

School of Public Health

**Milk Man: Investigating the Effectiveness of a Socially Connected
Breastfeeding App Targeting Fathers**

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Doctor of Philosophy
of
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Author's Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Human Ethics

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number HR 82/2014.



Becky White

5th February 2018

Date

Abstract

Background

Breastmilk is the ideal first food for babies. The National Health and Medical Research Council (NHMRC) of Australia recommends that babies are breastfed exclusively for the first six months and for breastfeeding to continue afterward with the introduction of solid foods. This advice is similar to the recommendations issued by the World Health Organization (WHO). Breastfeeding confers well-evidenced health benefits for both infants and mothers and there are significant benefits on a community level in terms of burden of disease and health economy.

Despite the health benefits and the recommendations about breastfeeding, Australian statistics demonstrate a consistent shortfall in achieving the target of exclusive breastfeeding for six months. Breastfeeding initiation rates are good, with 96% of Australian women initiating breastfeeding, however rates decline steadily after this, with only 15% of babies exclusively breastfed beyond five months. There are many factors that impact on breastfeeding including biomedical, socio-demographic and support factors. The support of fathers has been identified as particularly important for new mothers. Fathers however can feel unprepared for their role with breastfeeding and can feel left out of antenatal education and lacking in social support in the perinatal period. Previous research has demonstrated that targeting breastfeeding initiatives to the father can have an impact on breastfeeding duration.

The use of mobile technology in Australia is widespread, and mobile technology offers benefits in terms of influencing user engagement and the opportunity to deliver interventions as participants go about their daily lives. With so many people constantly connected via their mobile devices, there are real opportunities to use mobile technology to deliver health behaviour change interventions. Engagement is a vital component of mHealth interventions and further research is needed to understand the impact this has on health outcomes.

There is growing evidence of the impact of mobile technology in a range of health areas, yet more evidence from large trials is still needed. There are few digital breastfeeding interventions described in the literature, and fewer still that target fathers. To the authors' knowledge, Milk Man is the first breastfeeding mobile app targeted at fathers.

Aim

This research aimed to develop and evaluate the impact of a father-focused, socially connected, gamified breastfeeding app on exclusive breastfeeding. Breastfeeding outcomes were measured at six weeks postpartum.

Methods

The Milk Man mobile app was developed as an intervention for the Parent Infant Feeding initiative (PIFI), a four armed, factorial design randomised control trial. There was one control group, two medium intensity groups and one high intensity group. Of the two medium intensity groups, one received a male-facilitated antenatal class (M1) and the other the social support intervention (Milk Man app) (M2). The high intensity group (HI) received both the Milk Man app and the antenatal class.

The development of the Milk Man app was informed by Social Cognitive Theory. The app used a range of engagement techniques such as push notifications, a comprehensive information library, social connectivity and gamification, all designed to engage fathers in information and conversation about breastfeeding. The study aimed to examine the impact of this on exclusive breastfeeding duration. The research adopted a mixed methods approach to evaluation with both qualitative and quantitative data collected at different phases. A comprehensive evaluation plan was developed for the Milk Man app intervention that included evaluation indicators over five broad areas including: people, content, technology, computer mediated technology and health system integration. Process evaluation data was collected across the five areas to describe and understand how participants used the app. An engagement measure was applied to enable examination by level of app engagement. The primary outcome measure was risk of exclusive breastfeeding cessation prior to six week postpartum which was measured using a survival analyses.

Focus groups were held with members of the target group (n=18) and key stakeholders (n=16) to inform the app development. The prototype was then tested with fathers (n=4) using a think-aloud walkthrough and the Mobile App Rating Scale. The app aimed to engage fathers in information and conversation about breastfeeding and early parenting with a view to increasing their support for their breastfeeding partners. The app used a range of strategies designed to engage fathers.

Participants (n=1,426 couples) were recruited to the PIFI study between August 2015 and December 2016 through antenatal classes in public and private maternity hospitals in Perth, Western Australia. Couples were randomly allocated to a study arm. Fathers who were in a group that included access to the Milk Man app were provided with information on how they could access the app. Participant data were collected through a questionnaire that was completed at recruitment and at six weeks post birth. Additional data were collected from Milk Man participants through the app analytics framework. The study used both an intention-to-treat protocol and per-protocol analysis.

Results

The development of the Milk Man app was informed by formative research. The focus groups revealed four key areas to guide the implementation of the engagement strategies. The app rated highly, with test users scoring the app an average of 4.3 out of 5. The testing phase identified six areas of usability and functionality that could be improved.

In total, 86% of fathers randomised into an app group downloaded the app. Analysis of the process evaluation data collected at six weeks and the app analytics indicated that the Milk Man app intervention was an acceptable approach with parents.

People

Our whole cohort exhibited high rates of exclusive breastfeeding and the intention-to-treat analysis did not demonstrate any difference between groups in exclusive breastfeeding. However, using a per-protocol survival analysis, those couples who downloaded Milk Man were less likely to cease exclusive breastfeeding at any time point up to six weeks post birth compared with the control group (log rank test $p=0.052$; Breslow $p=0.046$; Tarone-Ware $p=0.049$). Users were stratified into three levels of engagement - low, moderate and high. Engagement levels had no impact on exclusive breastfeeding, and there were no demographic factors that predicted engagement level.

Content

The conversation forum emerged as the hub of app activity, rating highly with fathers and mothers. Push notifications were the number one factor fathers said motivated them to use the app and app analytics confirmed that the push notifications prompted use. The library was well received and trusted by most participants (79%), however fathers wanted more comprehensive information. Gamification was a powerful motivator in this study, however care needs to be taken to better understand how its inclusion may impact on those opposed to it, and the app should be fully functional without participating in the gamification. The app showed encouraging results in facilitating conversations between parents. Working in partnership with the app developer throughout the trial was beneficial.

Technology

Almost two thirds of fathers signed up for the app using iOS, Apple's operating system for mobile devices such as iPhones and iPads. App analytics showed fathers used the app most in the weeks around the birth of their baby, with the highest usage being in the week of their baby's birth (total number of unique days the app was opened in week of birth n= 575). There were two main technological events impacting on the app over the course of the trial. The first was the retiring of the Parse hosting service requiring the app database to be migrated mid-trial, and the second was the identification of a bug which prevented the conversation showing for some users for a short time.

Computer mediated technology

Overall the functionality and usability of the app was rated highly by participants. A total of 83% of participants said that they found the app easy to use, 78% agreed the visual design was appealing and 67% would recommend the app to other fathers. Participants had specific suggestions to improve the app conversation forum to further support community interaction, including the ability for users to post their own conversation topics.

Health system integration

Participants accessed the websites of other health services through the app a total of 912 times. The two most common websites visited were the Raising Children's Network and the Australian Breastfeeding Association. The app demonstrated good acceptability from mothers with a sentiment analysis on open text responses (n=129) demonstrating a strong positive response (94 responses coded positive, 25 coded as negative and 21 coded as neutral).

Conclusion

This study has shown that an intervention targeted at fathers can provide an avenue for breastfeeding support and education that benefits both fathers and mothers. mHealth research about father-focussed infant feeding interventions is very much in its infancy. This thesis has provided rich insight into specific engagement strategies that encourage app use which will be of relevance to health and education professionals seeking to support fathers in the perinatal period. There are clear pathways to further research in this innovative space.

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Dedication

I am fortunate to have an incredible family behind me. To my amazing parents who never let me think that anything was impossible and always supporting me, no matter how crazy the venture was. I hope I can do the same for my girls. And my two gorgeous girls, Annabel and Molly - I am so proud of you both. I hope you stay as curious about the world as you are.

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List of Abbreviations

App	Application (mobile)
BFHI	Baby Friendly Hospital Initiative
C	Control group (PIFI study group)
CI	Confidence interval
DBCI	Digital Behaviour Change Intervention
eHealth	electronic health
EI	Engagement Index
EMA	Ecological Momentary Assessment
EMI	Ecological Momentary Intervention
Fi	Feedback subindex
FIFI	Father Infant Feeding Initiative
HI	High Intensity (App and antenatal class PIFI study group)
li	Interaction subindex
IRSD	Index of Relative Socio-economic Disadvantage
Li	Loyalty subindex
M1	Medium Intensity group 1 (Dads antenatal session PIFI study group)
M2	Medium Intensity group 2 (App only PIFI study group)
MARS	Mobile App Rating Scale
mERA	mHealth Evidence Reporting and Assessment
mHealth	mobile health
NHMRC	National Health and Medical Research Council
OHC	Online Health Community
OS	Operating System
PIFI	Parents infant Feeding Initiative
RCT	Randomised Control Trial
Rei	Reading subindex
Ri	Recency subindex
SCT	Social Cognitive Theory
SES	Social Economic Status
std. dev.	standard deviation
UES	User Engagement Scale
WHO	World Health Organization

Chapter 1 Introduction, objectives, thesis structure

1.1 Introduction

Breastfeeding is an important public health issue and there are well-evidenced health benefits for infants and mothers (Chowdhury et al., 2015; Victora et al., 2016). One of the most important factors for breastfeeding women is the support of the father (Scott, Binns, Oddy, & Graham, 2006; Scott, Landers, Hughes, & Binns, 2001). While research has shown most fathers are supportive of their partner's breastfeeding, there are a range of factors that can impact that support (Brown & Davies, 2014; Sherriff, Hall, & Pickin, 2009; Tohotoa et al., 2011; Tohotoa et al., 2009). Other studies have demonstrated that targeting fathers with breastfeeding information, typically through antenatal classes, can positively impact on breastfeeding outcomes (Mitchell-Box & Braun, 2013; Yourkavitch, Alvey, Prosnitz, & Thomas, 2017).

Due to wide ownership and constant connectivity, mobile technology offers a great opportunity to reach individuals with health promotion initiatives and to impact on health behaviour. This thesis describes the development and testing of Milk Man, a socially connected, gamified mobile app about breastfeeding that targeted fathers. The primary aim was to investigate if usage of the app had any impact on exclusive breastfeeding duration. The study involved different phases and this thesis describes the current literature about breastfeeding and mobile technology, the development and trialling of the Milk Man app, as well as the comprehensive findings from the study.

This introductory chapter includes the aims and objectives, a statement of the study's significance and a description of the candidate's contribution to the Parent Infant Feeding Initiative (PIFI) research study that Milk Man was trialled in. It also describes the structure of the thesis chapters, reports on the World Health Organization's (WHO) guidelines for reporting of health interventions using mobile phones developed by the WHO mHealth Technical review group, and concludes with the publications, conference presentations and awards arising from this research.

1.2 Study design

The Milk Man mobile app was developed as an intervention for the PIFI, a four armed, factorial design Randomised Control Trial (RCT). There was one control group, two medium intensity groups and one high intensity group. Of the two medium intensity groups, one received a male-facilitated antenatal class (M1) and the other the social support intervention (Milk Man app) (M2). The high intensity (HI) group received both the Milk Man app and the antenatal class. Couples were recruited from antenatal classes in Perth, Western Australia and data were collected from participants via self-completed questionnaires at recruitment and at six, and 26 weeks postpartum. This thesis reports results to six weeks postpartum.

1.3 Aim and objectives

This research aimed to develop and evaluate the impact of a father-focused, socially connected, gamified breastfeeding app on the duration of exclusive breastfeeding. Breastfeeding outcomes were measured at six weeks postpartum. As well as the overall aim of the study, the research involved discrete yet connected phases with accompanying objectives.

1. To review the evidence of the use of mobile technology in health promotion initiatives in general, and with the target group.
2. To develop an engaging breastfeeding app for fathers, informed by the literature and marketing audit and with input from stakeholders and members of the target group, that would provide them with the information and support they need to effectively support their breastfeeding partners.
3. To conduct comprehensive process evaluation investigating which of the app engagement strategies were effective in motivating and engaging users.
4. To determine the effect of the Milk Man app on breastfeeding behaviour and whether level of app engagement was directly associated with breastfeeding outcomes.

1.4 Limitations of previous research

Despite evidence about the important role fathers have in supporting their partner's breastfeeding, there are few breastfeeding intervention studies that target fathers. Most of those that do, focus solely on offering support and education in the antenatal period. Findings from previous studies suggest that fathers want interventions delivered to them in a digital format, yet at the time of developing Milk Man, there were no mobile apps that focussed on breastfeeding and targeted fathers. There was also very limited information in the literature about what specific components of digital health interventions can be used to engage fathers. Another limitation of previous research is in describing evaluation plans that are both comprehensive in design, and appropriate to health promotion interventions utilising mobile technology. How best to measure engagement and apply the findings to intervention design remains an area where more research is needed.

1.5 Significance of the study

The PIFI study that the Milk Man app was trialled in builds on previous research and was the largest male-partner focussed breastfeeding intervention study at the time of development. Milk Man was the first breastfeeding mobile app targeted at fathers. This study provided evidence of the role of fathers in breastfeeding, as well as broader research implications for the design of mHealth interventions. This study was significant for the following reasons:

- It was the first study to show that a breastfeeding mobile app intervention targeting new fathers is an acceptable approach with this hard to reach group and one that can impact positively on breastfeeding outcomes.
- It is also the first to show that fathers will use an app-based forum in different ways to seek and offer social support, including that fathers are comfortable using this medium to share intimate information.
- The comprehensive evaluation plan developed for this research provides a model that can be adapted for other interventions.
- Broad process evaluation findings have contributed to knowledge of what specific strategies are effective in engaging fathers and how to best target an mHealth intervention.

- This study used an engagement index to stratify users into different groups depending on their engagement score and mapped this to breastfeeding outcomes. The findings add to the growing evidence about engagement and highlight the need for further research with *effective* engagement.

