting breaths confusing. Fast and difficult breathing were difficult concepts for caregivers and no one counted breaths or paid attention to it. Some caregivers said that they were willing to count breaths, but others did not want to do this.
		Change terms for fast breathing and difficult breathing	The local terms for fast and difficult breathing were added. One caregiver thought the terms "difficult breathing" and "fast breathing" were the same. This finding was confirmed in the local terminology study. However, this did not bias the answer to this question, because the question did not differentiate between fast and difficult breathing.
		Change answer options	It was decided to change the answer options, because in Mandarin it was not clear to say "fast or difficult breathing". The answer options had to be specified as "child had/didn't have".
17	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason……(please give reason) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子呼吸快或喘不上气/憋得慌是因为什么？ 请回复： 肺部问题/鼻腔堵塞/两者都有/其他原因（请列出）【县妇幼短信】	Rephrase question	It was decided to rephrase this question; information was moved in the question to the answer options. Caregivers said the previous question was unclear, because the answer options (a problem in the chest or a blocked nose) were in the question: "Were the fast breathing or difficult breathing due to a problem in the chest or a blocked nose?". Therefore, it was more appropriate to omit the answer options in the question. This also made the question shorter.

18	Did you seek advice or treatment for fever or cough outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 孩子发烧/咳嗽时，你为孩子寻求指导或治疗吗？ 请回复：向家里以外的人寻求指导或治疗了吗？请回复：寻求过/没有寻求【县妇幼短信】	Add information to clarify question meaning	See text message 11.
19	Why did you not seek advice for the fever or cough outside the home? Please respond by giving us one reason, the most important one [*Zhao County's Maternal and Child Health Hospital message*] 孩子发烧/咳嗽时您为什么没有到家庭外寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】	Add "outside the home"	It was decided to add "outside the home", because this was clearer and consistent with text message question 12.
		Add "Please respond by giving us one reason, the most important one"	See text message 12.
20	Where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to [*Zhao County's Maternal and Child Health Hospital message*] 孩子发烧/咳嗽时到哪里寻求指导或治疗？ 请回复列出去的所有地方。【县妇幼短信】	Add "Please respond by telling us all the places you went to"	See text message 13.
21	This is the end of the survey. Thank you very much for participating! You will receive the reimbursement for your text messages and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*] 调查结束，非常感谢您的参与！您将在两周内得到短信费及 5 元话费的补偿，将直接充到您的手机上。【县妇幼短信】	Add "end question"	It was decided to add a final text message that indicated the end of the survey.

Table 42 Text messages with changes marked, based on cognitive interviews round 2 day 1

Nr	Text messages in English and Mandarin with marked changes	Changes	Explanation for change based on findings and reasoning
1	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*] 您好，我们是赵县妇幼，想了解您家里最小的那个孩子健康有关情况。您的回复对我们很重要，可以帮助我们改善儿童健康状况。【县妇幼短信】	Change "health services" into "child health"	It was decided to change "health services" into "child health", because one caregiver said that she could not understand the words "health services". She suggested using "child health".
2	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*] 回短信无额外费用，并会返还短信费 1 角/条。答完所有问题可另得 5 元话费。2 周内充到您手机。您愿意回答吗？ 请回复：愿意/不愿意【县妇幼短信】	Add "¥0.1"	It was decided to add ¥0.1 to the sentence about paying back money for the text message fees, because caregivers thought they only received ¥5.
3	*Text message 3 was added at a later stage*	NA	NA
4	Diarrhoea is the passage of 3 or more loose or liquid stools per day. Has your youngest child had diarrhoea in the last 2 weeks (day till day)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*] 拉肚子（拉稀）指稀便或水样便一天三次或以上。您家最小孩子过去两周内（*…到…*）拉肚子/拉稀了吗？ 请回：拉了/没拉【县妇幼短信】		
5	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子有过因拉肚子/拉稀导致的大便里边带血吗？ 请回复：带血/不带血【县妇幼短信】		

6	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近一次拉肚子/拉稀期间，喝了口服补液盐吗？(一种治疗拉稀的药)请回复：喝了口服补液盐/没喝口服补液盐【县妇幼短信】	Change "drug which is a mixture of clean water, salt and sugar" into "drug for diarrhoea treatment"	It was decided to change the explanation from "drug which is a mixture of clean water, salt and sugar" into "drug for diarrhoea treatment", because caregivers did not understand the first explanation. Not all caregivers had heard about ORS; most caregivers who knew about ORS had a previous experience with treating their child's diarrhoea with ORS. The caregivers who knew about ORS suggested using "drug for diarrhoea treatment".
7	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近拉肚子/拉稀期间，是否喝了以下液体：母乳、配方奶、白开水、矿泉水、米汤、菜汤？ 请回：喝过这些/都没喝过【县妇幼短信】		
8	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子最近一次拉肚子/拉稀期间，是否喝了其他液体，如茶或饮料等？ 请回复：喝过其他液体/没喝其他液体【县妇幼短信】		
9	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: None/ Much less /Somewhat less/About the same/More [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，喝的液体量（汤水、母乳和配方奶）比平常怎样？ 请回：一点没喝/少得多/少些/一样/多些【县妇幼短信】		

10	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，吃固体、半固体、母乳和配方奶的量比平常怎样？ 请回：没吃/少很多/少些/一样/多些？【县妇幼短信】		
11	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，向家里以外的人寻求过指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】	Add "during this last episode of diarrhoea in your youngest child"	It was decided to add "during this last episode of diarrhoea in your youngest child", because caregivers were unclear about which occasion was asked about. They thought that was asked about seeking care in general for any disease and not specifically for this episode of diarrhoea in their child.
12	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，您为什么没有向家里以外的人寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】	Add "during this last episode of diarrhoea in your youngest child"	See text message 11.
13	During this last episode of diarrhoea in your youngest child, where did you seek advice or treatment? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次拉肚子/拉稀时，您到哪里寻求指导或治疗？请回复去的所有地方。【县妇幼短信】	Add "during this last episode of diarrhoea in your youngest child"	See text message 11.
14	Has your youngest child had fever at any time in the last 2 weeks (day till day)? Please respond: child had fever/child did not have fever. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（从...到...）有过发烧吗？ 请回复：发烧了/没发烧【县妇幼短信】		

15	Has your youngest child had cough caused by illness at any time in the last 2 weeks (day till day)? Please respond: child had cough caused by illness/child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（从…到…）有过因为生病引起咳嗽吗？ 请回复：有过生病引起的咳嗽/没有过生病引起的咳嗽【县妇幼短信】		
16	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (day till day)? Please respond: child had / child didn't have [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子 2 周内（从…到…）有过呼吸比平时快而短，或者有喘不上气/憋得慌吗？ 请回复：有过/没有【县妇幼短信】		
17	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason……(please give reason) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子呼吸快或喘不上气/憋得慌是因为什么？ 请回复： 肺部问题/鼻腔堵塞/两者都有/其他原因（请列出）【县妇幼短信】		
18	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时，向家里以外的人寻求指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】	Add "during this last episode of fever or cough in your youngest child"	It was decided to add "during this last episode of fever or cough in your youngest child", because caregivers were unclear about which occasion was asked about. They thought that was asked about seeking care in general for any disease and not specifically for this episode of fever or cough in their child.
19	During this last episode of fever or cough in your youngest child, why did you not seek advice for the fever or cough outside the home? Please respond by giving us one reason, the most important one [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时您为什么没有向家里以外的人寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】	Add "during this last episode of fever or cough in your youngest child"	See text message 18.

20	During this last episode of fever or cough in your youngest child, where did you seek advice or treatment when your youngest child had fever or cough? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时您到哪里寻求指导或治疗？ 请回复列出去的所有地方。【县妇幼短信】	Add "during this last episode of fever or cough in your youngest child"	See text message 18.
21	This is the end of the survey. Thank you very much for participating! You will receive the reimbursement for your text messages and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*] 调查结束，非常感谢您的参与！您将在 2 星期内得到返还的短信费及 5 元话费的补偿，将直接充到您的手机上。【县妇幼短信】		

Table 43 Text messages with changes marked, based on cognitive interviews round 2 day 2

Nr	Text messages in English and Mandarin with marked changes	Changes	Explanation for change based on findings and reasoning
1	Hello, this is Zhao County's Maternal and Child Health Hospital. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*] 您好，我们是赵县妇幼，想了解您家里最小的那个孩子健康有关情况。您的回复对我们很重要，可以帮助我们改善儿童健康状况。【县妇幼短信】		
2	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*] 回短信无额外费用，并会返还短信费 1 角/条。答完所有问题可另得 5 元话费。2 周内充到您手机。您愿意回答吗？ 请回复：愿意/不愿意【县妇幼短信】		
3	How does your child call you (the relationship between you and your child)? Please respond: mother/father/grandmother/grandfather/other…. .(please specify) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子管您叫什么（您与孩子的关系）？请回复：妈妈/爸爸/奶奶/爷爷/其他（请列出）【县妇幼短信】	New text message	It was decided to add this question to confirm whether the caregiver was the same caregiver as the caregiver who participated in the face-to-face interview.
4	Diarrhoea is the passage of 3 or more loose or watery stools per day. Has your youngest child had diarrhoea in the last 2 weeks (*month*/*day* till *day*)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*] 拉肚子（拉稀）指稀便或水样便一天三次或以上。您家最小孩子过去两周内（*…月…日到…日*）拉稀了吗？ 请回：拉了/没拉【县妇幼短信】	Add "month"	It was decided to add the month to all the questions in which was asked about the last two weeks. Earlier it was decided not to add the month to save space, because it seemed clear to caregivers. However, one caregiver was unclear about the month. Therefore, the month was added. In the cross-over study, the two weeks fell in one month (March) and only one month had to be added. However, in future studies, the two weeks may fall in separate months and then the text messages may have to be adapted so that two months can fit in the text message.

5	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子有过因拉肚子/拉稀导致的大便里边带血吗？ 请回复：带血/不带血【县妇幼短信】	
6	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近一次拉肚子/拉稀期间，喝了口服补液盐吗？(一种治疗拉稀的药)请回复：喝了口服补液盐/没喝口服补液盐【县妇幼短信】	
7	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soup? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近拉肚子/拉稀期间，是否喝了以下液体：母乳、配方奶、白开水、矿泉水、米汤、菜汤？ 请回：喝过这些/都没喝过【县妇幼短信】	
8	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea and drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子最近一次拉肚子/拉稀期间，是否喝了其他液体，如茶或饮料等？ 请回复：喝过其他液体/没喝其他液体【县妇幼短信】	
9	During your youngest child's diarrhoea, how much did he/she drink (liquids, breast milk or formula) compared to usual? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，喝的液体量（汤水、母乳和配方奶）比平常怎样？ 请回：一点没喝/少得多/少些/一样/多些【县妇幼短信】	

10	When your youngest child had diarrhoea, how much did he/she eat (including solid and semi-solid foods, breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子/拉稀期间，吃固体、半固体、母乳和配方奶的量比平常怎样？ 请回：没吃/少很多/少些/一样/多些？【县妇幼短信】		
11	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: Yes, outside the home/No, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，向家里以外的人寻求过指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】		
12	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，您为什么没有向家里以外的人寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】		
13	During this last episode of diarrhoea in your youngest child, where did you seek advice or treatment? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] *After response, prompt:* Did you go anywhere else during the last episode of diarrhoea in your youngest child? Please respond by telling us all the places you want to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次拉肚子/拉稀时您到哪里寻求指导或治疗？请回复所有去的地方。【县妇幼短信】 最小孩子最近那次拉肚子/拉稀时，您还去过其他地方吗？请回复所有去的地方。【县妇幼短信】	Adding a new text message	It was decided to add an additional text message asking about other places where caregivers sought care. Earlier this was not asked, because caregivers were already asked to list all places they went to. However, caregivers did not mention all places they went to.

14	Has your youngest child had fever at any time in the last 2 weeks (*month*/*day* till *day*)? Please respond: Child had fever/Child did not have fever [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（…月…日到…日）有过发烧吗？ 请回复：发烧了/没发烧【县妇幼短信】	Add "month"	See text message 4.
15	Has your youngest child had cough caused by illness at any time in the last 2 weeks (*month*/*day* till *day*)? Please respond: Child had cough caused by illness/Child did not have cough caused by illness [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（…月…日到…日）有过因为生病引起咳嗽吗？ 请回复：有过生病引起的咳嗽/没有过生病引起的咳嗽【县妇幼短信】	Add "month"	See text message 4.
16	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (*month*/*day* till *day*)? Please respond: child had/child didn't have [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子 2 周内（…月…日到…日）有过呼吸比平时快而短，或者有喘不上气/憋得慌吗？ 请回复：有过/没有【县妇幼短信】	Add "month"	See text message 4.
17	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason……(please give reason) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子呼吸快或喘不上气/憋得慌是因为什么？ 请回复： 肺部问题/鼻腔堵塞/两者都有/其他原因（请列出）【县妇幼短信】		
18	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时，向家里以外的人寻求指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】		

19	During this last episode of fever or cough in your youngest child, why did you not seek advice for the fever or cough outside the home? Please respond by giving us one reason, the most important one. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时您为什么没有向家里以外的人寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】		
20	During this last episode of fever or cough in your youngest child, where did you seek advice or treatment? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] *After response, prompt:* Did you go anywhere else during the last episode of fever and cough in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时您到哪里寻求指导或治疗？ 请回复列出所有去的地方。【县妇幼短信】 最小孩子最近那次发烧/咳嗽时，您还去过其他地方吗？ 请回复列出所有去的地方。【县妇幼短信】	Adding a new text message	See text message 13.
21	This is the end of the survey. Thank you very much for participating! You will receive ¥0.1 per text message and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*] 调查结束，非常感谢您的参与！您将在 2 星期内得到返还的短信费 1 角/条及 5 元话费的补偿，将直接充到您的手机上。【县妇幼短信】	Add "¥0.1 per text message"	It was decided to add how much caregivers were paid back for sending their text messages, because it was unclear to caregivers how much money was given.

Table 44 Text messages with changes marked, based on pilot

Nr	Text messages in English and Chinese with marked changes	Changes	Explanation for change based on findings and reasoning
1	Hello, this is *Zhao County's Maternal and Child Health Hospital*. We want to ask you questions about your youngest child's health. Your responses to our questions are meaningful to us, it can help us improving child health. [*Zhao County's Maternal and Child Health Hospital message*] 您好，我们是赵县妇幼，想了解您家里最小的那个孩子健康有关情况。您的回复对我们很重要，可以帮助我们改善儿童健康状况。【县妇幼短信】		
2	You do not have to pay extra fees and you will be paid back ¥0.1 for replying to messages. In addition, if you answer all the questions, you will receive ¥5 extra recharged on your mobile phone credit within 2 weeks. Are you willing to answer questions? Please respond: I am willing/I am not willing [*Zhao County's Maternal and Child Health Hospital message*] 回短信无额外费用，并会返还短信费 1 角/条。答完所有问题可另得 5 元话费。2 周内充到您手机。您愿意回答吗？ 请回复：愿意/不愿意【县妇幼短信】		
3	How does your child call you (the relationship between you and your child)? Please respond: mother/father/grandmother/grandfather/other.....(please specify) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子管您叫什么（您与孩子的关系）？请回复：妈妈/爸爸/奶奶/爷爷/其他（请列出）【县妇幼短信】		
4	Diarrhoea is the passage of 3 or more loose or liquid stools, compared to usual, per day. Has your youngest child had diarrhoea in the last 2 weeks (from *month/day* till today)? Please respond: child had diarrhoea/child didn't have diarrhoea [*Zhao County's Maternal and Child Health Hospital message*]. 拉肚子（拉稀）指比平常稀的大便或水样便一天三次或以上。您家最小孩子过去两周内（*…月…日到…今天*）拉肚子/拉稀了吗？ 请回：拉了/没拉【县妇幼短信】	Add "compared to usual" Change date into "from month/ day till today"	It was decided to add "compared to usual", because for caregivers with young infants it could be difficult to distinguish loose or watery stools from diarrhoea as stools in young infants are usually loose or watery. It was decided to change the data format, because this was the shortest in Chinese and clear to caregivers.

	Did your youngest child have blood in the stools (caused by diarrhoea)? Please respond: child had blood in stools/child did not have blood in stools [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子有过因拉肚子/拉稀导致的大便带血（拉粑粑里边带血）吗？ 请回复：带血/不带血【县妇幼短信】		
6	During this last episode of diarrhoea, did your youngest child drink a fluid made from a packet called ORS (drug for diarrhoea treatment)? Please respond: child had ORS/child did not have ORS [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近一次拉肚子/拉稀期间，喝了口服补液盐吗？(一种治疗拉稀的药)请回复：喝了口服补液盐/没喝口服补液盐【县妇幼短信】		
7	During this last episode of diarrhoea, did your youngest child drink one of the following fluids: breast milk, formula, tap water, mineral water, rice water or soups? Please respond: child drank one or more of those fluids/child did not drink those fluids [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近拉肚子/拉稀期间，是否喝了以下液体：母乳、配方奶、白开水、矿泉水、米汤、菜汤？ 请回：喝过这些/都没喝过【县妇幼短信】		
8	During this last episode of diarrhoea, did your youngest child drink other fluids such as tea, drinks, water with honey or any sugary drinks? Please respond: child drunk other fluids/child did not drink other fluids [*Zhao County's Maternal and Child Health Hospital message*] 您家最小的孩子最近一次拉肚子/拉稀期间，是否喝了其他液体，如茶、饮料、蜂蜜水或任何甜水等？ 请回复：喝过其他液体/没喝其他液体【县妇幼短信】	Add "water with honey or any sugary drinks"	It was decided to add "water with honey or any sugary drinks", because these liquids were commonly given to children in Zhao County.

9	During your youngest child's diarrhoea, how much did he/she drink (anything the child can drink, including breast milk or formula) compared to usual? Please respond: none/much less /somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子那次拉肚子期间，喝的（任何能喝的，包括母乳和配方奶）比平常怎样？ 请回：一点没喝/少得多/少些/一样/多些【县妇幼短信】	Add "anything the child can drink, including"	It was decided to add "anything the child can drink, including", because caregivers said that they did not understand what liquids were.
10	Has your youngest child ever been introduced to foods such as rice, noodles, manto, meat, eggs, vegetables, fruits (excluding breast milk or formula)? Please respond: child received foods before/child never received foods before [*Zhao County's Maternal and Child Health Hospital message*] *For children who received complementary foods before sent:* When your youngest child had diarrhoea, how much did he/she eat (including all foods, excluding breast milk and formula) compared to usual? Please respond: none/much less/somewhat less/about the same/more [*Zhao County's Maternal and Child Health Hospital message*] 您最小的孩子吃过米饭、面条、馒头、肉、蛋、蔬菜或水果这样的物件吗？（除母乳及配方奶）请回：吃过物件/从没吃过物件【县妇幼短信】 对已经添加了辅食的孩子发送： 您最小孩子那次拉肚子期间，吃物件（母乳和配方奶不算）的量比平常怎样？ 请回：没吃/少很多/少些/一样/多些？【县妇幼短信】	Add pre-selection question on whether child has been introduced to complementary food	It was decided to add a pre-selection question on whether the child had been introduced to complementary food. The question about how much the child ate did not include the answer option "child was not introduced to complementary food". Caregivers with children who had not been introduced to complementary food could then potentially either fill in "none" or "child was not introduced to complementary food", because they may not have been clear about which answer option was appropriate. However, without the option "child was not introduced to complementary food", it was unclear which children had been introduced to complementary food and which children had not. This information was needed to calculate the corresponding indicator. Therefore, by adding this pre-selection question, children who had been introduced to complementary food could be distinguished from the children who had not.
		Add "excluding breast milk and formula"	It was decided to clarify that eating did not mean breastfeeding or formula. This question was only asked to caregivers of children who received complementary food. For these children, the previous question about drinking during diarrhoea already asked about breastfeeding and formula.

11	During this last episode of diarrhoea in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，除了住在一起的家人，您还寻求过指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】	Add "living with you"	It was decided to add "living with you", because the question meant to ask about people outside the household.
12	During this last episode of diarrhoea in your youngest child, why did you not seek advice diarrhoea outside the home? Please respond by giving us one reason, the most important one [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近这次拉肚子/拉稀时，除了住在一起的家人，您为什么没有寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】		
13	During this last episode of diarrhoea in your youngest child, where did you seek advice or treatment? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] *After response, prompt:* Did you go anywhere else during the last episode of diarrhoea in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次拉肚子/拉稀时您到哪里寻求指导或治疗？请回复去的所有地方。【县妇幼短信】 回复后，追问： 最小孩子最近那次拉肚子/拉稀时，您还去过其他地方吗？请回复列出所有去的地方。【县妇幼短信】		
14	Has your youngest child had fever at any time in the last 2 weeks (from *month/day* till to*day*)? Please respond: child had fever/child did not have fever [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（*…月…日到…今天*）有过发烧吗？ 请回复：发烧了/没发烧【县妇幼短信】	Change date into "from month/ day till today"	See text message 4.