1.6 Candidate’s contribution

The Milk Man app intervention described in this thesis was developed as an intervention arm in the PIFI. The PIFI followed couples to 26 weeks postpartum to report on breastfeeding outcomes at six months; this thesis reports on data to six weeks postpartum only. The candidate led on all aspects of the Milk Man app intervention, and contributed to the wider study. The candidate’s contribution to the PIFI study is described in Table 1.1.

Table 1.1. Candidate’s contribution to PIFI study

Intervention development	Led on all aspects of formative research and development of the Milk Man app intervention including literature reviews, organising and facilitating focus groups, scoping the app’s content and design, and coordinating feedback with the developer and the research team.
	Contributed to the development of antenatal class materials and the training of educators.
Intervention implementation	Led on app intervention implementation including database management, participant grouping, moderation, posting new content and troubleshooting.
	Led on the development of an evaluation plan and an engagement measure for Milk Man.
	Contributed to the recruitment of participants from antenatal classes at hospital sites involving recruitment visits to hospital sites 72 times.

Contributed to the ongoing monitoring, training and liaison with male-facilitators for antenatal classes.

Contributed to ongoing liaison and visits with hospital staff.

Conducted phone interviews for participants who chose not to complete the follow-up questionnaires online.

Intervention analysis	Led on the app analytics analysis and descriptive process and impact analysis.
	Led on the qualitative analysis of the Milk Man conversation forum.
	Contributed to the health outcome analysis.

1.7 Thesis structure

The structure of the thesis is described below, with a brief summary of each chapter. Table 1.2 describes which chapter in this thesis addressed each of the study objectives.

Table 1.2. Objectives mapped to thesis chapter

	Objective 1.	Objective 2.	Objective 3.	Objective 4.
Chapter 2				
Chapter 3				
Chapter 4				
Chapter 5				
Chapter 6				
Chapter 7				
Chapter 8				
Chapter 9				

Chapter 2. Literature review

The literature review is presented in four sections. The first examines literature about breastfeeding including the health benefits and influencing factors. The second section explores the paternal influence on breastfeeding, including types of paternal support, factors impacting on paternal support and father-focussed breastfeeding interventions. Section three reviews the literature on mobile technology and health promotion. Digital breastfeeding interventions are discussed, including those that have directly targeted fathers. This section discusses ways of using technology to engage with participants through gamification, social connection and the use of push notifications, and reviews current ways of measuring engagement. Section four contains a review and description of Social Cognitive Theory (SCT) which provided the theoretical framework for the Milk Man app intervention.

Chapter 3. Methods

This chapter describes the methods underpinning this research. This includes a description and methods of the PIFI, the RCT the Milk Man app was developed for and tested within. Methods specific to the Milk Man app development and implementation are also described in this chapter.

Chapter 4. Milk Man evaluation plan

Chapter four is a peer reviewed journal article that reviews current best practise in evaluating mHealth interventions and describes the evaluation plan developed for the Milk Man app intervention. Based on the collaborative adaptive interactive technology framework, the paper describes formative, process and impact evaluation indicators over five areas of evaluation focus: people, content, technology, health systems integration and computer mediated technology.

Chapter 5. Formative evaluation

This chapter describes the focus groups held with fathers and stakeholders (health professionals) to inform the development and design of the Milk Man app. A semi-structured interview guide was developed based on SCT, designed to investigate the mobile device usage behaviour of participants, as well as their experiences with using apps and their needs as new fathers.

Chapter 6. Developing the Milk Man app

This chapter describes the development of the Milk Man app. This includes detailed description of the app design process guided by SCT, including the marketing audit, engagement strategies, software platforms and app management protocols developed for the intervention. The different components of the app are described, as well as the testing and iteration phase with end-users.

Chapter 7. Process and impact evaluation results

This chapter describes the results from the Milk Man app intervention. This includes a description of participant demographics and specifically focusses on objectives three and four. Results are structured as per the evaluation plan described in Chapter 4, in the five different areas of focus for both process and impact evaluation.

Chapter 8. Qualitative analysis of Milk Man app forum

Chapter 8 presents a qualitative analysis of the Milk Man app forum, which describes the way fathers in the Milk Man intervention used the app to communicate with each other, and seek and offer support.

Chapter 9. Discussion, recommendations and conclusions

Chapter 9 discusses the findings of the study, recommendations and implications for further research.

1.8 Reporting compliance

This thesis complies with the guidelines for reporting of health interventions using mobile phones developed by the WHO mHealth Technical review group (Agarwal et al., 2016). The mHealth Evidence Reporting and Assessment (mERA) guidelines comprise a 16-item checklist aiming to standardise reporting on the content, context and technical features of an mHealth intervention. Table 1.3 contains the mERA criteria and description as well as the section in this thesis which reports against the item.

Table 1.3. mERA guidelines

Criteria	Item no	Thesis Section
Infrastructure (population level) Describes infrastructure available to support technological operations in study location	1	Section 2.4.1
Technology platform Description of software and hardware	2	Section 6.2.4
Interoperability/Health information systems (HIS) context Describes how mHealth can integrate into existing health information systems	3	Section 7.2.5 & 7.3.5
Intervention delivery Detailed description of the mHealth intervention	4	Chapter 3 & Chapter 6
Intervention content Details of intervention contents are described	5	Section 6.3
Usability/content testing Formative research and usability testing with target group	6	Chapter 5 & Section 6.4
User feedback Describes user feedback and satisfaction with the intervention	7	Section 7.2
Access of individual participants Mentions barriers or facilitator to the adoption of the intervention with participants	8	Section 7.2 & 9.4.1
Cost assessment Presents basic cost assessment of the mHealth intervention	9	Section 9.6
Adoption inputs/ programme entry Describes how people are informed about the program	10	Chapter 3
Limitations for delivery at scale Clearly presents limitations for delivery at scale	11	Section 9.6
Contextual adaptability Describes any tailoring or modifications resulting from pilot testing	12	Section 6.4

Criteria	Item no	Thesis Section
Replicability Clearly presents screenshots, examples of messages to support replicability	13	Chapter 6
Data security Describes the data security procedures	14	Section 3.2.4
Compliance with national guidelines or regulatory statutes Mechanism to assure content is in alignment with national guidelines	15	Section 6.3.4
Fidelity of the intervention Describes the intervention implementation outcomes	16	Section 7.2

1.9 Publications, conference abstracts and awards

1.9.1 First-authored peer-reviewed publications

White, B. K., A. Martin, J. A. White, S. K. Burns, B. R. Maycock, R. C. Giglia and J. A. Scott (2016). "Theory-Based Design and Development of a Socially Connected, Gamified Mobile App for Men About Breastfeeding (Milk Man)." *JMIR Mhealth Uhealth* 4(2): e81.

White, B. K., S. K. Burns, R. C. Giglia and J. A. Scott (2016). "Designing evaluation plans for health promotion mHealth interventions: a case study of the Milk Man mobile app." *Health Promot J Austr.*

White, B. K., Giglia, R. C., Scott, J. A. & Burns, S. K., (2018). "How do new and expecting fathers engage with an app-based online forum? A qualitative analysis." *JMIR Mhealth Uhealth* 6(6):e144

1.9.2 Co-authored peer-reviewed publications

Maycock, B. R., J. A. Scott, Y. L. Hauck, S. K. Burns, S. Robinson, R. Giglia, A. Jorgensen, **B. White**, A. Harries, S. Dhaliwal, P. A. Howat and C. W. Binns (2015). "A study to prolong breastfeeding duration: design and rationale of the Parent Infant Feeding Initiative (PIFI) randomised controlled trial." *BMC Pregnancy Childbirth* 15: 159.

1.9.3 Conference abstracts

White B, Burns S, Dhaliwal, S, Giglia R, Scott J. Process Evaluation of The Milk Man Mobile App: A Breastfeeding App For Fathers [Presentation], **World Congress on Public Health**, Melbourne, Australia, 3rd-7th April 2017

Campbell K, **White B**, Allman-Farinelli M, Maddison R, Laws R, Using technological approaches to promote health across the life-course [Panel]. **World Congress on Public Health**, Melbourne, Australia, 3rd-7th April 2017

White B, Burns S, Dhaliwal, S, Giglia R, Scott J. Engaging fathers with a breastfeeding app: Preliminary process evaluation from the Milk Man mobile app intervention [Presentation]. **Digital Health Behaviour Change Conference**, London, UK. 21st, 22nd Feb 2017.

Scott JA. **White BK**. The impact of digital technologies on breastfeeding practice [Presentation]. **Philips Avent Scientific Symposium**, London, UK 16th-17th Feb 2017, London.

White BK. Mobile technology and health promotion [Presentation]. **Philips Avent Scientific Symposium**, London, UK 16th-17th Feb 2017, London.

White B, Burns S, Giglia R, Scott J, Making Milk Man: The theory-based development of a breastfeeding mobile application for men [Presentation]. **Australian Health Promotion Association Conference**, Perth, Australia, 19th-22nd June 2016

1.9.4 Awards

- Asia Pacific 3-minute thesis finalist (2017)
- Curtin 3-minute thesis winner (2017)
- World Congress on Public Health - Best presentation by an early career researcher (2017)
- Mark Liveris Conference – Best paper award (2016)
- Curtin 3-Minute thesis finalist (2016)

Chapter 2 Literature review

2.1 Introduction

This chapter gives an overview of the current literature relating to this thesis. This chapter has been organised into the following sections:

1. Breastfeeding. This section provides an overview of the large body of evidence about the health benefits of breastfeeding and the factors that influence breastfeeding.
2. Paternal role in breastfeeding. The role of fathers in supporting their partner with breastfeeding and father-focussed breastfeeding interventions are described in this section.
3. Mobile technology and health promotion. This section gives an overview of the evidence about the use of mobile technology in health promotion initiatives including digital breastfeeding interventions.
4. Theoretical framework. This section describes the theoretical framework for the development and trialling of Milk Man which is based on Social Cognitive Theory.

2.2 Section 1: Breastfeeding

Breastfeeding is the optimal way of feeding infants. The WHO recommends infants are exclusively breastfed for six months, and for breastfeeding to continue with the introduction of complementary foods up to two years of age or beyond (World Health Organization, 2011a). The Australian NHMRC Infant Feeding Guidelines offer similar advice for Australian families, recommending exclusive breastfeeding for the first six months, and for breastfeeding to continue until 12 months of age and beyond (National Health and Medical Research Council, 2012).

According to the Australian National Infant Feeding Survey, 96% of mothers in Australia initiate breastfeeding (Australian Institute of Health and Welfare, 2011). There is however a steady decline in breastfeeding rates after this, with 39% of infants being *exclusively* breastfed (baby receiving breastmilk only) to three months and only 15% of babies still being exclusively breastfed to five months. Rates of *any* breastfeeding (baby receiving some breastmilk) show that approximately 69% of infants are still receiving some breastmilk at four months, followed by approximately 60% at six months.

The factors that influence breastfeeding initiation and duration are multiple and complex and include several socio demographic and societal factors. This following section describes the health benefits of breastfeeding for infants and mothers, and discusses the factors that can impact on breastfeeding initiation and duration.

2.2.1 Benefits of breastfeeding

The health benefits of breastfeeding for both infants and mothers are well-documented (Chowdhury et al., 2015; National Health and Medical Research Council, 2012; Victora et al., 2016; World Health Organization & UNICEF, 2003), and suboptimal breastfeeding rates have significant costs in terms of health expenditure (Bartick et al., 2016). In 2016, a study examined the health outcomes and costs of suboptimal breastfeeding on mothers and infants in the United States (Bartick et al., 2016). The study used Monte Carlo simulations to model a cohort of women and their children to examine disease and economic outcomes in relation to breastfeeding. They concluded that there are 3,340 excess deaths annually (721 of which were infants less than 12 months) attributable to suboptimal breastfeeding in the US. The estimated medical costs (using 2014 dollar values) of suboptimal breastfeeding in the US were \$US3 billion and the cost of premature death was estimated to be \$US14.2 billion.

Considering a global perspective, Victora et al. (2016) estimated the impact that scaling up breastfeeding in low and middle-income countries would have on mortality. Their modelling assumed that 95% of children under one month of age and 90% of children under six months were exclusively breastfed, and that 90% of infants aged 6-23 months were still receiving some breastmilk. The authors found this would result in an estimated 823,000 childhood deaths being prevented each year, as well as an estimated 20,000 deaths from breast cancer in women.

2.2.1.1 Health benefits for infants

Breastmilk is a dynamic fluid that adapts to fulfil the nutritional requirements of an infant as they grow (Kent et al., 2006; Mitoulas et al., 2002). It is a sterile food that is always available and at the perfect temperature when it is needed. There is compelling evidence that breastfed babies experience a range of health benefits. These can include protection from gastrointestinal and respiratory tract infections (Ip et al., 2007; Kramer et al., 2003; Victora et al., 2016), otitis media (Ip et al., 2007; Kørvel-Hanquist, Djurhuus, & Homøe, 2017; Victora et al., 2016), sudden infant death syndrome (SIDS) (Ip et al., 2007; McVea, Turner, & Pepler, 2000; Victora et al., 2016), a reduction in risk of obesity (Horta & Victora, 2013; Ip et al., 2007; Monasta et al., 2010; Victora et al., 2016), a reduction in the risk of developing diabetes (Victora et al., 2016), improved performance in intelligence tests (Horta, Loret de Mola, & Victora, 2015a), and a reduction in the risk of mental health issues later in life (Oddy et al., 2010).

In their meta-analysis of breastfeeding outcomes which included analysis of results from over 400 studies, Ip et al. (2007) reported an estimated 72% reduction in the risk of hospitalisation for respiratory disease in babies who were exclusively breastfed for four months or more compared with formula fed babies. In 2016, Victoria et al. published a meta-analysis of the benefits of breastfeeding. They reported the evidence of the impact breastfeeding has on diarrhoeal and respiratory infections as 'overwhelming' and surmised that breastfeeding could prevent approximately 50% of diarrhoeal episodes and one third of respiratory infections in infants.

An observational cohort study, nested within the PROBIT cluster-randomised control trial, conducted in Belarus compared 2,862 infants who were exclusively breastfed for three months, with 621 infants who were exclusively breastfed for six months (Kramer et al., 2003). There was a significant reduction in the incidence of gastrointestinal infection in the group where the infants were exclusively breastfed to six months. This same study did not find a difference in risk of respiratory infection when comparing these exclusively breastfed cohorts, yet there is a demonstrated reduction in risk when comparing breastfed babies with formula fed babies (Ip et al., 2007).

Several meta-analyses have reported an association between breastfeeding and a reduction in the risk of obesity (Horta & Victora, 2013; Ip et al., 2007; Monasta et al., 2010; Victora et al., 2016). Following a meta-analysis of high quality studies published in 2013, Horta and Victora (2013) concluded that there was an association between breastfeeding and reduced risk of overweight and obesity in later life (for studies of more than 1500 participants, OR 0.85, 95% CI, 0.80-0.91). A later review reinforced these conclusions finding breastfed infants were less likely to be overweight or obese in later life (OR 0.74 95%CI, 0.70-0.78) (Horta, Loret De Mola, & Victora, 2015b). In this 2015 systematic review and meta-analysis of 105 studies, Horta et al. (2015b) found subjects who had ever been breastfed were less likely to be overweight or obese later in life (pooled OR 0.74, 95% CI 0.70-0.78) than those who had never been breastfed. They also used a random-effect model to report subjects who were ever breastfed had a reduced risk of type two diabetes (pooled OR 0.65, 95% CI, 0.49-0.86).

A meta-analysis published in 2000 found breastfeeding was associated with a 50% reduction in risk of SIDS when compared with bottle-fed babies (McVea et al., 2000). However the authors stated the results should be interpreted with caution due to variability in the studies, a lack of conformity in controlling for confounders and the complexity in correctly assigning a breastfeeding classification (McVea et al., 2000). Another meta-analysis by Ip et al. (2007) included examination of seven case control studies looking at the links between SIDS and breastfeeding. They found breastfed babies had a 36% reduction in the risk of SIDS compared to non-breastfed babies. These findings were reinforced by a 2016 meta-analysis which included six studies and found that if a baby was ever breastfed, they had a 36% reduction in the risk of SIDS compared with infants who were never breastfed (Victora et al., 2016).

Five cohort studies investigating otitis media and breastfeeding were included in the Ip et al. (2007) meta-analysis. Compared with infants who had been exclusively formula fed, they reported a risk reduction of 23% for infants who had ever been breastfed and a 50% reduction for those who had been exclusively breastfed to three or six months. A more recent literature review has reported that introducing formula before six months increases the risk of otitis media, and that babies breastfed for at least six months have some protection for the first six years of life (Kørvel-Hanquist et al., 2017).

A systematic review of the literature about breastfeeding and intelligence pooled study estimates using a random-effects model (Horta et al., 2015a). The estimate showed participants who had been breastfed achieved an average IQ score 3.44 points higher (95% CI 2.30-4.58) than those who were not breastfed.

The Western Australian Pregnancy Cohort (Raine) Study is one of the world's largest prospective birth cohort studies (Oddy et al., 2010). In 2010, researchers examined the impact breastfeeding had on long-term mental health outcomes in children who were assessed at two year intervals from the age of two years to 14 years. They found that breastfeeding for less than six months was an independent predictor of childhood mental health problems.

2.2.1.2 Health benefits for mothers

Breastfeeding has significant health benefits for the mother, as well as the infant. For mothers, health benefits can include protection against ovarian and breast cancer (Chowdhury et al., 2015; Collaborative Group on Hormonal Factors in Breast Cancer, 2002; Ip et al., 2007; Labbok, 2001), diabetes (Chowdhury et al., 2015; Ip et al., 2007; Schwarz et al., 2009; Stuebe, Rich-Edwards, Willett, Manson, & Michels, 2005), hypertension (S. Y. Lee, Kim, Jee, & Yang, 2005; Schwarz et al., 2009), myocardial infarction (Peters et al., 2017; Schwarz et al., 2009; Stuebe et al., 2009), and improvement in bone remineralisation levels post lactation (Labbok, 2001). Breastfeeding can help promote attachment development between mother and baby by the regular intimate interaction it requires (Gribble, 2006; Labbok, 2001). Bartick et al. (2016) found that breastfeeding had a more significant impact on the health of women than had previously been appreciated and recommended that breastfeeding promotion efforts be more closely aligned to women's health.

A large number of studies have examined the link between breastfeeding and breast cancer risk and several meta-analyses have been conducted (Chowdhury et al., 2015; Ip et al., 2007; Labbok, 2001; Victora et al., 2016). A 2015 meta-analysis examined 98 studies examining the association between breastfeeding and the risk of developing breast cancer (Chowdhury et al., 2015). The authors surmised that *ever* breastfeeding was associated with a 22% reduction in the risk of developing breast cancer compared with *never* breastfeeding (OR 0.78, CI 0.74-0.82). Additionally, they found mothers who breastfed for more than 12 months, had a 26% lower risk of developing breast cancer than those who had not breastfed. One pooled analysis of individual data from 47 studies which included a total of 50,302 women with, and 96,973 women without breast cancer reported a reduced risk of developing breast cancer of 4.3% for each cumulative year of breastfeeding (Collaborative Group on Hormonal Factors in Breast Cancer, 2002).

The Chowdhury et al. (2015) meta-analysis included 41 studies that investigated an association between breastfeeding and ovarian cancer and found *ever* breastfeeding was associated with a 30% reduction in risk when compared with those who had *never* breastfed (OR 0.70, 95% CI 0.64-0.77).

The UK Nurses Health Study included both a prospective observational cohort study (n=83,585) and a retrospective cohort study (n=73,418) of women (Stuebe et al., 2005). The results showed an association between increased breastfeeding duration and reduction in risk of type 2 diabetes. Another US based study which examined data using multivariate modelling from 139,681 post-menopausal women, found women who had cumulatively breastfed for 12 months or more were less likely to develop diabetes (OR 0.80, p<0.001) compared to those who had never breastfed (Schwarz et al., 2009).

An examination of the data of postmenopausal women (n=139,681) found women who had breastfed for more than 12 months (cumulative) were less likely to experience hypertension than those who did not (OR 0.88, p<0.001) (Schwarz et al., 2009). Using multivariate modelling the study estimated 42.1% of women who did not breastfeed for 12 months would have hypertension, compared with 38.6% of women who breastfed for 12 months or longer. A cohort study with 177,749 Korean women also found breastfeeding may be a protective factor for hypertension in premenopausal women (S. Y. Lee et al., 2005).

Published in 2017, a prospective cohort study which included approximately 300,000 Chinese women found women who had *ever* breastfed were at a lower risk of cardiovascular disease (CVD) than women who had *never* breastfed (HR 0.88, 95% CO, 0.80-0.97) (Peters et al., 2017). The authors also found an inverse association between duration of breastfeeding and risk of several CVDs with women who breastfed between 6-12 months having a 7% lower risk of coronary heart disease compared with women who had never breastfed.

Data from the UK Nurses' Health cohort study (n=89,326) found women who had breastfed accumulatively for two years or more had a 37% lower risk of coronary heart disease compared with women who had never breastfed (Stuebe et al., 2009). Similar findings were reported in 2009 with women who had one live birth and breastfed for between 7-12 months having a 28% reduction in risk in developing CVD (HR 0.72, 95% CI 0.53-0.97) when compared with women who had never lactated (Schwarz et al., 2009).

2.2.1.3 Summary

There are compelling health and economic benefits of breastfeeding for infants, mothers, and society as a whole. The positive health benefits of breastfeeding are well-evidenced. As chronic disease contributes an increasing burden on the health system in Australia and around the world, the impact breastfeeding has on obesity, diabetes and heart disease will be important for public health. Breastfeeding promotion often centres on the short-term benefits for infants, yet there are significant long-term health benefits for infants and mothers. The factors impacting on breastfeeding are diverse and complex and health promotion interventions need to understand these factors and design targeted educational and supportive programs that increase awareness of the health benefits of breastfeeding.

2.2.2 Factors influencing breastfeeding duration and exclusivity

There is a broad range of factors that can impact both on the decision to initiate breastfeeding and the duration of breastfeeding. This includes a range of demographic factors such as age, socioeconomic status (SES) and level of education; biomedical factors such as method of delivery and hospital practices; as well as support from family and partners, and wider societal attitudes towards breastfeeding. The Theory of Planned Behaviour has been used extensively to predict and explain human behaviour. The theory outlines that intention is the precursor to behaviour (Ajzen, 1991). Three direct measures impact on intention, these are attitudes, subjective norms and perceived behavioural control. These measures have all been shown to be significant predictors of breastfeeding initiation, and all are influenced by external factors (Guo, Wang, Liao, & Huang, 2016). For instance, greater community awareness of the benefits of breastfeeding can impact on attitude. Midwives supporting a new mother can influence perceived behavioural control by spending time increasing her skills and confidence. Fathers being knowledgeable and encouraging about breastfeeding can influence subjective norms. This section describes a broad range of factors that can impact on a mother's attitudes, beliefs, intentions and motivations about breastfeeding.

2.2.2.1 Maternal Age

Many studies have reported an association with increased maternal age and longer breastfeeding duration (Dubois & Girard, 2003; Merewood et al., 2007; Scott & Binns, 1999). Analysis of a sub-set of data from a large Canadian longitudinal study which included 2,103 children, reported the odds of a child being breastfed was three times higher when their mother was aged 35 years or older (Dubois & Girard, 2003). Researchers from a Western Australian study using data from the Perth Infant Feeding Study involving 587 women found mothers aged under 30 years were less likely to be fully breastfeeding their babies than older mothers at six months postpartum (Scott, Binns, Oddy, et al., 2006).

While many countries have reported an association between maternal age and breastfeeding, a review of factors influencing infant feeding practises in Japan found no clear association between these two factors (Inoue, Binns, Otsuka, Jimba, & Matsubara, 2012). The review examined 12 articles and the results were mixed. One population-based study of 15,262 infants aged between three and six months showed the average age of mothers choosing formula feeding was significantly younger than those choosing any or exclusive breastfeeding (Yokoyama et al., 2006). Another cross sectional study of 53,575 Japanese infants found that mothers being aged 30 years or over was negatively associated with exclusive breastfeeding in the first six months (Kaneko et al., 2006).

2.2.2.2 Maternal education

Maternal education level has been demonstrated to be a factor influencing breastfeeding, with most studies in high income countries finding higher education levels are associated with increased breastfeeding outcomes (Ayton, van der Mei, Wills, Hansen, & Nelson, 2015; Dubois & Girard, 2003; van Rossem et al., 2009). Secondary analysis of the 22,202 mother and infant dyads from the 2010 Australian Infant Feeding Survey showed lower level of education was associated with a higher risk of cessation of exclusive breastfeeding in the first six months of life (Ayton et al., 2015).

A population survey of 2,914 women in the Netherlands found that women with higher education levels were more likely to initiate breastfeeding (95.5% of highest educated mothers, compared with 73.1% of lowest educated mothers), and to still be breastfeeding at two months postpartum (van Rossem et al., 2009). After the initial two months the association with education was no longer present. Canadian children whose mothers had a high school education were 60% more likely to be breastfed than those whose mothers had a lower level of education, and when the mother had a higher education than high school level the odds of breastfeeding were 3.5 times higher (Dubois & Girard, 2003).

Not all studies have reported a positive association between higher levels of education and increased breastfeeding. In their cohort study of 587 Western Australian new mothers, Scott et al. (2006) found no association between maternal education and breastfeeding initiation. The authors suggested that as initiation moves towards universality in Australia (94% of women left hospital breastfeeding), these factors that were previously strong indicators, are no longer so apparent.

2.2.2.3 Socioeconomic status

The Australian Bureau of Statistics (2011) defines SES as 'people's access to material and social resources as well as their ability to participate in society'. Several studies have looked for an association between SES and breastfeeding duration. An Australian study examined the association between SES and breastfeeding initiation and duration over three different National Health Survey data sets (1995, 2001 and 2004-05) (Amir & Donath, 2008). This study measured SES using the *Index of relative socio-economic disadvantage*, a score standardised by the Australian Bureau of Statistics and based on data collected from the Australian Census (Australian Bureau of Statistics, 2013). The authors found that although the overall rates of breastfeeding were similar across the 10-year period, children in higher socioeconomic areas were more likely to be breastfed in the 2004-05 study compared to the previous studies.

Another Australian study involving analysis of 22,202 mother, infant dyads from the Australian Infant Feeding Survey found that socioeconomic disadvantage was only weakly associated with cessation of exclusive breastfeeding (Ayton et al., 2015). Conversely, a study with Canadian children found that those from higher socio-economic circumstances were more likely to be breastfed (Dubois & Girard, 2003).

2.2.2.4 Maternal obesity

Maternal obesity has been repeatedly shown to be associated with a decreased breastfeeding duration (Ayton et al., 2015; Cox, Binns, & Giglia, 2015; Hauff, Leonard, & Rasmussen, 2014; Oddy et al., 2006). A prospective birth cohort study of new mothers in Perth, Western Australia found that women with a BMI that categorized them as overweight or obese were less likely to still be breastfeeding at any time before six months compared with women in the normal weight category (Oddy et al., 2006).

Data from a US based longitudinal cohort study of women, the Infant Feeding Practices Study 2, showed that while women who were overweight or obese had a similar intention to breastfeed to women who were in a normal weight range, they had lower odds of ever breastfeeding their babies (Hauff et al., 2014). They were also less confident about reaching their breastfeeding goals, reported fewer people around them who had breastfed, and lower levels of social support to breastfeed from other people.