15	Has your youngest child had cough caused by illness at any time in the last 2 weeks (from *month/day* till to*day*)? Please respond: child had cough caused by illness/child did not have cough caused by illness. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子在过去 2 周内（...月...日到...今天）有过因为生病引起咳嗽吗？ 请回复：有过生病引起的咳嗽/没有过生病引起的咳嗽【县妇幼短信】	Change date into "from month/day till today"	See text message 4.
16	Did your youngest child breathe faster than usual with short, fast breaths or have difficulty breathing in the last 2 weeks (from *month/day* till to*day*)? Please respond: child had /child didn't have [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子 2 周内（...月...日到...今天）有过呼吸比平时快而短，或者有喘不上气/憋得慌吗？ 请回复：有过/没有【县妇幼短信】	Change date into "from month/day till today"	See text message 4.
17	What's the reason for the fast breathing or difficult breathing? Please respond: problem in the chest/blocked nose/both problem in the chest and blocked nose/other reason......(please give reason) [*Zhao County's Maternal and Child Health Hospital message*] 您的孩子呼吸快或喘不上气/憋得慌是因为什么？ 请回复： 肺部问题/鼻腔堵塞/两者都有/其他原因（请列出）【县妇幼短信】		
18	During this last episode of fever or cough in your youngest child, did you seek advice or treatment outside the home (ask anyone who is not a family member living with you)? Please respond: yes, outside the home/no, at home [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时，除了住在一起的家人，您还寻求指导或治疗了吗？ 请回复：寻求过/没有寻求【县妇幼短信】	Add "living with you"	See text message 11.
19	During this last episode of fever or cough in your youngest child, why did you not seek advice for the fever or cough outside the home? Please respond by giving us one reason, the most important one [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时除了住在一起的家人，您为什么没有寻求指导或治疗? 请回复一个最主要原因【县妇幼短信】		

20	During this last episode of fever or cough in your youngest child, where did you seek advice or treatment? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] *After response, prompt:* Did you go anywhere else during the last episode of fever and cough in your youngest child? Please respond by telling us all the places you went to. [*Zhao County's Maternal and Child Health Hospital message*] 您最小孩子最近那次发烧/咳嗽时您到哪里寻求指导或治疗？ 请回复列出所有去的地方。【县妇幼短信】 回复后，追问： 最小孩子最近那次发烧/咳嗽时，您还去过其他地方吗？请回复列出所有去的地方。【县妇幼短信】
21	This is the end of the survey. Thank you very much for participating! You will receive ¥0.1 per text message and ¥5 for participating automatically on your mobile phone credit within two weeks. [*Zhao County's Maternal and Child Health Hospital message*] 调查结束，非常感谢您的参与！您将在 2 星期内得到返还的短信费及 5 元话费的补偿，将直接充到您的手机上。【县妇幼短信】

Appendix F Local terminology study

Overview

This appendix describes the methods and results of the local terminology study.

Methods

The study took place in Zhaozhou Township and the findings could be used for the entire study, because local terms in one township were similar to local terms in other townships in Zhao County.

A World Health Organization guidance was used for identifying and validating local terms in Zhao County [332]. The three steps for identifying and validating the terms to communicate more effectively with caregivers were as follows:

1. Assess current information on local terms; conduct step 2 if no consensus was reached in step 1; proceed to step 3 if consensus was reached in step 1;
2. Validate local terms through interviews with doctors and caregivers;
3. Select local terms and adapt the questionnaire.

Step 1: Assess current information on local terms

Six terms were identified in the existing World Health Organization Maternal, Newborn and Child Health Household survey to describe diarrhoea and pneumonia signs and symptoms: (i) diarrhoea; (ii) blood in stools; (iii) fever; (iv) cough; (v) fast breathing; and (vi) difficult breathing. It was aimed to assess the state of current information about those terms from three sources: (i) written materials; (ii) interviews with doctors; and (iii) interviews with caregivers.

It was attempted to find written materials on the local terms that were identified in the existing World Health Organization Maternal, Newborn and Child Health Household survey. The Zhao County Maternal and Child Health Hospital doctor was asked to help with providing written materials.

Interviews were conducted with doctors and caregivers about local terminology for diarrhoea and pneumonia signs and symptoms. The aim of these interviews was to ensure that the Mandarin for those signs and symptoms in survey questions had a similar local meaning. Fifteen caregivers and five village doctors were planned to be interviewed. Doctor participants were recruited with help of the township hospital and county hospital doctor who were familiar with the study. Caregivers were recruited with help of these doctors and village doctors.

YL, who was familiar with the local Zhao County dialect, conducted the interviews. The PhD candidate was present during the interviews to make notes. YL recorded information about participants' demographics (type of caregiver, type of doctor, gender and age) and asked the doctors and caregivers about the words or phrases that caregivers in Zhaozhou Township used for each term. YL emphasised that the aim of the interviews was to identify the terms that families used and encouraged participants to give more than one term when they believed that more than one term was applicable. YL recorded the interviews with a digital tape recorder after asking for permission from the caregiver.

The information from these sources was compared to assess the extent of consensus about the most appropriate local terms. YL and the PhD candidate discussed all the findings with YZ, an Integrated Management of Childhood Illness expert who had experience with local terminology studies, and with the county hospital doctor. If there was consensus for a particular term, there was no need to complete step 2.

Step 2: Validate local terms through interviews with caregivers

It was aimed to validate the meaning and use of local terms for symptoms that did not reach consensus during step 1. The interviewer took care to avoid giving the caregiver any signal to use "medical language". YL used informal simple language, did not wear a white coat and had a youthful appearance (caregivers were likely to expect doctors to be older). The interviews were conducted in Zhao County Maternal and Child Health Hospital, because a setting where these symptoms were available was required, such as a hospital ward or outpatient clinic. It was aimed to find caregivers who had a child with physical signs, because the words caregivers used had to be compared to the physical signs. Those caregivers were asked questions to describe the condition of the child. However, as it was expected that it could be difficult to find caregivers who had a child with physically present signs and were willing to participate, also videos from the World Health Organization were prepared to show caregivers children with signs. In case there were no children available, it was aimed to ask caregivers to tell the words they used for the observable signs they saw in the videos. In addition, caregivers were asked to explain the meaning of the terms found in step 1 to verify the meaning of those terms.

Step 3: Select local terms to adapt the questionnaire

Local terms that appeared to be most commonly used and understood were selected based on findings in step 1 and step 2. YL recorded the terms of which confidently could be said that they were the best terms to use. These were the terms for which there was relative consensus. The chosen terms were discussed with YZ. The terms for which there was relatively high consensus were selected among caregivers who were interviewed. There was space for two of the most appropriate terms for each of the six terms in the questionnaire. Therefore, it was considered to choose two terms in case more than one term was appropriate. If there was a disagreement between the terms obtained in step 1 and step 2, the terms identified through the validation interviews in step 2 were used. The selected terms were recorded and the survey questionnaire was adapted.

Results

Step 1: assess current information on local terms

Written materials

The Department of Pediatrics and Department of Women and Child Health in Zhaozhou Township hospital were visited. Staff was asked to provide written information, but they were not able to provide written materials. Therefore, the terms that were identified in the existing questionnaire were used.

Doctors

Five local doctors working in Zhao County Maternal and Child Health Hospital, Zhaozhou Township hospital, and village clinics in Zhaozhou Township were asked to participate in the interviews. All agreed to participate. All doctors were male, apart from the township hospital doctor. Despite their busy schedule, the doctors were cooperative and able to find time for an interview.

The interviews were conducted on a location of doctors' preference, usually a quiet room in their clinic. Doctors were asked if the interview could take place at a time at which they were not likely to be interrupted. However, during one interview, a grandmother with her grandson walked in to ask advice for her child, and later a mother with her husband and child walked in. All the other interviews were not interrupted by patients. The results for the local terms are presented in the following sections.

Diarrhoea

All doctors identified "拉肚子 Lādùzi", one of the two terms used in the existing World Health Organization Maternal, Newborn and Child Health Household survey. The second most used term was "拉稀 Lāxī". However, none of the doctors identified the other term in the existing questionnaire, "腹泻 Fùxiè".

Blood in stools

It was found that "大便带血 Dàbiàn dài xiě" (which was the same as in the existing questionnaire) and "大便里边带血 Dàbiàn lǐbian dài xiě" (which was similar) were the most identified terms.

Fever

All doctors mentioned "发烧 Fāshāo" (which was the same as in the existing questionnaire), but no doctors mentioned the second term used in the existing questionnaire, "发热 Fārè".

Cough

For cough, all village doctors mentioned "咳嗽 Ké sou", the same term that was used in the existing questionnaire.

Fast breathing

Doctors reached lower consensus on the terms for fast breathing. Three doctors mentioned “喘 Chuǎn”, which was also confusingly used by three doctors for difficult breathing (“喘 Chuǎn” means fast breathing). Two doctors mentioned “呼吸快 Hū xī kuài”, which had the same meaning as the term in the existing questionnaire (“呼吸比平时快而短 Hū xī bǐ píng shí kuài ér duǎn”).

Difficult breathing

Doctors also reached lower consensus on the terms for difficult breathing. Four doctors mentioned “憋得慌 Biē de huāng”. No one mentioned “呼吸困难 Hū xī kùn nán”, the term in the existing questionnaire.

Photograph 32 Village doctor and YL during local terminology interview

Photograph from the PhD candidate’s personal collection

Caregivers

Thirdly, 12 caregivers were interviewed in Zhao County Maternal and Child Health Hospital, which serves a population that is typical for Zhaozhou Township. Terms that were most used by caregivers and that were appropriate based on discussions within the team were selected (Table 45). There was low consensus for fast and difficult breathing and it was aimed to validate these terms by conducting step 2.

Diarrhoea

Seven caregivers identified “拉肚子 Lādùzi”, one of the two terms used in the existing questionnaire. Also, seven caregivers used the term “拉稀 Lāxī”. However, similar to the doctors, none of the caregivers identified the other terms in the existing questionnaire, “腹泻 Fùxiè”.

Blood in stools

It was found that “大便带血 Dàbiàn dài xiě” (which was the same as in the existing questionnaire) and “大便里边带血 Dàbiàn lǐbian dài xiě” (which was very similar) were the most commonly identified terms. Also, two caregivers mentioned the term “拉粑粑里边带血 Lā bābā lǐbian dài xiě” and one caregiver mentioned a very similar term “粑粑里边带血 Bābā lǐbian dài xiě”.

Fever

Nine caregivers mentioned “发烧 Fāshāo” (which was the same as in the existing questionnaire), but no caregivers mentioned the second term used in the existing questionnaire, “发热 Fārè”.

Cough

All caregivers identified “咳嗽 Ké sou”, the same term that was used in the existing questionnaire.

Fast breathing

Similar to the doctors, caregivers also reached lower consensus on the terms for fast breathing. Eight caregivers mentioned a term similar to "呼吸快 Hū xī kuài" (which had a similar meaning as the term in the existing questionnaire "呼吸比平时快而短 Hū xī bǐ píngshí kuài ér duǎn"). Seven terms were merged together into "呼吸快 Hū xī kuài"; the numbers of caregivers were combined for these terms, because they were very similar and had a similar meaning. Five caregivers mentioned "喘 Chuǎn", or "喘气 Chuǎn qì", "喘 Chuǎn" and "喘得快 Chuǎn de kuài", which all meant fast breathing. However, these terms were confusingly also used for difficult breathing.

Difficult breathing

Caregivers also reached lower consensus on the terms for difficult breathing. Seven caregivers mentioned "喘不上气 Chuǎn bù shàng qì", which was confusingly also used for difficult breathing. This term meant "cannot breathe out" and had a different meaning (by adding "bù shàng qì") than "喘 Chuǎn" with the meaning "fast breathing". No one mentioned the term in the existing questionnaire: "呼吸困难 Hū xī kùn nɑn".

Step 2: validate local terms through interviews with caregivers

Four caregivers in Zhao County Maternal and Child Health Hospital were interviewed. One caregiver wished to discontinue the interview, because she wanted to see her child and did not answer the questions about fast breathing.

It was aimed to find caregivers of children with fast or difficult breathing, but despite efforts to find children, there were no children with these symptoms. Therefore, the videos were used to show caregivers fast and difficult breathing and they were asked to tell the words for these symptoms. However, as the videos were not specifically designed for caregivers but for health workers, caregivers were confused about the content of the videos and they could not explain which words they used for the symptoms that children in the videos had. Caregivers were then asked to explain the meaning of the most appropriate terms for fast and difficult breathing that were identified in step 1.

It was found that caregivers could not distinguish fast and difficult breathing ("喘 Chuǎn"). Only one caregiver could explain the difference, but the three other caregivers could only explain what fast breathing was. However, to correctly answer the question related to these terms, caregivers did not have to distinguish between the two terms, because the question asked whether the child had fast or difficult breathing. All caregivers could explain the local terms for fast and difficult breathing that were found in step 1. Therefore, these terms were chose for the questionnaire (Table 46).

Photograph 33 Mother and interviewer during validation interview

Photograph from the PhD candidate's personal collection

Step 3: select local terms to adapt the questionnaire

The most appropriate terms were selected by consulting YZ (Table 47). There was high consensus for four terms: (i) diarrhoea; (ii) blood in stools; (iii) fever; and (iv) cough. For diarrhoea "拉肚子 Lādùzi" and "拉稀 Lāxī" were selected. For blood in stools "大便带血 Dàbiàn dài xiě" and "拉粑粑里边带血 Lā bābā lǐbian dài xiě" were selected. For fever "发烧 Fāshāo" was selected and for cough "咳嗽 Ké sou" was selected.

There was low consensus for the terms for fast and difficult breathing in step 1. Therefore, it was attempted to validate these terms in step 2. However, this was challenging, because there were no children with those symptoms and no appropriate videos available. Still it was found terms that caregivers could understand. It was decided to use the appropriate term "呼吸比平时快而短 Hūxī bǐ píngshí kuài ér duǎn" for fast breathing, which was very similar to "呼吸快 Hū xī kuài", but more accurate and also understandable to caregivers. For difficult breathing, it was decided to use both terms that caregivers identified in step 1: "喘不上气 Chuǎn bù shàng qì" and "憋得慌 Biē de huāng". It was decided not to use "喘 Chuǎn" with the meaning "fast breathing", because it was found in step 1 that caregivers also used this term for difficult breathing.

Table 45 Results of step 1: assess current information on local terms

	Term in existing maternal, newborn and child health questionnaire			Local term from interviews						
Nr	**English**	**Characters**	**Pinyin**	**Characters**	**Pinyin**	**Meaning**	**N caregivers using term (12)**	**N doctors using term (5)**	**Chosen?***	**Reason for choosing**
1	Diarrhoea	拉肚子 腹泻	Lādùzi Fùxiè	拉肚子	Lādùzi	Loose stools, more times a day than usual	7	5	Yes	High consensus caregivers and doctors, used existing questionnaire
				拉稀	Lāxī	Loose stools, more times a day than usual	7	2	Yes	Appropriate, high consensus caregivers and doctors
				显拉把	Xiǎn lā bǎ	Loose stools, more times a day than usual	0	1	No	Only mentioned by 1 doctor
				拉粑粑	Lā bāba	Loose stools, more times a day than ususal, also used for normal stools	4	1	No	Confusing term with multiple meanings
				窜稀	Cuàn xī	Loose stools, more times a day than usual	3	1	No	Mentioned by minority of caregivers and doctors
				闹肚子	Nàodùzi	Loose stools, more times day than usual	1	0	No	Only mentioned by 1 caregiver
				跑肚	Pǎo dù	Loose stools, more times day than usual	1	0	No	Only mentioned by 1 caregiver

2	Blood in stools	大便带血	Dàbiàn dài xiě	大便带血	Dàbiàn dài xiě	Blood in stools	4	3	Yes	Mentioned by majority of caregivers and doctors, used in existing questionnaire
				大便里边带血	Dàbiàn lǐbian dài xiě	Blood inside stools	2	2	Yes	Very similar to “dàbiàn dài xiě”; “lǐbian” means inside
				大便里边有血	Dàbiàn lǐbian yǒu xiě	Blood inside stools (yǒu xiě=dài xiě=with blood)	1	1	No	Only mentioned by 1 caregiver and doctor
				大便出血	Dàbiàn chūxiě	Blood inside stools	1	0	No	Only mentioned by 1 caregiver
				大便边上有点血	Dàbiàn biān shàng yǒudiǎn xuè	Blood outside stools	0	1	No	Only mentioned by 1 doctor
				大便里边混有血	Dàbiàn lǐbian hùn yǒu xuè	Blood mixed in stools	0	1	No	Only mentioned by 1 doctor
				大便红	Dàbiàn hóng	Stools are red	0	1	No	Only mentioned by 1 doctor
				大便发红	Dàbiàn fā hóng	Stools look red	0	1	No	Only mentioned by 1 doctor
				拉粑粑里边带血	Lā bābā lǐbian dài xiě	Blood inside stools, lā bābā was the local term for stools	2	0	Yes	Mentioned by 2 caregivers
				拉粑粑里边带点血丝	Lā bābā lǐbian dài diǎn xuèsī	Stripes of blood inside stools	1	0	No	Only mentioned by 1 caregiver
				粑粑里边带血	Bābā lǐbian dài xiě	Blood inside stools (bābā=lā bābā)	1	1	No	Only mentioned by 1 caregiver and doctor
				拉血	Lā xiě	Blood in stools	1	0	No	Only mentioned by 1 caregiver
3	Fever	发烧 发热	Fāshāo Fārè	发烧	Fāshāo	Fever	9	5	Yes	High consensus among caregivers and doctors, used in existing questionnaire

				烧的慌	Shāo de huāng	Fever	0	1	No	Only mentioned by 1 doctor
				烧	Shāo	Fever	3	1	No	Similar to chosen term
				热呼呼	Rèhūhū	Very warm	1	0	No	Only mentioned by 1 caregiver
				烫	Tàng	Very hot	3	0	No	Mentioned by minority of caregivers and not mentioned by doctors
4	Cough	咳嗽	Ké sou	咳嗽	Ké sou	Cough	5	5	Yes	Very high consensus among caregivers and doctors, used in existing questionnaire
5	Fast breath ing	呼吸比平时快而短	Hū xī bǐ píng shí kuài ér duǎn	呼吸快	Hū xī kuài	The breath is fast	8	2	Yes	Appropriate merged term, mentioned by most caregivers and doctors, similar to term in existing questionnaire
				呼吸快	Hū xī kuài	The breath is fast	4	2		
				吸气快	Hū qì kuài	Breathing in fast	1	0		
				出气快	Chū qì kuài	Breathing out fast	2	0		
				气快	Qì kuài	The breath is fast	1	0		
				呼吸急促	Hū xī jí cù	The breath is short and fast	2	0		
				喘得快	Chuǎn de kuài	The breath is fast	2	0		
				喘气快	Chuǎn qì kuài	The breath is fast	1	0		
				喘†	Chuǎn	The breath is fast	5	3	No	Confusing as term was also used for difficult breathing
				喘	Chuǎn	The breath is short and fast	3	2		
				喘气	Chuǎn qì	The sound of the breath is loud/ breathing deeply	0	1		
				喘粗	Chuǎn cū	The sound of the breath is loud/ breathing deeply	1	0		

				呼歇喘气	Hū xīe chuǎn qì	Difficulty with breathing	1	0		
				吭吭	Kēng kēng	Cough with sound from the throat	0	1	No	Only mentioned by 1 doctor
				憋得慌	Biē de huāng	Feel uncomfortable because of lack of air	0	1	No	Only mentioned by 1 doctor
				喘不过来气	Chuǎn bù guò lái qì	Out of breath	1	0	No	Only mentioned by 1 caregiver
				呼噜	Hūlū	Make sounds from throat	0	1	No	Only mentioned by 1 doctor
				吸气费劲	Xī qì fèi jìn	Difficulty with breathing in	1	0	No	Only mentioned by 1 caregiver
				出气费劲	Chū qì fèi jìn	Difficulty with breathing out	1	0	No	Only mentioned by 1 caregiver
6	Difficult breathing	呼吸困难	Hū xī kùn nán	喘不上气†	Chuǎn bù shàng qì (Hébìng)	Cannot breath out	7	0	Yes	Appropriate merged term, mentioned most caregivers and doctors
				喘不上气	Chuǎn bù shàng qì	Out of breath	2	0		
				喘不过气	Chuǎn bù guò qì	Out of breath	1	0		
				喘气费劲	Chuǎn qì fèi jìn	Difficulty breathing	1	0		
				呼气费劲	Hū qì fèi jìn	Difficulty breathing out	1	0		
				出气费劲	Chū qì fèi jìn	Difficulty breathing out	1	0		
				喘不过气来	Chuǎn bù guò lái qì	Out of breath	1	0		
				喘不上来气	Chuǎn bù shàng lái qì	Out of breath	1	0		
				上不来气	Shàng bù lái qì	Out of breath	1	0		

憋得慌 †	Biē de huāng	Feeling uncomfortable because of lack of air	4	4	Yes	Appropriate merged term, mentioned by most caregivers and doctors
憋得慌	Biē de huāng	Feeling uncomfortable because of lack of air	4	2		
堵得慌	Dǔ de huāng	A feeling like something is blocked in the chest	1	1		
憋气	Biē qì	Cannot breath	0	2		
喘	Chuǎn	Breathing short and fast	4	2	No	Confusing as term was also used for fast breathing
喘气	Chuǎn qì	The sound of breathing is loud/ breathing deeply	0	1	No	Only mentioned by 1 doctor
喘得快	Chuǎn de kuài	Breath is fast	1	0	No	Only mentioned by 1 caregiver
出气不匀实	Chū qì bù yún shí	The air breath out is not fluency	0	1	No	Only mentioned by 1 doctor
气短	Qì duǎn	The interval/air of breath it short	2	0	No	Mentioned by minority of caregivers
吭吭	Kēng kēng	Cough with sound from the throat	0	1	No	Only mentioned by 1 doctor
发闷	Fā mèn	Feeling of not being able to breath	0	1	No	Only mentioned by 1 doctor

*White is chosen local terms, grey is not chosen local terms.