Maternal obesity was one of the strongest factors related to exclusive breastfeeding cessation in the 2010 Australian Infant Feeding Survey (Ayton et al., 2015). The study reported women who were obese had an increased risk of exclusive breastfeeding cessation of 29% compared with mothers in the normal weight range.

2.2.2.5 Return to work

The length of time women can be away from work to care for their baby has an impact on breastfeeding. A recent study looked at a representative sample of Australian women (n=2,300) and investigated the impact that returning to work had on breastfeeding (Xiang, Zadoroznyj, Tomaszewski, & Martin, 2016). The study found that women who returned to work within six months of their baby's birth and worked for more than 20 hours a week were less likely to be breastfeeding at six months than mothers who had not returned to work. When women returned to work for less than 19 hours a week, there was no reported significant impact on breastfeeding at six months. This reinforced findings from an earlier Australian study that found women who returned to work before their baby was six months old were less likely to be breastfeeding at 12 months compared to women who returned to work between 6-12 months (Scott, Binns, Oddy, et al., 2006).

Similar results have been reported in international studies. A survey of mothers of two to four year olds in Turkey (n=196) found a shorter breastfeeding duration in working mothers compared with non-working mothers (Şencan, Tekin, & Tatli, 2013). Another study using data from a longitudinal cohort study from the United States found that women who did not return to work before their baby was six weeks old were more likely to initiate breastfeeding and to continue breastfeeding past six months than mothers who returned to work in this time period (Ogbuanu, Glover, Probst, Liu, & Hussey, 2011). It appears that early return to work can be a significant factor in both breastfeeding initiation and duration.

2.2.2.6 Use of pacifiers

The early introduction of pacifiers (dummies) can interfere with breastfeeding establishment (Ayton et al., 2015; Buccini, Pérez-Escamilla, Paulino, Araújo, & Venancio, 2016; Howard et al., 2003; Scott, Binns, Oddy, et al., 2006). Findings from an Australian cohort study found infants who were introduced to a pacifier at four weeks or younger were less likely to be receiving any breastmilk at all time points from seven days of age up to 12 months, and less likely to be exclusively breastfed after one month (Scott, Binns, Oddy, et al., 2006). Analysis of the 2010 Australian Infant Feeding Survey has reinforced the negative impact regular pacifier use can have on breastfeeding, finding that when pacifiers are used regularly there is a 37% increased risk of exclusive breastfeeding cessation in the first six months (Ayton et al., 2015).

The authors of a systematic review and meta-analysis of the use of pacifiers and interruption of exclusive breastfeeding identified 44 observational studies which reported an association between the use of pacifiers and increased risk of the interruption of exclusive breastfeeding (and two RCTs that did not) (Buccini et al., 2016). They concluded that mothers should be taught techniques that help them to not rely on pacifiers as a means of soothing their babies, as the use of them may lead to premature interruption of exclusive breastfeeding.

2.2.2.7 Biomedical factors

Biomedical factors such as mode of delivery, hospital practices and support from health professionals can impact breastfeeding. A prospective pregnancy cohort study from Canada found that planned caesarean sections were associated with early breastfeeding cessation (Hobbs, Mannion, McDonald, Brockway, & Tough, 2016). This finding is reinforced by data from the US Infant Feeding Practices Study 2 which also found women who had a planned caesarean were less likely to initiate breastfeeding or be exclusively breastfeeding at two months postpartum (Palla & Kitsanta, 2017). A birth cohort study with 1,035 mothers in Australia also found women who gave birth via caesarean were less likely to breastfeed than those who delivered vaginally (AOR=0.27, 95% CI 0.14-0.52) (Arora et al., 2017). The authors recommended that women who give birth via caesarean be targeted with increased breastfeeding support programs.

Breastfeeding support from health professionals at different time points in the perinatal period can have a significant positive impact on breastfeeding duration (Protheroe, Dyson, Renfrew, Bull, & Mulvihill, 2003; Sikorski, Renfrew, Pindoria, & Wade, 2003). In 1991 UNICEF and the WHO launched the Baby Friendly Hospital Initiative (BFHI) (World Health Organization, 2017b). The initiative is based around the promotion of 10 steps to creating a breastfeeding supportive environment. Hospitals and maternity centres can gain accreditation as a BFHI facility when they have implemented the 10 steps and do not accept free or low cost formula or teats. Since the initiatives launch, the BFHI has experienced high uptake with 86% of countries responding to a recent WHO review reporting implementation of the BFHI (World Health Organization, 2017b). More than 15,000 facilities across 134 countries have achieved BFHI accreditation and UNICEF reports improved breastfeeding in many of these areas (UNICEF, n.d). Working to create an optimal supportive environment for breastfeeding in hospital is important as women who experience breastfeeding difficulties in hospital are less likely to be breastfeeding at six months postpartum (Merewood et al., 2007). A systematic review of the impact of the BFHI on breastfeeding and child health outcomes found that adherence to the initiative has a positive impact on short-term and long-term breastfeeding outcomes (Pérez-Escamilla, Martinez, & Segura-Pérez, 2016).

Despite evidence about the importance of professional support, and the creation of supportive environments for breastfeeding mothers, studies have found a lack of uniformity in training and knowledge of policy and best practice of health care providers (Bleakney & McErlain, 1996). Health professionals have reported finding it difficult to strike a balance between encouragement and persuasion when talking to women about breastfeeding and in not wanting breastfeeding promotion to impact on the patient relationship by being perceived as pressure (Battersby, 2014; Marks & O'Connor, 2015; Tennant, Wallace, & Law, 2006). Health care professionals can find it difficult to access and keep up to date with new information and changing best practice guidelines (Marks & O'Connor, 2015; Tennant et al., 2006). Additionally, competing demands on a midwife's time can lead to a reduction in the time they are able to spend helping new mothers to establish breastfeeding (Battersby, 2014). Training health professionals as a stand-alone intervention however, was not found to be an effective strategy in the UK and including this training as part of a package of interventions, including the creation of supportive environments, can be more effective (Protheroe et al., 2003).

2.2.2.8 Family support and wider societal attitudes

As well as support from health care professionals, family support is also important for breastfeeding mothers, and particularly important is support from the father and the maternal grandmother (Susin, Giugliani, & Kummer, 2005). Support from the father is one of the most important factors influencing breastfeeding and many studies demonstrate that when fathers are supportive of their partner breastfeeding, mothers have better breastfeeding outcomes (Arora et al., 2017; Hunter, Cattelona, & Ann, 2014; Maycock et al., 2013; Scott, Binns, Graham, & Oddy, 2006; Şencan et al., 2013; Wolfberg et al., 2004). The support of fathers and the factors influencing paternal support is discussed in more detail in Section 2.3.

A systematic review of the influence grandmothers (i.e. an infant's grandmother) can have on breastfeeding rates examined 13 articles (Negin, Coffman, Vizintin, & Raynes-Greenow, 2016). The authors reported that when the grandmothers had breastfed themselves or were positive about breastfeeding, mothers were between 1.6 - 12.4 times more likely to breastfeed (Negin et al., 2016). If grandmothers are not supportive of breastfeeding it can impact negatively on a mother's likelihood of initiating breastfeeding (Kohlhuber, Rebhan, Schwegler, Koletzko, & Fromme, 2008).

There are several ways that wider societal attitudes and practices can impact breastfeeding. The marketing of infant formula, pressure to wean and a lack of previous exposure to breastfeeding women are all factors that can impact on a mother's decision to breastfeed (Dykes & Griffiths, 1998). More recent qualitative research with New Zealand mothers has found that women can experience a societal pressure to breastfeed, that may be difficult to navigate if they are not able to successfully breastfeed (McBride-Henry, 2010). Negative community attitudes towards breastfeeding in public was also a factor raised by women in this research (McBride-Henry, 2010), and fathers' attitudes to public breastfeeding is discussed further in Section 2.3.1.4.

2.2.2.9 Summary of influencing factors

The factors that impact on breastfeeding are broad and complex. The BFHI is a comprehensive program that supports hospitals and birth centres to provide supportive environments conducive to breastfeeding, yet there are many factors outside of this that are important. Demographic factors such as age, education and SES can have an impact on breastfeeding, and these factors are difficult to modify. Early return to work is an important factor and there needs to be continued promotion of the need for breastfeeding friendly workplaces and policies, and flexible working hours for breastfeeding women.

Education about breastfeeding and the health benefits still needs to be a key component of breastfeeding initiatives. This education needs to be especially targeted at younger disadvantaged parents who are most at risk of early breastfeeding cessation. Including fathers in any breastfeeding promotional and educational initiatives is vital. Family members are important in influencing, advocating for and supporting breastfeeding. Recognising the role that both parents play in breastfeeding and the importance of including and supporting mothers and fathers in antenatal and postnatal programs has potential to improve health outcomes for the whole family.

2.3 Section 2: Paternal role in breastfeeding

Fathers influence the decision for a mother to start breastfeeding, as well as how long she breastfeeds for, and there is a long history of studies from both Australia, and overseas that have confirmed the importance and influence of fathers on breastfeeding. In 1989, a study in Israel (n=1,000) investigating demographic factors influencing breastfeeding initiation found that a positive paternal attitude towards breastfeeding was the major determinant for breastfeeding initiation (Birenbaum, Fuchs, & Reichman, 1989). In 1994, a study in the United States found that the father's opinion about breastfeeding was the most important factor influencing a mother's decision to breastfeed and called for a re-evaluation of antenatal care with a focus on including fathers in breastfeeding education programs (Giugliani, Caiaffa, Vogelhut, Witter, & Perman, 1994). In 2004, Rempel & Rempel published a Canadian study that included 317 first time mothers and found that the attitudes of the father predicted breastfeeding behaviour to a greater extent even than the mother's intentions (Rempel & Rempel, 2004). In contrast, in 2004 a study of pregnant women in Glasgow, Scotland (n=108) found maternal attitudes, and not paternal attitudes, positively influenced breastfeeding at discharge from hospital (Scott, Shaker, & Reid, 2004). In this study the authors found a strong correlation between maternal and paternal attitudes towards breastfeeding and suggested that paternal attitudes may be a proxy for maternal attitudes only in the absence of information about maternal attitude.

In Australia, there is compelling empirical evidence, reinforced over time, about the importance of fathers. In 1997, results from the Perth Infant Feeding Study (n=556) found that women who perceived their partners preferred them to breastfeed were 10 times more likely to initiate breastfeeding (Scott, Binns, & Aroni, 1997). Subsequent data from the second Perth Infant Feeding Study found that when women perceived their partner to be supportive of breastfeeding, they were more likely to initiate breastfeeding and be breastfeeding on discharge from hospital (Scott, Binns, Graham, et al., 2006). The authors also found 59% of women who perceived their partner to be supportive of them breastfeeding were still breastfeeding at six months compared with 30% of women who did not perceive such support (Scott, Binns, Oddy, et al., 2006). These findings reinforce earlier research from the same authors that similarly found perceived social support for breastfeeding from the baby's father was positively associated with breastfeeding duration (Scott et al., 2001).

Paternal preference for breastfeeding was identified as one of the three key factors influencing the duration of exclusive breastfeeding in the 2010 Australian Infant Feeding Survey (Ayton et al., 2015). The paper identified that amongst women who initiated breastfeeding, women were at an 86% higher risk of discontinuing exclusive breastfeeding if their partners preferred bottle-feeding. The authors surmise that engaging and supporting fathers is essential in seeking to increase exclusive breastfeeding duration. A recently published birth cohort study from New South Wales (n=1,035) found that when their partner preferred breastfeeding mothers were significantly more likely to breastfeed (AOR=11.77, 95%CI 1.31-5.97) (Arora et al., 2017).

With such compelling evidence of the influence fathers have on breastfeeding, including them in antenatal and postnatal education and support services is vital. A 2017 literature review examined paternal breastfeeding attitudes and fathers' support of their partners (Al Namir, Brady, & Gallagher, 2017). The review of 48 papers found that including fathers in breastfeeding preparation and education is important and will impact on breastfeeding duration. The authors also found that excluding fathers from breastfeeding education may result in decreased self-efficacy and decreased quality of life. Despite these findings, there is evidence that fathers are not routinely included in breastfeeding education programs or can feel excluded from the support provided by health professionals. There is a range of other factors that can also impact on a father's support for his breastfeeding partner, which are discussed in the next section.

2.3.1 Fathers as a conduit: Factors effecting paternal support

While it is widely acknowledged that the inclusion of fathers in parenting programs is ideal, a systematic review published in 2014 found that fathers are often excluded from such programs, and evidence from programs that have included fathers is typically of a low quality (Panter-Brick et al., 2014). The support of fathers is an important factor influencing a woman's decision to initiate breastfeeding, and the duration of time she breastfeeds for (Kong & Lee, 2004; Scott et al., 1997; Scott, Binns, Graham, et al., 2006; Şencan et al., 2013; Wolfberg et al., 2004). While fathers typically indicate they are supportive of breastfeeding, the literature highlights several factors that can impact their level of support (Brown & Davies, 2014; Sherriff et al., 2009; Tohotoa et al., 2011; Tohotoa et al., 2009). These factors can be categorised into the following themes: social support, knowledge, empowerment and specific barriers.

2.3.1.1 Social support

A lack of social support being available for fathers during the antenatal and postnatal period is a commonly expressed concern by fathers (Halle et al., 2008; Tohotoa et al., 2009). The Fathers Infant Feeding initiative (FIFI) study found that fathers often felt left out of antenatal education that was focussed primarily on the mother, and that they lacked opportunities to learn and share information that would have been useful for them (Tohotoa et al., 2009). With the exception of the FIFI, the few programs that have specifically targeted fathers of breastfed babies have mostly done so in the antenatal period, through an antenatal class or a specific education session. This is despite the need for broader social support in the postnatal period being commonly identified by fathers themselves (Brown & Davies, 2014; Halle et al., 2008; Mitchell-Box & Braun, 2012; Tohotoa et al., 2011; Tohotoa et al., 2009).

Qualitative research offers insight into the needs of fathers, and the expressed desire for peer support and educational opportunities. Brown & Davies (2014) completed a qualitative descriptive analysis on the open-ended survey questions administered to 117 fathers about their breastfeeding experiences. Four key themes were identified including: attitude towards breastfeeding; experience of breastfeeding; experience of education and promotion; and future support. One of the central themes was how fathers expressed a lack of opportunities to mix with other fathers and experience peer support.

Not many of my friends had babies and they tended to bottle-feed. I wanted to know how other dads felt and whether they felt excluded or fed up (Brown & Davies, 2014, p. 520).

The information was all aimed at my wife. What she could eat, do, experience etc. I know she was the key player here but I felt that it was nothing to do with me (Brown & Davies, 2014, p. 519).

A qualitative study involving a series of focus groups sought to better understand paternal support and breastfeeding. The study found that fathers were influential and their support made a difference to mothers, and identified that fathers wanted more opportunities to learn and share in the perinatal period (Tohotoa et al., 2009).

[It would have been useful to have...]A no bullshit idea of what to expect and how to help even if that means doing nothing but being there with her and the baby (Tohotoa et al., 2009, p. 6).

That research led to the development of male-facilitated antenatal classes in which fathers described their appreciation for the opportunity to participate in a peer-led session.

[Men talked about] being informed by a father and sharing with other men [as the most important part of the program]. (Tohotoa et al., 2011, p. 356).

The concept of father-focussed peer-led education in the perinatal period has been a common suggestion from studies focussing on fathers (Brown & Davies, 2014; Mitchell-Box & Braun, 2012). Fathers have reported feeling more comfortable engaging in discussion in male only antenatal classes (Schmied, Myors, Wills, & Cooke, 2002). When gender-specific discussions were included in antenatal classes for both mums and dads, both parents rated them highly, and experienced benefits, especially in relation to discussions about relationship issues (Schmied et al., 2002). Others who have participated in father-focussed antenatal education have rated the peer-led component as being the most important aspect of the class and reported that the male-only environment led to men feeling more relaxed and helped to normalise concerns (Tohotoa et al., 2011).

The lack of social support available for fathers in the perinatal period can have a significant impact on fathers and mothers. A lack of available support may lead to fathers struggling to develop a secure attachment to their infant (Halle et al., 2008). Encouraging situations where men can learn appropriate, sensitive fathering from other fathers may help (Halle et al., 2008). Focusing on fathers' needs in the perinatal period can reduce paternal stress (Tohotoa et al., 2011). With evidence showing the importance of the father for the breastfeeding mother, supporting the father needs to be considered a family imperative.

2.3.1.2 Knowledge

Many studies report that fathers can feel unprepared for breastfeeding and that they lack relevant information (Brown & Davies, 2014; Cohen, Lange, & Slusser, 2002; Mitchell-Box & Braun, 2012; Rempel & Rempel, 2011; Sherriff et al., 2009; Tohotoa et al., 2011).

Breastfeeding information in antenatal classes can be deemed maternally biased which can reinforce the feeling of the information not being relevant for fathers (Tohotoa et al., 2011).

A number of studies have reported on the broad range of information fathers want which includes:

- Practical suggestions on how they can help their partners (Cohen et al., 2002; Mitchell-Box & Braun, 2012; Rempel & Rempel, 2011; Tohotoa et al., 2009)
- Specific information about breastfeeding including health benefits (Cohen et al., 2002; Mitchell-Box & Braun, 2012; Rempel & Rempel, 2011; Tohotoa et al., 2011; Tohotoa et al., 2009)
- Post-natal depression (Tohotoa et al., 2011; Tohotoa et al., 2009)
- Managing expectations about issues such as sex, relationship changes and sleep (Hearn, Miller, & Fletcher, 2013; Mitchell-Box & Braun, 2012; Tohotoa et al., 2009)

Structuring information for fathers should focus on emphasising the importance of the male role in supporting breastfeeding and providing practical suggestions and examples (Cohen et al., 2002). Using strategies such as visual cues (for example comparing a baby's stomach size to a walnut), cost comparisons of breastfeeding and formula feeding and specific strategies to reduce discomfort with public breastfeeding are all examples of how information can be better targeted to include fathers (Brown & Davies, 2014; Cohen et al., 2002; Tohotoa et al., 2011).

Breastfeeding does not happen in a vacuum and there are a range of factors that can impact on parents. Providing a broad range of information, such as those outlined above by fathers, will help provide support over several key areas, which may help support breastfeeding.

2.3.1.3 Empowerment

Fathers report antenatal information and classes are not always tailored to include them, or to appreciate the role fathers play in childbirth, breastfeeding and early parenting (Brown & Davies, 2014; Sherriff et al., 2009; Tohotoa et al., 2011). Brown & Davies (2014) found that the fathers they spoke with appreciated the importance of breastfeeding and wanted to help and to support their partner, yet many reported feeling excluded from antenatal breastfeeding education and that they were considered unimportant in post-natal support.

I wanted information on how to help my partner. There was nothing on that (Brown & Davies, 2014, p. 518).

Tohotoa et al. (2009) found fathers reported feeling ill-informed and unempowered, even after attending antenatal classes. Having practical ideas to support their partners would have helped fathers to feel more involved.

You want similar information that mothers are given in mother's group on how to feed, nurture, and bond. Antenatal classes give the impression that fathers have nothing to do with their child (Tohotoa et al., 2009, p. 6).

How to support your partner, things you can do to be involved. How to comfort your partner, the kind words you can say to support her. Hints on helping and understanding new mothers. Some advice on caring for the new baby (Tohotoa et al., 2009, p. 6).

Other research has called for initiatives to empower men to be more engaged with breastfeeding (Halle et al., 2008; Mitchell-Box & Braun, 2012). Assisting fathers to develop effective communication strategies and supporting them to share their feelings can have a positive impact on the family (Halle et al., 2008). Given the influence fathers have on a woman's decision to initiate and continue breastfeeding, empowerment of fathers in this period of change is an important consideration for health professionals and researchers planning interventions.

2.3.1.4 Specific barriers

The literature highlights specific barriers that can impact paternal support for breastfeeding. These include public breastfeeding, bonding postponement and feeling left out of the relationship (with their partner, with their baby, and within their new family).

Public breastfeeding

One study examining infant feeding attitudes of parents found that fathers are more likely to disapprove of women breastfeeding in public than mothers (Shaker, Scott, & Reid, 2004). While many fathers state they are comfortable with their partner breastfeeding in public, some fathers report feeling uncomfortable with it. Research differs in the prevalence of feelings of unease with public breastfeeding. Analysis of the Texas sample of the Behaviour Risk Factor Surveillance System (n=2,145) found 21% of men agreed or strongly agreed that they were embarrassed by a woman breastfeeding in front of them, and 11% of participants agreed or strongly agreed that a mother should only breastfeed in their own home (Vaaler et al., 2011). A subsample of this study found that fathers who had more positive attitudes about breastfeeding (including in relation to public breastfeeding), were more likely to have children who were breastfed.

A small qualitative study with men in Hawaii found that 10 of the 14 interviewed felt public breastfeeding was inappropriate and expressed feelings of discomfort with it (Mitchell-Box & Braun, 2012). Five of these fathers supported public breastfeeding if mothers covered up, but five others said they should be out of sight. Another US based study (n=502) aiming to evaluate men's perceptions of public breastfeeding through imagery showed that men were more favourable to images depicting mothers breastfeeding in a private setting, as opposed to breastfeeding in public (Magnusson et al., 2017).

A qualitative study from the UK reported that many fathers said they felt embarrassed with their partner feeding in front of people initially, although most also reported that the feeling dissipated over time (Brown & Davies, 2014).

At first I freaked out about her feeding in front of people. I couldn't stop thinking that she had her breast out in front of my father or my friends and that they were getting an eyeful. Thankfully I grew up though and realized you couldn't really see anything and it was better than the screaming! (Brown & Davies, 2014, p. 517).

While most men report being supportive of women breastfeeding in public, it remains a significant concern for some fathers. Initiatives should focus on changing attitudes to increase fathers' comfort with public breastfeeding and offering specific strategies for fathers to be involved in breastfeeding (Mitchell-Box & Braun, 2012). Facilitating opportunities where fathers can learn from other fathers about how they have overcome feelings of embarrassment can be a useful strategy (Brown & Davies, 2014).

Bonding postponement and feeling left out

A significant amount of a newborn baby's awake time can be spent breastfeeding. Studies have found that this time spent exclusively with the mother can lead to fathers feeling left out, feeling unable to support their partner and can be a barrier to them bonding with their baby (Brown & Davies, 2014; Gamble & Morse, 1993; Jordan & Wall, 1990; Mitchell-Box & Braun, 2012; Rempel & Rempel, 2011; Sherriff et al., 2009). Fathers can feel hurt by the close mother-infant bond and helpless in caring for their child as they are unable to meet their most basic need themselves (Gamble & Morse, 1993; Jordan & Wall, 1990; Nyström & Öhring, 2004). This can lead to a desire to introduce bottles and infant formula to enable fathers to participate in the feeding process and to bond with their baby through feeding, as well as providing help to their partner (Brown & Davies, 2014; Sherriff et al., 2009). Introducing bottles in the early weeks before breastfeeding has been successfully established can be detrimental (Howard et al., 2003). Qualitative research with fathers offers insight into how some fathers see infant feeding as an important practice for them to participate in.

I wanted to feed him so thought we would bottle feed. I was sad at the thought that I couldn't join in (Brown & Davies, 2014, p. 516).

I asked the midwife what I could do to help my wife. She said cook her dinner, bath the baby and so on. I understood that but I wanted to help and join in with the feeding experience and I couldn't. I was annoyed (Brown & Davies, 2014, p. 516).

Over a third of fathers interviewed in a study by Halle et al. (2008) felt that their partners no longer gave them attention after the birth of the baby. Qualitative interviews with 56 new and expecting fathers indicated that fathers have concerns about breastfeeding including that it will lead to a lack of opportunity to bond with their baby and a feeling of separation from their baby by their partner (Jordan & Wall, 1990).

When you are breastfeeding that creates certain problems with both parents parenting... I'm trying to do a bottle every night. I feel like I'm missing out a little bit on the bonding that is going on because we [father and baby] can't do that (Jordan & Wall, 1990, p. 211).

Another qualitative study in the UK found that while some fathers reported feeling that using formula would help them be more involved and bond with their baby, others had identified their own solutions (Sherriff et al., 2009).

Do I feel alienated or excluded? No I don't, absolutely not... I get bonding times in other ways like to calm him, soothe him and play with him, that's my bit (Sherriff et al., 2009, p. 226).

The FIFI study identified 'wanting to be involved' as a major emergent theme and that fathers can feel like they lack the relevant skills and information to fulfil this role effectively (Tohotoa et al., 2009). The issue of perceived bonding postponement should be an important consideration in planning breastfeeding interventions. Fathers should be encouraged to consider other ways of bonding with their child that do not involve feeding, have access to appropriate information and practical solutions to help them develop skills, support their partner, and grow into their new role.

2.3.2 Types of paternal support

With recognition of the importance of fathers, and the factors that can impact their support, understanding how different types of support functions is also important. Social support has been defined as '*an exchange of resources between two individuals perceived by the provider or the recipient to be intended to enhance the wellbeing of the recipient*' (Shumaker & Brownell, 1984, p. 11). Social support has been categorised into four different ways of exhibiting supportive behaviours (Glanz, Rimer, & Viswanath, 2008).

These are:

- Emotional support (expressions of empathy, love, trust and caring)
- Instrumental support (tangible aid and services)
- Informational support (advice, suggestions and information)
- Appraisal support (information that is useful for self-evaluation)

In adapting and applying these types of social support to breastfeeding, Emmott & Mace describe emotional and information support as focussing on the '*transfer and maintenance of pro- breastfeeding attitudes, such as supporting the idea to breastfeed and boosting maternal confidence to do so*' and instrumental and practical support such as '*helping behaviour and financial transfers*' (Emmott & Mace, 2015, p. 3).

In 2015, the authors examined the impact different types of social support received from fathers had on breastfeeding in the UK millennium cohort study (Emmott & Mace, 2015). Their findings suggested that 'practical' support from fathers (defined as supportive behaviours including active assistance and financial support), may be associated with a shorter breastfeeding duration. The authors speculated that practical support can discourage breastfeeding if this support extends to shared caregiving whereby formula feeding becomes a more convenient and viable option which can be shared by both parents.

Rempel, Remple & Moore (2016) published a paper reporting on types of paternal support and the impact on breastfeeding. Their findings reinforced those from the UK millennium cohort study. They found when fathers claimed higher levels of appreciation and presence, women breastfed for shorter durations. The authors stated that it is possible helpful behaviours increased with breastfeeding difficulties which may explain the correlation. Other studies have also found that the more involved fathers are in child care, the less likely women are to breastfeed (Ito, Fujiwara, & Barr, 2013). Encouraging parents to work together as a team is likely to result in the most appropriate support, and the best breastfeeding outcomes (Rempel et al., 2016).

2.3.3 Father-focussed interventions

There is clear evidence that paternal support is important, and it is a key modifiable factor in breastfeeding. A number of studies have sought to quantify the impact that father-focussed interventions in the perinatal period can have on breastfeeding outcomes and paternal attitudes, most of them delivering interventions solely in the antenatal period.