Table 46 Results of step 2: validate local terms through interviews with caregivers (N=4)

Generic term in English	Term in existing question-naire in Chinese charac ters	Term in existing question-naire in pinyin	Term in Chinese charac ters	Term in pinyin	Meaning	Con firm †	Meaning according to care-givers
5 Fast breathing *	呼吸比平时快而短	Hū xī bǐ píngshí kuài ér duǎn	呼吸快 / 呼吸比平时快而短	Hū xī kuài/ Hū xī bū píngshí kuài ér duǎn	The breath is fast (merged)/ The breath is faster and shorter	3	"breath is fast (chuǎn qì kuài)" "breath is fast" "is "chuǎn" which means breath is fast and with sounds"
			喘	Chuǎn	The breath is fast (merged)	3	Caregivers could not distinguish "hū xī kuài" from "chuǎn"
6 Difficult breathing	呼吸困难	Hū xī kùn nán	喘不上气	Chuǎn bù shàng qì	Out of breath (merged)	4	"someone cannot breath (chuǎn bù shàng lái qì) or difficulty in breathing" "difficulty in breathing because of lack of oxygen" "someone cannot breath or breaths difficult" "same meaning as biē de huāng"
			憋得慌	Biē de huāng	Feeling uncomfor table because of lack of air	4	"difficult to breath out" "difficult to breath, lack of oxygen" "difficult to breath (chuǎn qì kùnnán)" "same meaning as chuǎn bù shàng qì"

*One caregiver did not complete the interview.
†Caregivers confirming meaning of the term.

Table 47 Results of step 3: select local terms to adapt the questionnaire

Nr	Generic term in English	Local term in characters	Local term in pinyin
1	Diarrhoea	拉肚子 拉稀	Lādùzi Lāxī
2	Blood in stools	大便带血 拉粑粑里边带血	Dàbiàn dài xiě Lā bābā lǐbian dài xiě
3	Fever	发烧	Fā shāo
4	Cough	咳嗽	Ké sou
5	Fast breathing	呼吸比平时快而短	Hūxī bǐ píngshí kuài ér duǎn
6	Difficult breathing	喘不上气 憋得慌	Chuǎn bù shàng qì Biē de huāng

Appendix G Additional tables for cross-over study

Overview

This appendix provides Tables 48-61 for the cross-over study reported in Chapter 6 and 7.

Table 48 Comparison of conditions of children and responses between group 1 and group 2

Status number	**Conditions***		**Total group (N=651)**	**Group 1 (n=229)**	**Group 2 (n=422)**
	-Diarrhoea (D) -Complementary feeding (CF)	**-Cough (C) -Fever (F) -Fast or difficult breathing (B)**	**n respond to all questions**	**n respond to all questions**	**n respond to all questions**
1	None	None	276	103	173
2	None	F	12	5	7
3	None	C	35	13	22
4	None	B	4	2	2
5	None	C and F	17	7	10
6	None	C and B	4	2	2
7	None	F and B	0	0	0
8	None	C, F and B	2	1	1
9	D, CF	None	1	1	0
10	D, CF	F	0	0	0
11	D, CF	C	0	0	0
12	D, CF	B	0	0	0
13	D, CF	C and F	0	0	0
14	D, CF	C and B	0	0	0
15	D, CF	F and B	0	0	0
16	D, CF	C, F and B	0	0	0
17	D	None	5	3	2
18	D	F	0	0	0
19	D	C	0	0	0
20	D	B	0	0	0
21	D	C and F	0	0	0
22	D	C and B	0	0	0
23	D	F and B	0	0	0
24	D	C, F and B	0	0	0
Completion†			356	137	219

*The response rate per status could not be calculated for separate statuses, because it was not known to which status non-responders belonged.
†All statuses combined; participants who responded to all asked text message questions.

Table 49 Item response rate and overall response rate

Text message question number: brief content	**Total group (N=1014)**			**Group 1 (n=371)**			**Group 2 (n=643)**			**Comparison**	
	n respond	**n text messages sent**	**Response rate (%)**	**n respond**	**n text messages sent**	**Response rate (%)**	**n respond**	**n text messages sent**	**Response rate (%)**	χ^2	***P* value**
2: willingness to participate	662	1014	65.3	233	371	62.8	429	643	66.7	1.59	0.21
2: said "yes" for willingness to participate	651	1014	64.2	229	371	61.7	422	643	65.6	1.56	0.21
3: which caregiver	585	651	89.9	203	229	88.6	382	422	90.5	0.57	0.45
4: child had diarrhoea	538	585	92.0	189	203	93.1	349	382	91.4	0.54	0.46
5: child had blood in stools	41	44	93.2	14	14	100.0	27	30	90.0	-	0.54*
6: child drank ORS	38	41	92.7	14	14	100.0	24	27	88.9	-	0.54*
7: child drank recommended fluids	31	38	81.6	12	14	85.7	19	24	79.2	-	1.00*
8: child drank other fluids	29	31	93.5	12	12	100.0	17	19	89.5	-	0.51*
9: how much did child drank during diarrhoea	27	29	93.1	11	12	91.7	16	17	94.1	-	1.00*
10: child had been introduced to complementary food	23	27	85.2	8	11	72.7	15	16	93.8	-	0.27*
10a: how much child ate during diarrhoea	10	13	76.9	4	5	80.0	6	8	75.0	-	1.00*
11: sought care for diarrhoea	18	20	90.0	7	7	100.0	11	13	84.6	-	0.52*

12: why no care was sought for diarrhoea	7	7	100.0	2	2	100.0	5	5	100.0	-	-[†]
13: where care was sought for diarrhoea	9	11	81.8	5	5	100.0	4	6	66.7	-	0.45[*]
14: child had fever	474	510	92.9	167	182	91.8	307	328	93.6	0.60	0.44
15: child had illness with cough	433	474	91.4	159	167	95.2	274	307	89.3	4.86	0.03[‡]
16: child breathed fast or with difficulty	398	433	91.9	149	159	93.7	249	274	90.9	1.09	0.30
17: cause of fast or difficult breathing	11	13	84.6	5	6	83.3	6	7	85.7	-	1.00[*]
18: sought care for the child during fever or cough	95	110	86.4	37	39	94.8	58	71	81.7	3.88	0.049[‡]
19: why no care was sought for fever or cough	4	10	40.0	2	5	40.0	2	5	40.0	-	1.00[*]
20: where care was sought for fever or cough	66	85	77.6	26	32	81.3	40	53	75.5	0.48	0.49
Completion[§]	356	651	54.7	137	229	59.8	219	422	51.9	3.77	0.05

[*] Fisher's exact test.
[†] No statistics could be calculated.
[‡] *P*<0.05
[§] Completed all questions participants were supposed to complete; calculated based on numbers in Table 48.

Table 50 Characteristics of responders versus non-responders in group 1

Variables	Total (N=371)	Did not respond (n=138)	Respond (n=233)	Comparison Statistics*	P value
Gender, n (%)				χ^2=0.70	0.40
Boy	204 (55.0)	72 (52.2)	132 (56.7)		
Girl	167 (45.0)	66 (47.8)	101 (43.3)		
Age child groups, n (%)				MWU z=-0.28	0.78
0-11 months	74 (20.0)	29 (21.0)	45 (19.3)		
12-23 months	112 (30.2)	41 (29.7)	71 (30.5)		
24-59 months	185 (49.8)	68 (49.3)	117 (50.2)		
Number of children, n (%)				MWU z=-1.87	0.06
1	174 (46.9)	57 (41.3)	117 (50.2)		
2	192 (51.8)	77 (55.8)	115 (49.4)		
3	4 (1.1)	3 (2.2)	1 (0.4)		
4	1 (0.2)	1 (0.7)	0 (0.0)		
Mother's age in years, median (Q1-Q3)	28 (26-31)	29 (27-32)	28 (26-31)	MWU z=-1.09	0.27
Mother's education level, median (Q1-Q3)†	3 (3-4)	3 (3-4)	3 (3-4)	MWU z=-0.11	0.91
Mother's number of years of education, median (Q1-Q3)	9 (9-11)	9 (9-12)	9 (9-11)	MWU z=-0.38	0.70
Mother's occupation, n (%)				Fisher's exact Test	0.11
Home	171 (46.1)	70 (50.7)	101 (43.4)		
Work	199 (53.6)	67 (48.6)	132 (56.6)		
Do not know	1 (0.3)	1 (0.7)	0 (0.0)		
Father's age in years, median (Q1-Q3)	29 (27-32)	29 (27-32)	29 (27-31)	MWU z=-1.46	0.14
Father's education level, median (Q1-Q3)†	3 (3-4)	3 (3-4)	3 (3-4)	MWU z=-0.25	0.80
Father's number of years of education, median (Q1-Q3)	9 (9-12)	9 (9-11)	9 (9-12)	MWU z=-0.10	0.92
Father's occupation, n (%)				Fisher's exact Test	0.05
Home	6 (1.6)	4 (2.9)	2 (0.9)		
Work	363 (97.8)	132 (95.7)	231 (99.1)		
Do not know	2 (0.6)	2 (1.4)	0 (0.0)		
Relation to the child, n (%)				Fisher's exact Test	0.06
Mother	300 (80.9)	120 (87.0)	180 (77.3)		
Father	58 (15.6)	17 (12.3)	41 (17.6)		
Grandmother	9 (2.4)	1 (0.7)	8 (3.4)		
Grandfather	4 (1.1)	0 (0.0)	4 (1.7)		
Participant is primary caregiver, n (%)				χ^2=2.39	0.12
Yes	279 (75.2)	110 (79.7)	169 (72.5)		
No	92 (24.8)	28 (20.3)	64 (27.5)		
Type of *Hukou* child, n (%)				χ^2=8.10	0.004‡
Urban	34 (9.2)	5 (3.6)	29 (12.5)		
Rural	337 (90.8)	133 (96.4)	204 (87.5)		