A quasi-experimental study in Vietnam aimed to measure the impact of a breastfeeding intervention targeting fathers on attitudinal change (Bich & Cuong, 2016). Fathers in the intervention group received information through a range of means including home visits, community events and mass media. Knowledge and attitude changes were measured using a pre-and post-test design. The study found that post-test, fathers in the intervention group had a significantly higher knowledge score ($p < 0.001$) and a significantly higher attitude score (reflecting more favourable breastfeeding attitudes) ($P < 0.001$). This study did not report breastfeeding outcomes.

There are several studies that have targeted fathers as part of a perinatal education initiative, and have included breastfeeding outcomes as an evaluation measure. The ones that have, provide compelling evidence of the impact father-focussed interventions can have on breastfeeding.

An Italian study (n=280) in which fathers in the intervention group received a breastfeeding training session, reported a 10% difference ($p < 0.05$) in breastfeeding at six months, 25% in the intervention group compared with 15% in the control group (Pisacane, Continisio, Aldinucci, D'Amora, & Continisio, 2005). Another study from the US that included a special peer-led antenatal class for fathers reported similarly positive results (Wolfberg et al., 2004). Women whose partners had been in the intervention group were more likely to initiate breastfeeding (74%) compared with the control group (41%) ($p = 0.02$), but there was no statistically significant difference in breastfeeding duration from four weeks of age (Wolfberg et al., 2004).

A more recent quasi-experimental trial in China evaluated the effectiveness of an antenatal session that delivered targeted breastfeeding information to fathers (Su & Ouyang, 2016). This study found that fathers in the intervention group provided more support to their partners. Rates of exclusive breastfeeding at six months were significantly higher ($p = 0.041$) in the intervention group (40%) than in the control group (17.6%) (Su & Ouyang, 2016). A Brazilian trial (n=596 families) also investigated the impact of father-focused antenatal education on exclusive breastfeeding (Susin & Giugliani, 2008). This study found fathers' inclusion in the intervention significantly increased exclusive breastfeeding duration; 16.5% at four months in the intervention group compared with 5.7% in the control group ($p = 0.003$) although inclusion did not impact on rates of any breastfeeding.

However, another US based study did not find a significantly positive result (Lovera, Sanderson, Bogle, & Vela Acosta, 2010). The Peer Dad study evaluated a breastfeeding peer-support program for Hispanic fathers (n=101). Peer-dads acted as roles models for new and expecting fathers and facilitated counselling and classes. The study used an unconditional logistic regression to estimate breastfeeding likelihood past six months and found no significant difference in breastfeeding between groups (OR 1.44, 95% CI 0.82-2.54). The authors did not report on breastfeeding at other time points and noted several limitations with the study, including a low statistical power.

The evidence supporting the importance of father-focused education is compelling. The State of the World's Fathers report was commissioned by MenCare, a global campaign promoting partner involvement as equal caregivers (Heilman B, Levtov R, van der Gaag N, Hassink A, & Barker G, 2017). One of the four priority areas for action in the 2017 report is advocating for policy change in father-inclusive parenting training. The reports states that father-inclusive parenting classes should be available to all new fathers, with a focus on young fathers to help shape early attitudes about parenting.

2.3.3.1 Fathers Infant Feeding Initiative

The Fathers Infant Feeding initiative (FIFI) was a Healthway funded RCT conducted in Perth, Western Australia by members of the same team involved in the PIFI study described in this thesis (Maycock et al., 2013). The FIFI study sought to establish the effect an antenatal education session and a postnatal support intervention targeted to fathers had on breastfeeding duration. A total of 699 couples were recruited from antenatal classes being held in public maternity hospitals in Perth, Western Australia over a 13-month period from May 2008 - June 2009.

Fathers were randomly assigned to either a control or intervention group. Those assigned to the intervention group received a two-hour, male facilitated antenatal class which was followed up by a schedule of supportive information mailed out each week for the first six weeks postpartum. The antenatal sessions had a focus on breastfeeding and planning realistically for problems in the early days, as well as infant developmental milestones and other topics including postnatal depression (Tohotoa et al., 2011).

The FIFI reported on breastfeeding rates at six weeks post birth and found a statistically significant difference in the rates of any breastfeeding and full formula feeding between the intervention and control groups (Maycock et al., 2013). At six weeks of age, 81.6% of infants in the intervention group compared to 75.2% (OR 1.46, 95% CI, 1.01-2.13) in the control group were receiving some breastmilk. After controlling for paternal age and SES, infants in the control group were statistically significantly more likely to be fully formula fed at six weeks of age (18.4% intervention group, 24.9% control group P=0.047). The study reported no difference in exclusive breastfeeding.

The results of this study indicated that targeting fathers with information and support can be an effective approach for increasing breastfeeding duration. Fathers participating in the study identified barriers to support services such as accessibility and flexibility (particularly the need to balance work commitments) and the use of information technology to overcome these barriers was one recommendation (Tohotoa et al., 2011; Tohotoa et al., 2009). The authors recommended separating the two interventions so the relative impact of the antenatal class and the follow-up support package could be determined both separately and together, and to extend the study to six months. The PIFI study directly builds on the results of the FIFI and the recommendations made regarding further research.

2.3.4 Conclusion

There are many factors that impact breastfeeding, and research suggests that the role of fathers is a particularly important factor. There is evidence that targeting interventions at fathers can impact breastfeeding duration. This section has highlighted several key areas that can influence the support fathers offer to their breastfeeding partners and these areas offer opportunity in terms of reaching fathers to impact breastfeeding. Initiatives designed to increase breastfeeding duration should consider the factors that influence paternal support and be inclusive of mothers and fathers. Designing interventions with a broad focus on information and support that extends beyond breastfeeding and into other areas of early parenting, and encouraging communication between couples, may be an effective way to reach new and expecting parents and impact on breastfeeding duration.

2.4 Section 3: Mobile technology and health promotion

2.4.1 Introduction

Mobile health, or mHealth, is one of a number of terms that have evolved over the past two decades since the first smartphones began appearing around the early to mid-nineties (The Telegraph, 2017). Words such as eHealth, mHealth, telehealth and mobile technology are now common and are often used in overlapping ways. Digital health (used as an umbrella term to cover mHealth, wearables, and telehealth) (US Food and Drug Administration, 2017) and eHealth (the use of information technology for a health resource) (World Health Organization, 2017a) are broad terms that are often used interchangeably. Telehealth involves the use of information technology to deliver health services over a distance (Department of Health, 2015), with video conferencing being perhaps the most common application. mHealth refers to the use of mobile technology in health and medical interventions (Rouse, 2011). The WHO has defined mHealth as: *medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices* (World Health Organization, 2011b).

mHealth initiatives involve the use of mobile devices, including inbuilt sensors, Short Message Service (SMS), Global Positioning System (GPS) and Bluetooth to deliver health interventions and information. Interventions that use mobile apps or the web to deliver initiatives that aim to change health behaviour have been referred to as Digital Behaviour Change Interventions (DBCI) (Perski, Blandford, West, & Michie, 2016). These can include interventions that target behaviours such as, smoking cessation, physical activity or healthy eating.

The penetration of mobile devices both in Australia and internationally has increased exponentially. In 2016 Deloitte estimated that approximately 84% of Australian adults owned a smartphone which represents a nearing of peak market saturation (Deloitte, 2016). In 2015, 59% of Australian households had a mobile tablet (Deloitte., 2015). In addition, multiple device ownership increased, with six out of 10 Australians owning multiple devices in 2015, compared to 44% in 2014 (Deloitte., 2015).

In 2016 the Australian smartphone market was dominated by two major players, Apple (43%) and Samsung (33%) (Deloitte, 2016). Apple mobile devices use iOS, Apple's proprietary mobile operating system. Samsung, Sony, Motorola, HTC and a number of smaller manufacturers market devices using Android, an open source mobile operating system developed and maintained by Google. iOS and Android are by far the most popular operating systems in Australia. In October 2017, the iOS market share in Australia was 56.11%, and Android was 41.91% (StatCounter Global Stats, 2017). Less than 2% of smartphones in Australia use an operating system other than Android or iOS.

In October 2016, there were an estimated 231,000 mobile health and fitness apps in the two major app stores (Google Play, and the Apple App Store), published by an estimated 58,000 app developers (Research2guidance, 2016). Approximately 75% of apps available on the app stores are made available for both the Android and iOS operating systems (Research2guidance, 2016).

Individuals' use of their smartphone is increasingly intimate and constant. Approximately 81% of Australians check their phone within an hour of waking, with over 50% doing so within 15 minutes (Deloitte., 2015). One UK study found that people were using their smartphones an average of 3hrs and 16 mins each day to complete an average of 221 tasks (Tecmark, 2014). Australians now access the internet more from smartphones than they do from personal computers (Nielsen, 2015). A recent survey of Australian smartphone users (n=14,000) conducted by the Australian Broadcasting Corporation and researchers from Monash and Griffith universities found that 40% of respondents used their mobile for a minimum of three hours each day and an additional 47% used it for between one and two hours a day (Andrews, 2017). The authors noted that this figure is likely to be an underestimate. This change in how people access information, as well as how they engage with technology and with other people has implications for what people expect from information communication. The field is becoming increasingly sophisticated and specialised as consumer expectations mature (Yardley et al., 2016).

The constant connection to devices creates opportunity for the delivery of Ecological Momentary Interventions (EMI), and Ecological Momentary Assessments (EMA). An EMA involves collecting 'in the moment' data from participants (Shiffman, Stone, & Hufford, 2008) and can be an effective way of reducing recall bias and ensuring compliance (Wen, Schneider, Stone, & Spruijt-Metz, 2017). Mobile-based EMAs have been conducted with alcohol (C. J. C. Wright et al., 2017; C. Yang et al., 2015), weight loss (Burke et al., 2017) and breastfeeding assessments (Demirci & Bogen, 2017). An EMI is an intervention that occurs as people participate in their daily life and in their own environment (Heron & Smyth, 2010). Mobile-based EMIs have been developed for a wide range of interventions and a 2010 review of 27 interventions, including physical activity, alcohol use and smoking cessation interventions, found that these offer specific benefits including the ability to tailor the intervention to the user's individual requirements (Heron & Smyth, 2010).

The changes in user behaviour, along with the sophistication of mobile devices provides opportunities for health promotion professionals to use mobile technology for health benefit. Yet with this opportunity comes a number of associated challenges that are explored in this section (Becker et al., 2014; B. K. White, Burns, Giglia, & Scott, 2016).

2.4.2 Evidence in health promotion initiatives

Mobile technology offers health promotion professionals an opportunity to reach individuals with interventions and health information (Crane, Garnett, Brown, West, & Michie, 2017). Mobile apps provide the opportunity to tailor and personalise information and strategies which, along with the wide potential reach of smartphone based interventions, makes this an attractive option in aiming to develop health interventions. This tailoring and personalisation of information and interventions is where mobile technology can offer unique benefits (Holmen, Wahl, Cvancarova Småstuen, & Ribu, 2017). A smoking cessation app for pregnant women, for example could ask a user to input their name and due date of their child to enable specific, personalised motivational messages (Australian Government, 2013). A physical activity intervention can incorporate gamification elements to utilise social connectivity and rewards to motivate users (Hamari & Koivisto, 2015).

There has been excitement and enthusiasm about the potential for mobile initiatives to help public health practitioners better reach people and improve health (Becker et al., 2014; Klasnja & Pratt, 2012). However, robust evidence of their impact on health behaviour change, although growing, remains limited (Zhao, Freeman, & Li, 2016). Health professionals have reported seeing the potential mobile apps have for their practice, yet want more information on credibility and the evidence base (Chen, Lieffers, Bauman, Hanning, & Allman-Farinelli, 2017). In addition, they value health professional involvement in the development of apps. To quote Professor Michie and colleagues in their 2017 paper discussing results from an intervention workshop on digital interventions, *'we are still mainly in the age of promise rather than delivery'* (Michie, Yardley, West, Patrick, & Greaves, 2017, p. 1).

There is a paradox in the literature in the call for there to be more evidence about the efficacy of mHealth interventions from adequately powered RCTs (Baskerville et al., 2015; Free et al., 2013; O'Neil A. et al., 2017; Zhao et al., 2016), and the challenges associated with running app-based studies over the longer time periods typically needed for an RCT (Mohr et al., 2015; O'Neil A. et al., 2017). The extended periods of time often required for recruitment and delivery of an adequately powered RCT can be at odds with the speed of technological change, and this can lead to the study results being outdated, even before they are published (Mohr et al., 2015). A review of evaluation methodologies (registered on ClinicalTrials.gov) used in mHealth interventions found that despite the acknowledgement of the need for more innovation methods of evaluation, ways of evaluating mHealth interventions have not deviated far from traditional methods (Pham, Wiljer, & Cafazzo, 2016).

There are also considerations and challenges associated with digital inclusion. While mobile ownership is wide-spread in Australia, there are pockets of the population that experience lower levels of digital inclusion (Thomas et al., 2017). The digital inclusion index is calculated across three areas: access, affordability and digital ability. The 2017 report states that the gap between digitally included and excluded Australians is growing, particularly between high and low SES households and older and younger Australians (Thomas et al., 2017). Aboriginal and Torres Strait Islander Australians also have a lower inclusion score than the general population, however this score had increased over the previous four years. There is also substantial difference in inclusion scores for individuals living in some rural and regional areas (Thomas et al., 2017).