Family net income in last year in ¥, median (Q1-Q3)	20,000 (15,000-35,000)	20,000 (10,000-30,000)	24,500 (15,000-40,000)	MWU z=-1.18	0.24
Family living expenses in the last year in ¥, median (Q1-Q3)	20,000 (10,000-20,000)	15,000 (10,000-20,000)	20,000 (10,000-20,000)	MWU z=-1.15	0.25
Use smartphone, n (%)				χ^2=0.007	0.98
Yes	167 (45.0)	62 (44.9)	105 (45.1)		
No	204 (55.0)	76 (55.1)	128 (54.9)		
Primary usage of mobile phone for calls and text messages, n (%)				Fisher's exact test	0.54
Calling	297 (80.1)	114 (82.6)	183 (78.5)		
Text messaging	10 (2.7)	2 (1.4)	8 (3.4)		
Both in equal measure	62 (16.7)	22 (16.0)	40 (17.2)		
Other	2 (0.5)	0 (0.0)	2 (0.9)		
Primary usage of mobile phone for *QQ* and text messages, n (%)				Fisher's exact test	0.61
Text message	124 (33.4)	40 (29.0)	84 (36.1)		
QQ	147 (39.6)	57 (41.3)	90 (38.6)		
Both in equal measure	22 (5.9)	9 (6.5)	13 (5.6)		
Do not use either	77 (20.8)	32 (23.2)	45 (19.3)		
Other (seldom use)	1 (0.3)	0 (0.0)	1 (0.4)		
Number of calls made per week, median (Q1-Q3)	10 (7-21)	10 (5-20)	13.5 (7-21)	MWU z=-1.89	0.06
Number of calls received per week, median (Q1-Q3)	10 (6-21)	10 (6-20)	11.5 (7-21)	MWU z=-1.22	0.22
Number of text messages sent per week, median (Q1-Q3)	1 (0-7)	1 (0-5)	2 (0-7)	MWU z=-1.58	0.11
Number of text messages received per week, median (Q1-Q3)	8 (5-15)	7 (4-14)	10 (5-15)	MWU z=-1.99	0.046[‡]
Have phone number of health facility, n (%)				χ^2=3.40	0.07
Yes	245 (66.0)	83 (60.1)	162 (69.5)		
No	126 (34.0)	55 (39.9)	71 (30.5)		
Number of times using mobile phone to obtain health information in past 3 months, median (Q1-Q3)	1 (1-3)	1 (1-3)	1 (1-3)	MWU z=-0.32	0.75
Child had diarrhoea, n (%)				Fisher's exact test	0.06
Yes	21 (5.7)	4 (2.9)	17 (7.3)		
No	349 (94.1)	133 (96.4)	216 (92.7)		
Not known	1 (0.2)	1 (0.7)	0 (0.0)		

Sought care for diarrhoea, n (%)				Fisher's exact test	0.24
Sought care	19 (5.1)	4 (2.9)	15 (6.4)		
Did not seek care	2 (0.5)	0 (0.0)	2 (0.9)		
No diarrhoea	349 (94.4)	133 (97.1)	216 (92.7)		
Child had fever, n (%)				Fisher's exact test	0.60
Yes	34 (9.2)	10 (7.3)	24 (10.3)		
No	336 (90.6)	128 (92.7)	208 (89.3)		
Not known	1 (0.2)	0 (0.0)	1 (0.4)		
Child had cough, n (%)				χ^2=1.69	0.19
Yes	92 (24.8)	29 (21.0)	63 (27.0)		
No	279 (75.2)	109 (79.0)	170 (73.0)		
Sought care for fever or cough, n (%)				Fisher's exact test	0.14
Sought care	88 (23.7)	29 (21.0)	59 (25.3)		
Did not seek care	13 (3.5)	2 (1.5)	11 (4.7)		
No fever or cough	270 (72.8)	107 (77.5)	163 (70.0)		
Child breathed fast or with difficulty, n (%)				χ^2=0.46	0.50
Yes	17 (4.6)	5 (3.6)	12 (5.2)		
No	354 (95.4)	133 (96.4)	221 (94.8)		

[*] Chi-square (χ^2), Mann-Whitney U (MWU), z-score (z).
[†] 3=junior high school, 4=senior high school/technical school.
[‡] P<0.05

Table 51 Characteristics of completers versus non-completers in group 1

Variables	Total (N=371)	Did not completed (n=234)	Completed (n=137)	Comparison Statistics*	*P* value
Gender, n (%)				χ^2=0.13	0.72
Boy	204 (55.0)	127 (54.3)	77 (56.2)		
Girl	167 (45.0)	107 (45.7)	60 (43.8)		
Age child groups, n (%)				MWU z=0.71	0.48
0-11 months	74 (20.0)	51 (21.8)	23 (16.8)		
12-23 months	112 (30.2)	68 (29.1)	44 (32.1)		
24-59 months	185 (49.8)	115 (49.1)	70 (51.1)		
Number of children, n (%)				MWU z=-1.10	0.27
1	174 (46.9)	105 (44.9)	69 (50.4)		
2	192 (51.8)	125 (53.4)	67 (48.9)		
3	4 (1.1)	3 (1.3)	1 (0.7)		
4	1 (0.2)	1 (0.4)	0 (0.0)		
Mother's age in years, median (Q1-Q3)	28.0 (26.0-31.0)	29.0 (26.0-31.0)	28.0 (26.0-31.0)	MWU z=-0.99	0.32
Mother's education level, median (Q1-Q3)†	3 (3-4)	3 (3-4)	3 (3-4)	MWU z=-0.48	0.63
Mother's number of years of education, median (Q1-Q3)	9.0 (9.0-11.0)	9.0 (9.0-11.0)	9.0 (9.0-11.0)	MWU z=-1.00	0.32
Mother's occupation, n (%)				Fisher's exact test	0.27
Home	171 (46.1)	114 (48.7)	57 (41.6)		
Work	199 (53.6)	119 (50.9)	80 (58.4)		
Do not know	1 (0.3)	1 (0.4)	0 (0.00)		
Father's age in years, median (Q1-Q3)	29.0 (27.0-32.0)	29.0 (27.0-32.0)	29.0 (26.0-31.0)	MWU z=-0.92	0.36
Father's education level, median (Q1-Q3)†	3 (3-4)	3 (3-3)	3 (3-4)	MWU z=1.58	0.11
Father's number of years of education, median (Q1-Q3)	9.0 (9.0-12.0)	9.0 (9.0-11.0)	9.0 (9.0-12.0)	MWU z=0.45	0.65
Father's occupation, n (%)				Fisher's exact test	0.39
Home	6 (1.6)	5 (2.1)	1 (0.7)		
Work	363 (97.8)	227 (97.0)	136 (99.3)		
Do not know	2 (0.6)	2 (0.9)	0 (0.0)		
Relationship to the child, n (%)				Fisher's exact test	0.78
Mother	300 (80.9)	192 (82.1)	108 (78.8)		
Father	58 (15.6)	34 (14.5)	24 (17.5)		
Grandmother	9 (2.4)	6 (2.6)	3 (2.2)		
Grandfather	4 (1.1)	2 (0.8)	2 (1.5)		

Participant is primary caregiver, n (%)				χ^2=3.06	0.08
Yes	279 (75.2)	183 (78.2)	96 (70.1)		
No	92 (24.8)	51 (21.8)	41 (29.9)		
Type of *Hukou* child, n (%)				χ^2=0.83	0.36
Urban	34 (9.2)	19 (8.1)	15 (11.0)		
Rural	337 (90.8)	215 (91.9)	122 (89.0)		
Family net income in last year in ¥, median (Q1-Q3)	20,000 (15,000-35,000)	20,000 (15,000-35,000)	30,000 (15,000-40,000)	MWU z=1.07	0.28
Family living expenses in the last year in ¥, median (Q1-Q3)	20,000 (10,000-20,000)	20,000 (10,000-20,000)	20,000 (10,000-20,000)	MWU z=-0.01	1.00
Use smartphone, n (%)				χ^2=0.25	0.61
Yes	167 (45.0)	103 (44.0)	64 (46.7)		
No	204 (55.0)	131 (56.0)	73 (53.3)		
Primary usage of mobile phone for calls and text messages, n (%)				Fisher's exact test	0.49
Calling	297 (80.1)	183 (78.2)	114 (83.2)		
Text messaging	10 (2.7)	8 (3.4)	2 (1.5)		
Both in equal measure	62 (16.7)	42 (18.0)	20 (14.6)		
Other	2 (0.5)	1 (0.4)	1 (0.7)		
Primary usage of mobile phone for *QQ* and text messages, n (%)				Fisher's exact test	0.16
Text message	124 (33.4)	69 (29.5)	55 (40.2)		
QQ	147 (39.6)	98 (41.9)	49 (35.8)		
Both in equal measure	22 (5.9)	15 (6.4)	7 (5.1)		
Do not use either	77 (20.8)	52 (22.2)	25 (18.3)		
Other (seldom use)	1 (0.3)	0 (0.0)	1 (0.6)		
Number of calls made per week, median (Q1-Q3)	10 (7-21)	10 (6-20)	14 (7-28)	MWU z=1.49	0.14
Number of calls received per week, median (Q1-Q3)	10 (6-21)	10 (5.5-20)	10 (7-21)	MWU z=0.88	0.38
Number of text messages sent per week, median (Q1-Q3)	1 (0-7)	2 (0-7)	1 (0-5)	MWU z=-0.82	0.41
Number of text messages received per week, median (Q1-Q3)	8 (5-15)	7 (5-15)	10 (5-14)	MWU z=1.12	0.26
Have phone number of health facility, n (%)				χ^2=1.06	0.30
Yes	245 (66.0)	150 (64.1)	95 (69.3)		
No	126 (34.0)	84 (35.9)	42 (30.7)		