While the number of published studies in the literature is increasing, they range widely in terms of study quality, sample size, research rigour and area of health focus. A systematic review from 2013 aimed to review the current literature on online prevention initiatives targeting healthy lifestyle behaviours, and to identify research gaps (Kohl, Crutzen, & de Vries, 2013). The authors found that evaluations needed to be outcome focussed, more priority needed to be placed on working with diverse groups and more research is needed to examine what works with online interventions. Research in this field moves quickly and a 2016 review of the effectiveness of mobile phone apps to influence behaviour change identified 23 publications meeting their inclusion criteria, which included 11 different health areas (Zhao et al., 2016). The authors found 17 of these studies reported statistically significant positive effects on the respective health behaviours. Over 50% of these studies had a sample size of fewer than 60 participants per group. There is clearly a need for more research involving larger sample sizes, diverse populations and evaluation of health outcomes. Evidence about the efficacy of mobile health interventions targeting different health areas is discussed briefly below.

2.4.2.1 Physical activity and healthy eating

There are more apps available to consumers about physical activity and healthy eating than there are about any other health issue (Sama, Eapen, Weinfurt, Shah, & Schulman, 2014). Correspondingly, there is a substantial amount of research into their effectiveness. A 2017 systematic review and meta-analysis looked at the effectiveness of mHealth technologies on sedentary behaviour and physical activity (Direito, Carraça, Rawstorn, Whittaker, & Maddison, 2017). The review included 21 RCTs (total participants = 1,701) and the authors found an overall small to modest impact on decreasing sedentary behaviour and physical activity.

Another systematic review of app based interventions that targeted these two health behaviours was published in 2016, and included 27 studies in the final review (Schoeppe et al., 2016). Nineteen of these studies were RCTs, and most targeted adults. The review showed modest evidence of the efficacy of app-based interventions to impact on diet, physical activity and sedentary lifestyles. Multicomponent interventions (where an app was used in combination with other strategies, such as with the provision of physical activity equipment) appeared to have the most effect. In terms of intervention design, those studies that included goal-setting, self-monitoring and performance feedback in the app design showed significant improvements in health outcomes and behavioural outcomes. Of the 23 studies targeting adults, 11 demonstrated significant differences between-groups in diet, physical activity and weight. Seven of the studies reported significant positive changes in diet, physical activity, weight and sedentary behaviour within-group (Schoeppe et al., 2016). Interestingly, while engagement is known to be an important component of app usage, only three of the 11 studies that reported app usage statistics described an association between app usage and the associated outcomes. All three demonstrated that higher app usage was associated with better health outcomes in terms of physical activity and healthy eating. All but one of the published studies were from wealthy western countries (Schoeppe et al., 2016).

A recent review examined the efficacy of social media and interventions that utilised gaming strategies for nutrition programs with young adults (Nour, Yeung, Partridge, & Allman-Farinelli, 2017). The review included 11 social media based programs and six game-based interventions. The authors found that social media seemed to be more effective when used as part of a broader program, and that while some game-based interventions reported positive knowledge change outcomes, more research is needed to understand the impact on behaviour change. Another recent review reported similar findings when looking at the use of apps for nutrition interventions, reporting that multicomponent interventions appeared to have the most promise but that more research is needed in this area (Allman-Farinelli & Gemming, 2017).

Analysis of the US based National Cancer Institute's 2015 Health information National Trends Survey involved 3,677 adults and showed that health apps may be more likely to be used by people who are younger, have a higher income and education and enjoy excellent health (Carroll et al., 2017). Of the 2,392 study participants who owned a smartphone, 816 participants (34%) had at least one health app on their device. Over half of these participants (n=472, 58%) said these apps had helped them achieve a positive lifestyle change. Those aged 18-44 years were more likely to use a health app than those aged over 45 years ($p < 0.001$).

The survey results found that although there was no association between increased fruit and vegetable consumption for participants who used a health app, users were more likely to exercise for more than two hours each week (Carroll et al., 2017). They also showed individuals who used health apps were significantly more likely to report intention to improve physical activity, healthy eating and to increase weight loss. There was no information available in this paper about the types or numbers of health apps used and the duration of time they were used for.

A study of 500 young Norwegian app users aged between 18-35 years (mean 25.8 years std. dev. 5.1) of healthy eating and physical activity apps found app usage to be associated with a number of self-reported healthier behaviours (Q. Wang, Egeland, Amdam, Almlie, & Oostindjer, 2016). These included dietary behaviours such as lower fat diets, decreased consumption of sugar-sweetened beverages, and positive physical activity behaviour changes including joining a gym, entering physical activity competitions with friends and family and searching for physical activity information.

This study also found that participants who used physical activity and nutrition apps felt that they were effective in helping to facilitate their healthier behaviours (Q. Wang et al., 2016). Participants who reported using nutrition apps for more than a month were more likely to perceive that the apps were effective in helping them to increase fruit and vegetable consumption ($p = 0.01$), and those who had increased app usage were more likely to report that the apps were helping them to increase low fat dairy consumption than those with decreased app use ($P < 0.001$).

A recent study aimed to examine the efficacy of a multifaceted mHealth intervention to impact on healthy eating and physical activity in pregnant women (n=91) (Willcox et al., 2017). The intervention involved tailored text messages being sent to participants four to five times a week, a study website and social interaction facilitated through Facebook. Women in the intervention group had access to the study materials from recruitment until 36 weeks gestation. The study found that women in the intervention group had a significantly lower gestational weight gain than those in the control group (avg. 7.8kg in intervention group, avg. 9.7kg in control group p=0.041).

The connecting health and technology (CHAT) study was a three-armed RCT that aimed to evaluate the impact that sending a weekly text message and providing tailored feedback on diet had on the fruit and vegetable consumption of young adults (aged 18-30 years) in Australia (Kerr et al., 2016). A mobile food diary (the mobile food record app) was used to assess dietary intake. One group received feedback on their diet as well as weekly supportive text messages (n=82); one group received the feedback only (n=83), and the third group acted as a control group (n=82). The trial ran for six months. There was no reported difference in food group serving but there were some other interesting outcomes. Although it was not a specified aim of the study, participants in the dietary feedback group who were in the overweight BMI category at baseline did lose weight, an average of 1.75kg during the study (p=0.01. 95%CI [-3.1 to -0.4]). There was a reduction in the consumption of energy-dense nutrient-poor foods in both the intervention groups (p=<0.001. 95% CI [-0.8 to 0.2]) compared with the control group (Kerr et al., 2016).

Another weight management intervention tested the effect of intervention delivery via an app (My Meal Mate), website, or a paper diary (Carter, Burley, Nykjaer, & Cade, 2013). The app utilised behaviour change techniques such as goal setting, self-monitoring and feedback with a sample of overweight volunteers (n=128). Reported retention rate at six months in the app-based group was 93% compared to 55% in the website group and 53% in the paper diary group. Adherence was similarly higher in the app-based group; however, it did decline over time in all three groups. The study used an intention to treat analysis and found a significantly higher weight loss in the app-based group -4.6kg (95% CI -6.2 to -3.0), compared with -2.9kg (95% CI -4.7 to -1.1) in the paper diary group and -1.3kg (95% CI -2.7 to 0.1) in the website group (Carter et al., 2013). This intervention was a pilot RCT and did not calculate a formal sample size. However, a common criticism of mHealth interventions has been that they did not follow participants for long enough (Agarwal, Perry, Long, & Labrique, 2015; Baskerville et al., 2015) and a strength of the Carter et al. (2013) study is that it followed participants to six months. It also used an intention to treat protocol, which may be useful in mHealth interventions as reporting just on participants who fully adhered to the intervention may limit the translation of results to real world situations (Heron & Smyth, 2010).

2.4.2.2 Mental health

Along with physical activity and nutrition, mental health is one of the key health areas where many mobile apps have been developed both by researchers and commercial app developers. Mood tracker apps such as Happiness (Good to Hear, 2017) and GottaFeeling (2017) are available for individuals to purchase to track their mood over time. These apps claim to positively impact a user's life with the benefits of using GottaFeeling listed as being 'greater happiness, better decisions and improved communication' (GottaFeeling, 2017). In Australia, Beyond Blue, a large mental health charity, has partnered with Smiling Mind since 2014 (Smiling Mind, n.d.). Smiling Mind is a guided meditation app that offers customisable programs and utilises gamification. Smiling Mind was evaluated in the Australian state of Victoria with 1,853 students and 104 teachers across 12 state schools (Smiling Mind, 2016). The evaluation report found that use of the mindfulness app impacted on learning engagement and wellbeing in students, and a range of indicators for teachers including sleep and tension. There were no peer-reviewed publications reporting these results at the time of writing.

In 2017, Australian researchers conducted a review of mental health apps and potential consumer issues (Grundy et al., 2017). They identified areas of potential concerns including that claims of their efficacy were not based on evidence, that privacy and data collection methods were not transparent and that they lacked diversity in terms of mental health outcomes. Additionally, they found it can be difficult for a consumer to even identify who authored the app content and that most were commercial endeavours. While there is a market, the number of apps on the app store will continue to grow while the evidence base will follow. The following two studies provide recent examples of research in the mental health space.

The Grey Matters RCT (n=144) published in 2016 aimed to investigate the effect of a bespoke mobile app – the Grey Matters app, on the risk of a person developing Alzheimer’s disease (Hartin et al., 2016). Risk factors for developing Alzheimer’s disease include high BMI, poor diet, poor cardiovascular health and a range of psychosocial factors such as education, and social participation. The Grey Matters app was designed as an educational intervention providing daily tips, a self-monitoring log and data gathered from a provided activity monitor as well as using gamification functions. Participants in the intervention group demonstrated better clinical outcomes in terms of BMI and systolic blood pressure, and there was evidence that increased app exposure impacted on these outcomes. Interestingly, the largest benefit was seen in those who used the app the most (opened the app more than seven times per week). The researchers found that the app was successful in preparing participants for change and that most users intended to continue with their behaviour change efforts post-intervention (Hartin et al., 2016).

In 2016, Beiwinkel and colleagues (2016) ran a small pilot study (n=13) testing the efficacy of an app that tracked mood, physical activity and social community, in patients with bipolar disorder. The participants used the self-monitoring app for up to 12 months. The authors found an association between some clinical symptoms and smartphone measures including a decrease in social communication and physical activity predicting an increase in depressive symptoms. They concluded that although there is potential for smartphones to play a greater role in monitoring patients with bipolar disorder, more research is needed, with increased sample sizes (Beiwinkel et al., 2016).

2.4.2.3 Alcohol

A 2017 review of the efficacy of digital interventions on alcohol consumption reviewed 41 studies and found moderate-quality evidence of the impact of interventions to lower alcohol consumption by up to three standard drinks per week (Kaner et al., 2017). The authors found that personalised digital advice can be beneficial in reducing heavy drinking compared to general information or no intervention, yet there was no difference when compared to face-to-face interventions.

One innovative example of an app based intervention targeting individuals with alcohol disorders is the Location-Based Monitoring and Intervention for Alcohol use Disorders (LBMI-A) (Dulin, Gonzalez, King, Giroux, & Bacon, 2013; Gonzalez & Dulin, 2015). The app used a seven-stepped approach to developing a comprehensive and personalised program for users. This included using location-based technology to alert users to areas of high risk (including where they had consumed alcohol in the past), developing a preselected list of supportive people to call on in times of need as well as functions designed to better deal with craving and increase problem-solving skills. The app was tested in a small pilot study with participants who had an alcohol disorder having access to either the LBMI-A (n=28) or an online program called the Drinkers Check-Up (n=26) which is a brief assessment and motivational intervention for individuals experiencing alcohol related problems (Gonzalez & Dulin, 2015). Participants in both groups experienced significant reduction in alcohol consumption over the intervention period with users in an app-based group having significantly more alcohol free days and a lower number of heavy drinking days and overall drinks per week than the group with access to the online intervention only (Dulin et al., 2013).

This study had some positive results yet the authors cited limitations and suggested results needed to be interpreted with caution (Dulin et al., 2013). As with many other app-based studies, the small sample size means generalisation is not possible and the authors concluded that an RCT is needed to further evaluate the efficacy. Additionally, participants in the app group only (not the online group) were encouraged to record their daily alcohol consumption and cravings and were compensated \$5 each day for doing so. This may have impacted on adherence within the app only group, and may not be sustainable over time.

While this study has reported interesting results, another app-based RCT targeting Swedish University students who demonstrated risky alcohol consumption did not find any effect on alcohol consumption patterns (Gajecki, Berman, Sinadinovic, Rosendahl, & Andersson, 2014). There is certainly potential for app-based alcohol interventions to reach people and impact on behaviour and there are a few large RCTs currently being trialled (Berman, Gajecki, Fredriksson, Sinadinovic, & Andersson, 2015; Garnett, Crane, Michie, West, & Brown, 2016) which should provide more evidence about the most effective approaches.

2.4.2.4 Smoking cessation

There are a plethora of health apps in the app stores, and as the number of available apps increases faster than research in the published literature, many researchers are looking to the app stores and evaluating the availability, content, usability and popularity of publically available apps. One such review on smoking cessation was published in 2017 and examined the smartphone apps available in the Portuguese language (Formagini et al., 2017). Their search revealed 51 apps on the Apple App Store and 600 on Google Play. After exclusion for lack of availability in Brazil, and duplication, 14 apps were included for final review (three for Android and 12 for iOS with one app being available for both platforms). The authors stated that 90% of devices in Brazil use the Android operating system (Formagini et al., 2017).

The apps were classified according to the National Tobacco Cessation Collaboration categories and scored as to their adherence to the Treating Tobacco Use and Dependence guidelines (Fiore et al., 2008). A checklist of the 21 items from the guidelines were developed and apps were assigned a zero score for non-adherence, a one for being partially present and a two for fully present (Formagini et al., 2017). The authors found that overall, the apps in their review scored poorly in terms of adherence to the guidelines which forms the evidence base in terms of smoking cessation. The highest scored item was interactive (92.8%), while several items scored 0% including:

- Evaluates desire to quit
- Helps with a quit plan: social support during treatment
- Helps with a quit plan: recommend approved medications
- Recommend counselling and medicines
- Referral for treatment and connected to quit hotline

The review included no information about how well-used the apps were or their impact in terms of smoking cessation (Formagini et al., 2017). Yet it did highlight the difficulty facing consumers when they may be faced with choosing between up to 600 apps in one app store. If they do choose an app related to smoking cessation, this study would suggest that they are then likely to find it adheres poorly to the evidence-based guidelines. It also highlights a significant gap in the market.