Number of times using mobile phone to obtain health information in past 3 months, median (Q1-Q3)	1 (1-3)	1 (1-3)	1 (1-3)	MWU z=-0.65	0.52
Child had diarrhoea, n (%)				Fisher's exact test	0.03[‡]
Yes	21 (5.7)	18 (7.7)	3 (2.2)		
No	349 (94.0)	215 (91.9)	134 (97.8)		
Not known	1 (0.3)	1 (0.4)	0 (0.00)		
Sought care for diarrhoea, n (%)				Fisher's exact test	0.06
Sought care	19 (5.1)	16 (6.9)	3 (2.2)		
Did not seek care	2 (0.5)	2 (0.9)	0 (0.0)		
No diarrhoea	349 (94.4)	215 (92.2)	134 (97.8)		
Child had fever, n (%)				Fisher's exact test	0.48
Yes	34 (9.2)	21 (9.0)	13 (9.5)		
No	336 (90.6)	213 (91.0)	123 (89.8)		
Not known	1 (0.2)	0 (0.0)	1 (0.7)		
Child had cough, n (%)				χ^2=0.26	0.61
Yes	92 (24.8)	56 (23.9)	36 (26.3)		
No	279 (75.2)	178 (76.1)	101 (73.7)		
Sought care for fever or cough, n (%)				Fisher's exact test	0.89
Sought care	88 (23.7)	54 (23.1)	34 (24.8)		
Did not seek care	13 (3.5)	8 (3.4)	5 (3.7)		
No fever or cough	270 (72.8)	172 (73.5)	98 (71.5)		
Child breathed fast or with difficulty, n (%)				χ^2=0.14	0.71
Yes	17 (4.6)	10 (4.3)	7 (5.1)		
No	354 (95.4)	224 (95.7)	130 (94.9)		

[*]Chi-square (χ^2), Mann-Whitney U (MWU), z-score (z).
[†]3=junior high school, 4=senior high school/technical school.
[‡]P<0.05

Table 52 Face-to-face versus text message answers to nominal dichotomous questions (N=409)

Face-to-face*	**Text message**		
Text message: brief content	**Yes**	**No**	**Do not know**
4: child had diarrhoea (n=409)			
Yes	23	2	0
No	9	373	1
Do not know	0	1	0
5: child had blood in stools (n=21)			
Yes	0	0	0
No	0	21	0
Do not know	0	0	0
6: child drank ORS (n=19)			
Yes	1	2	0
No	1	15	0
Do not know	0	0	0
7: child drank recommended fluids (n=16)			
Yes	14	2	0
No	0	0	0
Do not know	0	0	0
8: child drank other fluids (n=16)			
Yes	5	0	0
No	2	9	0
Do not know	0	0	0
11: sought care for diarrhoea (n=10)			
Yes	5	1	0
No	2	2	0
Do not know	0	0	0
14: child had fever (n=365)			
Yes	25	7	0
No	10	322	0
Do not know	1	0	0
15: child had illness with cough (n=332)			
Yes	62	19	0
No	18	233	0
Do not know	0	0	0
16: child breathed fast or with difficulty (n=308)			
Yes	9	6	0
No	2	290	0
Do not know	0	1	0
18: sought care for child during fever or cough (n=55)			
Yes	46	2	0
No	1	6	0
Do not know	0	0	0

*Grey indicates answers that were the same when comparing the face-to-face and text messaging survey; black indicates answers that were different when comparing the face-to-face and text messaging survey.

Table 53 Face-to-face versus text message answers to nominal non-dichotomous question about cause of fast or difficult breathing (N=409)

Face-to-face*	Text message			
Text message: brief content	**Problem in chest**	**Blocked nose**	**Both**	**Other**
17: cause of breathing fast or difficult (n=8)				
Problem in chest	2	0	1	0
Blocked nose	0	4	0	0
Both	0	0	0	0
Other*	1	0	0	0

*Bronchitis.

Table 54 Face-to-face versus text message answers to nominal non-dichotomous questions about reason for not seeking care (N=409)

Face-to-face	Text message
Text message: brief content	**Mild disease**
12: why care was not sought for diarrhoea (n=2)	
Mild disease	2
19: why care was not sought for fever or cough (n=2)	
Mild disease	2

Table 55 Face-to-face versus text message answers to nominal non-dichotomous question about where participants sought care for diarrhoea (N=409)

Face-to-face	Text message	
Text message: brief content	**Village clinic**	**Village clinic, county level hospital or above*, county-level Maternal and Child Health Hospital**
13: where sought care for diarrhoea (n=4)		
Village clinic	3	0
Village clinic, county level hospital or above*, county-level Maternal and Child Health Hospital	1	0

*Excluding county level Maternal and Child Health Hospital.

Table 56 Face-to-face versus text message answers to nominal non-dichotomous question about where participants sought care for fever or cough (N=409)

Face-to-face*	Text message											
Text message: brief content	**1**	**2**	**3**	**4**	**5**	**6**	**1+4**	**1+6**	**2+6**	**4+5**	**4+6**	**4+7**
20: where care was sought for fever or cough (n=40)												
0	0	0	1	1	0	0	0	0	0	0	0	1
1	2	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	1	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	16	0	2	0	0	0	1	1	0
5	0	0	0	0	1	1	0	0	0	0	0	0
6	0	0	0	1	0	4	0	1	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
1+2	0	1	0	0	0	0	0	0	0	0	0	0
1+4	0	0	0	0	0	0	1	0	0	0	0	0
2+6	0	0	0	0	0	0	0	0	1	0	0	0
3+4	0	0	0	0	0	0	0	0	0	0	0	0
4+6	0	0	0	0	0	0	0	0	0	0	1	0
4+8	0	0	0	1	0	0	0	0	0	0	0	0
1+2+6	0	0	0	0	0	1	0	0	0	0	0	0

*Places where care was sought were listed as follows:
0= no places reported; participants said "no" for all the places where care was sought and no place was recorded in the face-to-face interview;
1= County level hospital or above (excluding Maternal and Child Health Hospital);
2= County level Maternal and Child Health Hospital;
3= Township hospital;
4= Village clinic;
5= Private hospital;
6= Private clinic;
7= Pharmacy;
8= Community health station.

Table 57 Face-to-face versus text message answers to ordinal questions (N=409)

Face-to-face	Text message					
Text message: brief content	**None**	**Much less**	**Little less**	**About the same**	**More**	**No foods yet**
9: how much child drank during diarrhoea (n=14)						
None	0	0	0	0	0	NA
Much less	0	2	0	0	0	
Little less	0	0	0	0	0	
About the same	1	0	1	9	0	
More	0	0	0	0	1	
10: how much child ate during diarrhoea (n=11)						
None	0	0	0	0	0	1
Much less	0	2	0	1	0	0
Little less	0	0	1	0	0	0
About the same	0	0	0	0	1	3
More	0	0	0	0	1	0
No foods yet	0	0	0	0	0	1

Table 58 Face-to-face versus text message answers to question about being introduced to complementary foods (N=409)

Face-to-face	**Text message**	
Text message: brief content	Yes	No
10a: introduced to complementary food (n=12)*		
Yes	7	4
No	0	1

*One participant said that the child was introduced to complementary food in the text messaging survey, but did not respond to the next question in text message 10 about how much food was given. Therefore, the number of participants is 12 and not 11 as indicated for text message 10 in Table 57.

Table 59 Face-to-face versus text message number of places participants reported for question about seeking care for diarrhoea (N=409)

Number of face-to-face responses	**Number (n) of text message responses**		
Text message: brief content	**1**	**2**	**3**
13: where care was sought for diarrhoea (n=4)			
1	3	0	0
2	0	0	0
3	1	0	0

Table 60 Face-to-face versus text message number of places participants reported for question about seeking care for fever or cough (N=409)

Number of face-to-face responses	**Number (n) of text message responses**		
Text message: brief content	**1**	**2**	**3**
20: where care was sought for fever or cough (n=40)			
0	2	1	0
1	27	4	0
2	2	3	0
3	1	0	0

Table 61 Participants' reasons for different responses in group 2 (n=226)

			Text message‡						**Face-to-face§**					**Other||**	
Text message: brief content	**n***	**Missing†**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
4: child had diarrhoea	12	2	2	2	1		1	1	1	2					
5: child had blood in stools	0														
6: child drank ORS	2	1								1					
7: child drank recommended fluids	0														
8: child drank other fluids	0														
9: how much child drank during diarrhoea	0														
10a: how much child ate during diarrhoea	4	2		1						1					
11: sought care for diarrhoea	2	2													
12: why no care was sought for diarrhoea	1	1													
13: where care was sought for diarrhoea	0														
14: child had fever	10		3		1	1			1	1	1	1		1	
15: child had illness with cough	16		3		1				5	1	2	1	1	1	1
16: child breathed fast or with difficulty	5	1							1	1	1				
17: cause of fast or difficult breathing	0														
18: sought care for child during fever or cough	0														
19: why no care was sought for fever or cough	0														
20: where care was sought for fever or cough	0														
Total	51	9	8	3	3	1	1	1	8	7	4	2	1	2	1

*Number of the same caregivers responding to both text message and face-to-face question and giving a different response.
†Missing because forgot to ask (text message 4, 6, 10a, 11, 16) or error in text message answer (question 12).
‡ <u>text message related reasons:</u>
A= did not see the date (there were dates in the text messages to ask about the past two weeks);
B= misunderstood question;
C= replied carelessly and did not pay attention;
D= put wrong answer by mistake;
E= forgot how reply was given;
F= did not see the accurate definition of diarrhoea.
§<u>face-to-face related reasons:</u>
G= did not know the accurate definition of a symptom, diarrhoea (number 4) the temperature of fever (number 14), cough caused by illness (number 15), fast and difficult breathing (number 16);
H= misunderstood question;
I= did not understand the date clearly;
J= did not hear the question clearly;
K= interviewer was in a hurry.
||<u>other reasons (not mentioned to be related to text message or face-to-face method):</u>
L= could not recall the requested information for the question;
M= changed mind.

Appendix H Additional tables for researchers' observations

Overview

This appendix provides Tables 62-64 for the observations of researchers reported in Chapter 8 and 9.

Table 62 Researchers' observations about recruitment visit 1 in group 1

Village number	Category of number of villagers[*]	Category of number of children <5[†]	Total number of caregivers recruited	Month. Day	Loud speaker used? (Yes (Y), No (N), Unavailable (U), Not Applicable (NA))	Phone numbers provided by township?	Phone numbers provided by village doctor?	Other recruitment methods used?	Cooperative village doctor?	Comments
1	3	2	15	3.17	U	Y, 53	Y	N	Y	Village doctor made all phone calls.
3	4	2	13	3.16	U	Y, 33	N	N	Y	Some children were not from this village, possibly mistakes in the list of names. Village doctor took interviewers to caregivers' houses.
4	3	4	21	3.16	U	N	N	N	N	Village doctor complained about payment. Some children were not from village; may be mistakes in the list of names.
10	3	4	18	3.16	U	N	N	A notice near a temple, caregivers were asked to ask others	Y	Most mothers worked as guide around temple. Village doctor wrote down the information on a notice board and also asked them to tell others; 4 pm was right time for recruitment.
12	3	3	15	3.16	U	N	N	Village doctor went to homes.	Y	Difficult to recruit, because it was a large village, but no loudspeaker or phone numbers were available.
13	3	3	4 3	3.16	Y	N	N	N	Y	Village doctor asked many eligible parents to come.
16	2	1	15	3.17	Y	Y, 28	Y	N	Y	Village doctor helped checking the vaccination card of caregivers (used for identification).
17	3	2	2 7	3.17	U	Y, 78	N	Village doctors asked on the street and went to houses.	Y	Village doctor had experience with gathering caregivers; could not finish calling all caregivers.
20	4	3	4 7	3.17	Y	Y, 101	N	N	Y	Good quality loudspeakers; village doctor made announcement several times. Did not have time to call all phone numbers.

27	2	2	4	3.17	Y	N	N	N	N	Interviewers walked to village because of road works. Based on previous experiences it was expected that recruitment would be difficult. Scheduled recruitment in late afternoon, but this was not successful. Loudspeaker not of good quality. Village doctor not willing to call caregivers and was busy (had to pick up their child). Found mother from this village in another village.
32	3	4	41	3.16	Y	N	Y	Asked caregivers to as others.	Y	Village doctor made calls.
36	2	2	33	3.17	Y	N	N	N	Y	Village doctor made announcement before interviewers came.
40	4	5	31	3.16	Y	N	N	N	Y	Initially, supervisors did not give a list of names to village doctor, because it was expected that the village doctor had the names. Village doctor used own money to make the announcement with private loudspeaker, but did not want to go to homes. Village doctor participated in previous research, but thought this was not useful or helpful for mothers.
43	4	3	37	3.21	Y	N	N	Went to market to ask people.	Y	It was market day and the market was just outside the village clinic. Village doctor wanted more payment.
45	1	1	0	3.21	U, broken	N	NA	Asked people on the street.	NA	Village doctor passed away. Village chief went through the list of names, but could not find caregivers.
46	2	2	11	3.16	Y	N	N	Asked people on the street.	Y	Initially, a list of names was not given. The loudspeaker was not of good quality. Villagers neither trusted the interviewers nor the village doctor, despite explanation of study. Village doctor said most of the villagers were doing business on their own and therefore recruitment was hard. Villagers feared being deluded, because they saw this on television. Village doctors asked for more payment, even after explanation. There was no other study before. Village 39 is next to this village, but recruitment was much better there.

*Number of villagers: 1=<500, 2=500-1000, 3=1000-2000, 4=>2000.
†Number of children under five: 1=<50, 2=50-100, 3=100-150, 4=150-200, 5=>200.

Table 63 Researchers' observations recruitment visit 2 in group 1

Village number	Month. Day	Loudspeaker used? (Yes (Y), No (N), Unavailable (U), Not Applicable (NA))	Other method used?	Comments
1	3.25	N	Phone calls	Not effective recruitment.
3	3.24	N	Phone calls (32)	-
4	3.22	N	N	Village doctor again complained about payment.
10	3.25	N	N	Village doctor was busy with patients and not willing to help.
12	3.26	N	Village doctor took interviewers to homes.	-
13	3.22	N	Going to houses and asked people on the street.	Village doctor helped to visit houses and also asked caregivers on the street.
16	NA	NA	NA	No second visit, because all efforts to recruit caregivers were made during first visit.
17	3.24	N	Phone calls (36)	Completed calling all phone numbers.
20	3.22	Y, twice	Phone calls and asked caregivers to ask others.	Village doctor said to not mind about the money and was willing to do everything to help.
27	3.25	NA	NA	Not able to visit village, road completely blocked.
32	3.24	Y	N	Village doctor was busy and not able to go to houses; was not as cooperative as during first visit.
36	3.25	N	Went to the homes.	-
40	3.23	Y	Asked people on the street.	Supervisors gave the list of names. Right time of visit (10 am) and better recruitment compared with first visit.
43	3.24	Y	N	-
45	NA	NA	NA	NA
46	3.21	Y	Asked people on the street.	One caregiver could not understand the study. One caregiver said that the grandparents took care of the children and they should be asked. Caregivers feared being deluded.

Table 64 Researchers' observations recruitment in group 2

Village number	Category of number of villagers*	Category of number of children <5†	Total number of caregivers recruited	Month. Day	Loud speaker used? (Yes (Y), No (N), Unavailable (U), Not Applicable (NA)	Phone numbers provided by township?	Phone numbers provided by village doctor?	Other recruitment methods used?	Cooperative village doctor?	Comments
2	2	1	17	3.18	U	Y, 23	N	N	N	Village doctor was also a dentist and too busy during the time the interviewers were there.
5	3	2	7	3.19	U	Y, 53	N	Village doctor made phone calls on day before recruitment	Y	Village doctor said to not know some of the children on the list of names and maybe some of them were not from this village.
6	2	1	0	NA	NA	NA	NA	NA	NA	Township doctor said that the village did not have a village doctor.
7	3	2	11	3.21	Y	Y, 45	N	N	Y	Village doctor helped calling and asked people to inform others.
8	2	1	24	3.21	Not sure; late arrival	Y, 34	N	N	Y	Communication problem resulted in late arrival. There were many caregivers (mainly grandparents) waiting for the interviewers and took much time to comfort them. Did not have time to call phone numbers.
9	2	2	23	3.18	U	N	N	N	Y	Difficult to recruit caregivers, because there was no loudspeaker
11	3	5	16	3.18	U	No	Y	Asked caregivers to ask others before arrival		Village doctor made phone calls. Recruitment was better than for a previous study.
14	3	2	0	3.18	Y	N	N	N	N	Village doctor was too busy with patients and prescribing medicines and not willing to help. Supervisors made the announcement; only two mothers came to the clinic, but could not text message.
15	3	3	7	3.20	Y	N	N	N	Y	Village doctor knew almost all parents and knew if they were going to work or were at home.
18	2	1	12	3.20	Y	Y, 32	N	N	Y	Called 27 phone numbers, but could not call the last 5.

19	2	1	14	3.20	Y	Y, 17	N	N	Y	Called all phone numbers.
21	3	3	24	3.20	Y	N	N	N	Y	Made the announcement several times.
22	2	2	10	3.20	Y	N	N	Asked caregivers to ask others	Y	Village clinic was close to a nursery where interviewers asked caregivers.
23	3	3	15	3.21	Y	N	N	Asked caregivers to ask others	Y	Village doctor helped to explain the study to the caregivers and asked them to tell more people to come.
24	3	2	24	3.19	Y	N	N	N	Y	-
25	3	3	4	3.19	Y	N	N	Went to nursery and asked on the street	N	Village doctor was drunk when county hospital doctor made visit. Teacher in nursery said village doctor "was not good". Village doctor gave the impression to lie during interview.
26	2	2	12	3.19	U	N	N	Asked caregivers to ask others	Y	-
28	3	3	16	3.20	Y	N	Y	N	Y	Made the announcement and phone calls.
29	4	5	36	3.20	Y	N	N	Village doctor went to homes	Y	Village doctor wanted to earn more money and went to homes, but did not find caregivers.
30	4	5	0	NA	NA	NA	N	NA	NA	Village doctor was not available for a personal reason.
31	2	4	34	3.20	Y	N	N	N	Y	Village doctor asked many eligible parents to come. Village doctor said caregivers lived far away from the clinic and was busy and not willing to take the interviewers there.
33	3	4	38	3.20	Y	N	N	N	Y	Village doctor asked many eligible parents.
34	3	4	31	3.19	Y	N	N	N	Y	Village doctor asked many caregivers. When interviewers got there, many parents were waiting for them.
35	3	3	43	3.19	Y	N	N	N	Y	Village doctor was nice and asked lots of eligible parents to come.
37	3	4	47	3.19	Y	N	N	N	Y	Village doctor asked many eligible parents to come.
38	1	1	15	3.19	Y	N	N	N	Y	Village doctor knew villagers well.
39	3	3	19	3.18	Y	N	N	N	Y	-
41	3	3	38	3.18	Y	N	N	N	N	Village doctor was old man and not willing to visit houses; reluctant to help.
42	4	5	89	3.17	Y	N	N	Asked caregivers to ask others	Y	Village doctor's partner helped to make the announcement and many eligible mothers came. Village doctor said caregivers received health information calendar last year.
44	2	2	17	3.18	Y	N	N	Asked caregivers to ask others before arrival	Y	Several persistent grandmothers who wanted to participate, despite careful testing there was a potential risk that they could not text message.

*Number of villagers: 1=<500, 2=500-1000, 3=1000-2000, 4=>2000.
†Number of children under five: 1=<50, 2=50-100, 3=100-150, 4=150-200, 5=>200.

Appendix I Other published papers

1. **van Velthoven MH**, Tudor Car L, Gentry S, Car J. Telephone delivered interventions for preventing HIV infection in HIV-negative persons. Cochrane Database Syst Rev. 2013;5:Cd009190. Medline:23728688. doi:10.1002/14651858.CD009190.pub2
2. Gentry S, **van Velthoven MH**, Tudor Car L, Car J. Telephone delivered interventions for reducing morbidity and mortality in people with HIV infection. Cochrane Database Syst Rev. 2013;5:Cd009189. Medline:23728687. doi:10.1002/14651858.CD009189.pub2
3. Tudor Car L, Gentry S, **van Velthoven MH**, Car J. Telephone communication of HIV testing results for improving knowledge of HIV infection status. Cochrane Database Syst Rev. 2013;1:Cd009192. Medline:23440835. doi:10.1002/14651858.CD009192.pub2
4. Tudor Car L, **van Velthoven MH**, Brusamento S, Elmoniry H, Car J, Majeed A, Atun R. Integrating prevention of mother-to-child HIV transmission (PMTCT) programmes with other health services for preventing HIV infection and improving HIV outcomes in developing countries. Cochrane Database Syst Rev. 2011:Cd008741. Medline:21678382. doi:10.1002/14651858.CD008741.pub2
5. Tudor Car L, **van Velthoven MH**, Brusamento S, Elmoniry H, Car J, Majeed A, Tugwell P, Welch V, Marusic A, Atun R. Integrating prevention of mother-to-child HIV transmission programs to improve uptake: a systematic review. PloS One. 2012;7:e35268. Medline:22558134. doi:10.1371/journal.pone.0035268
6. Tudor Car L, Brusamento S, Elmoniry H, **van Velthoven MH**, Pape UJ, Welch V, Tugwell P, Majeed A, Rudan I, Car J, Atun R. The uptake of integrated perinatal prevention of mother-to-child HIV transmission programs in low- and middle-income countries: a systematic review. PloS One. 2013;8:e56550. Medline:23483887. doi:10.1371/journal.pone.0056550
7. Brusamento S, Ghanotakis E, Tudor Car L, **van Velthoven MH**, Majeed A, Car J. Male involvement for increasing the effectiveness of prevention of mother-to-child HIV transmission (PMTCT) programmes. Cochrane Database Syst Rev. 2012;10:Cd009468. Medline:23076959. doi:10.1002/14651858.CD009468.pub2