A trial of a smoking cessation app that does adhere to the evidence-based guidelines (Fiore et al., 2008) demonstrated that such approaches can be an effective way to reach people of lower socio economic status and engage them with a smoking cessation intervention (Businelle et al., 2016). The Smart-T app was developed as an EMI that sent a total of 102 supportive messages to participants (n=59) over a three-week period. The app showed good acceptability in a low-income population and 20% of participants were biochemically abstinent at the conclusion of the 12-week trial. In this study, the authors also reported an association between high use of the quit tips feature in the app, and non-abstinence and that participants with higher nicotine dependence accessed this feature the most. This is an interesting finding which shows that while the association was with non-abstinence, those who needed it the most, the heaviest smokers, were most likely to engage with the app to help with their cravings and to seek information and support. Smokers already motivated to quit could have found it easier to stop smoking and not felt the need to continue using the app after the initial motivation and information received (Businelle et al., 2016).

2.4.2.5 Recommendations for mHealth research

The examples above attest to the growing body of work being conducted in the field of mHealth across a number of different health areas, yet also confirm the lack of definite consensus on the efficacy of mHealth initiatives to impact on health. More research is needed from large sample size RCTs (Baskerville et al., 2015; Free et al., 2013), yet large trials require longer time periods to implement, which can often be contrary to software development principles (Mohr et al., 2015; O'Neil A. et al., 2017). Researchers are developing different ways to evaluate these types of initiatives to address these issues, but research methods are slow to change. Evaluation of mHealth interventions is discussed in detail in Chapter 4. Best practice guidelines for app development have been developed by VicHealth in Australia both for practitioners and app developers seeking to develop a health app (Dialogue Consulting, 2015).

While mHealth research is a diverse field, there is consensus in some integral factors important in app development for health behaviour change. The first is that using behaviour change theory to underpin the development of an app intervention is best practice (Dialogue Consulting, 2015), but one that is not always adhered to. In their 2016 review, only six of the eligible 23 studies reported using behaviour change theory to guide the development of their app (Zhao et al., 2016). The study reported the two most commonly used theories were Theory of Planned Behaviour and Social Cognitive Theory. Another review of alcohol based digital interventions found over half of the studies published made no reference to the use of theory (Kaner et al., 2017).

Another key factor in development is the importance of working in multidisciplinary teams. App development requires specialised skills involving software developers and health promotion or behaviour change experts (Dialogue Consulting, 2015). These skills may require researchers to look outside their established team and new multidisciplinary teams can take time to establish. Many experts stress the importance of working through these issues and ensuring app developers are brought on to the project team from early on in the planning process (Becker et al., 2014; Dialogue Consulting, 2015; Middelweerd, Mollee, van der Wal, Brug, & te Velde, 2014; Muessig, Pike, LeGrand, & Hightow-Weidman, 2013; Stollefson et al., 2015; B. K. White, White, Giglia, & Tawia, 2016; J. A. White, 2015).

2.4.3 Digital breastfeeding interventions

When planning for Milk Man, there were relatively few digital breastfeeding initiatives in the literature. Since then, the research in this area has grown in relation to interventions targeting mothers, yet at the time of writing there were no breastfeeding mobile app interventions in the published literature targeting fathers. The following section discusses published digital breastfeeding initiatives in the literature targeting mothers, fathers, and both parents. In the following description of research, Internet- and app-based interventions are described together as there are often overlapping components, in which the intervention may consist of website and / or an app. In addition, a mobile app intervention can be a web app (a web app is a website tailored for mobile use but that still delivers all content through a web browser) and it is sometimes difficult to categorise an intervention into one category or the other. Internet and app based interventions offer greater opportunities for enhanced user engagement and involvement than SMS intervention. Some of the unique ways researchers can use mobile interventions to reach and engage with users are discussed in Section 2.4.4.

2.4.3.1 Internet and mobile app interventions

There are more breastfeeding studies targeting mothers than there are targeting fathers, or both parents. One 2016 meta-analysis reviewed the effect on breastfeeding of 16 digital health studies that included 5,505 women (Lau, Htun, Tam, & Klainin-Yobas, 2016). The authors found that internet-based interventions improved attitudes and knowledge about breastfeeding as well as breastfeeding initiation, and the duration of exclusive breastfeeding. The reported benefits of internet-based interventions for women included portability, the reduction in geographical barriers and women being able to access and use the information at a time that suited them.

Giglia, Cox, Zhao & Binns (2015) reported on an internet intervention study designed to increase breastfeeding duration. Participants in the intervention group had access to the study website that focussed on providing best practice information and support about infant feeding. The website included a forum and the ability to contact other participants as well as health professionals through the site. The control group had access to a different website that directed them to publically available parenting and infant feeding websites. The authors found a positive statistically significant difference in breastfeeding at six months of age ($p=0.01$), but not at other time points (measured at hospital discharge ($p=0.510$), four weeks ($p=0.291$), 10 weeks ($p=0.145$) and 16 weeks ($p=0.054$)). Mothers in the study who experienced breastfeeding difficulties were more likely to access the internet, adding further evidence to the importance of the internet as an information source for perinatal women (Giglia et al., 2015).

An online intervention targeting mothers with infant feeding information in the UK is currently being conducted (Bartle et al., 2017). The iFeed website uses a range of behaviour change techniques to target mothers with information about breastfeeding and safe formula feeding. The study aims to investigate subsequent changes in motivations and perceptions of capability in terms of infant feeding.

The Healthy You, Healthy Baby (HYHB) website and app were developed based on formative research with parents to provide a clinically sound information resource for new parents (Hearn, Miller, & Lester, 2014). Consultation with parents revealed they wanted information on pregnancy and early childhood, nutrition, sleep, managing weight gain, breastfeeding, exercise and emotional wellbeing, amongst other topics. In response, the HYHB project offered a range of information to new parents including on diet, exercise, sleep and infant feeding. Additionally, HYHB offered personalisation, self-assessment and tailoring of the information and addressed the key areas of interest identified by parents in the formative consultation. After one year, the website had recorded 21,619 page views and the app had been downloaded 2,378 times.

The Growing Healthy study is an infant feeding intervention targeted at mothers delivered through a mobile app and a website (Denney-Wilson et al., 2015). It used a Facebook forum to offer additional support to mothers. Participants received three push notifications a week tailored to the age of their child, as well as their feeding method. The Growing Healthy trial has been completed, but at the time of writing outcome results were not yet published.

A breastfeeding education research initiative in Taiwan provided women in their third trimester of pregnancy access to a web-based educational package (Huang et al., 2007). Pre-and post-intervention questionnaires were carried out two weeks apart with women in the control group and those who had access to the intervention (n=60 in intervention group, n=60 in control group). Women in the intervention group reported higher average knowledge scores and more positive attitudes about breastfeeding at post-intervention. Exclusive breastfeeding rates were higher in the intervention group, 26.7% at six weeks in the intervention group compared with 20% in the control group ($p < 0.05$). The authors reported the flexibility of allowing women to choose their own pace of learning was a positive effect of utilising the web.

FeedFinder is a UK-based location-mapping app that encourages mothers to rate and review public spaces in terms of their suitability for breastfeeding (Balaam, Comber, Jenkins, Sutton, & Garbett, 2015). The app aims to help women feel more comfortable and confident breastfeeding in public. It does this by providing member reviews of public venues in terms of comfort, hygiene, privacy and baby facilities as well as providing a forum for mothers to leave reviews to be read by other mothers. In the first 12 months of FeedFinder being available to the public the authors reported 3,000 users signing up to the app, 1,900 venues being added to the app, 1,810 reviews received (star ratings) and 109 comments. By the end of 21 months analysis of the free text reviews revealed an increase to 1,757 comments being posted about 1,416 venues, from 783 active contributing reviewers. This suggested increased and sustained use of the app over time (Simpson, Garbett, Comber, & Balaam, 2016).

Feed Safe is an Australian mobile app designed to give breastfeeding women the best advice about alcohol and breastfeeding (B. K. White, White, et al., 2016). Based on the NHMRC guidelines it adopts a harm minimisation approach and provides practical advice for women choosing to consume alcohol while breastfeeding. Feed Safe was released for free download by the Australian public in 2014 and in its first year reported 28,330 downloads and 40,332 visits to the website. The app was used an average of 732 times each day across Australia in the reported study period. The app was initially developed and launched for the iOS platform. After significant interest from the community an Android version was released two years later in 2016.

A recent study used a commercially available mobile app, designed to enable women to log and keep track of their breastfeeding, to perform an EMA (Demirci & Bogen, 2017). The study required women to log their breastfeeds and send the information to researchers each week. Over the eight-week period, 38% of participants returned complete or near complete data, 24% sent some data and 38% returned no data. The app contained a diary feature where free text entries could be recorded and 58% of participants recorded at least one entry. The authors found the data collection method was reliable and acceptable to the majority of women and that an app based EMA can provide rich data from breastfeeding mothers.

While there are a number of digital breastfeeding interventions described in this discussion, there is a need for more digital breastfeeding interventions, especially those using mobile apps, to include breastfeeding outcomes as an evaluation indicator. The FeedFinder app study did not report any measure to evaluate breastfeeding outcomes nor breastfeeding self-efficacy or attitudinal change. The Feed Safe study did not evaluate breastfeeding outcomes, or alcohol consumption and the HYHB app did not include any measures on infant feeding outcomes. The results from this study of the Milk Man app and of the Growing Healthy trial when published will provide important guidance for this growing area.

2.4.3.2 SMS interventions

SMS, or short messaging service, refers to information sent from a mobile phone via text message (Fendelman, 2016). There are now many different messaging services available to consumers. SMS messages are sent via the user's cellular phone networks only. Other forms of messaging such as Whatsapp, Facebook messenger and Viber use the internet to transmit messages.

SMS is a particularly attractive choice in low resource settings and many mHealth interventions implemented in low and middle-income countries use SMS. A 2012 systematic review of SMS-based health interventions in developing countries identified 98 interventions in the peer-reviewed and grey literature (Déglise, Suggs, & Odermatt, 2012). SMS interventions have the advantage that it is a service with wide compatibility with mobile phones. Breastfeeding is one of many health areas where researchers have sought to use SMS to reach new and expectant parents with information and support.

Text4baby was a free, large scale, public health initiative in the US that aimed to deliver timely information to pregnant women and new mothers (Whittaker et al., 2012). Messages, which were developed by a multidisciplinary team, were refined to a maximum of 150 characters. Three text messages were sent out to mothers each week from the time they signed up until their baby was one year old. The messages were timed to be relevant to the perinatal stage of the participant. In their first 10 months of implementation 109,201 women had signed up to the service. Pilot evaluation of this program was carried out with participants from two clinics in Virginia, US (Evans, Wallace Jasmine, & Snider, 2012). Pre- and post-test results were reported with 86 participants (control group n=38; intervention group n=48). They showed a significant difference in mothers feeling that they were prepared for motherhood, and belief that drinking alcohol will harm their baby's health, but did not report significant differences in other prenatal attitudes and behaviours (Evans et al., 2012).

Mothers participating in a study in Shanghai, China, were sent time-relevant SMS messages each week about infant feeding from the third trimester of pregnancy, until their babies were 12 months old (n=582) (Jiang et al., 2014). Mothers in the intervention group reported a significant difference (OR 2.67 95%CI 1.45-4.91) in exclusive breastfeeding with 15.1% of mothers exclusively breastfeeding to six months, compared with 6.3% in the control group. The intervention group also had a lower rate of introducing solids before four months of age. By 12 months however, there was no reported difference in breastfeeding rates.

The Australian study, MumBubConnect aimed to investigate if an SMS intervention could impact on the rates of 'any' breastfeeding and on breastfeeding self-efficacy and coping (Gallegos, Russell-Bennett, Previte, & Parkinson, 2014). Breastfeeding women with an infant under the age of three months were sent an automated SMS once a week for eight weeks, which asked them to provide a reply from a set list of responses (n=114 in intervention group and n=86 in non-concurrent control group). Those participants who responded with an answer reflecting some distress or difficulty were contacted by an Australian Breastfeeding Association counsellor within 24 hours. Participants in the intervention group were significantly less likely to cease exclusive breastfeeding during the period ($p=0.04$), and reported better coping skills ($p<0.001$). The study had a few limitations including its non-concurrent prospective comparison design, with the comparison group recruited two years after the intervention group. The average age of the infant in the intervention group was older (61 days of age at recruitment in the intervention group compared with 47 days in the comparison group) and all mothers reported being pro-breastfeeding.

As discussed in this section, there are several interventions that have used SMS for breastfeeding initiatives, yet there are difficulties in drawing broad conclusions on the efficacy of the approach. These limitations include initiatives with low sample sizes, lack of comparison groups and a lack of evaluation of health outcomes.

2.4.3.3 Interventions targeted at fathers

Despite mounting evidence of the importance and influence of fathers in breastfeeding, as well as the potential for the reach and engagement with mobile apps, there has been very little published research about how an app can be used to reach fathers and influence breastfeeding. At the time of developing the Milk Man app, there was no available research either published, or in progress, that focussed on delivering a breastfeeding intervention to fathers via a mobile app and included breastfeeding outcomes as an evaluation indicator. There is however, a growing number of digital interventions that are focussed on fathers and an overview of these are provided in this section.

Sherriff, Hall & Panton (2014) conducted a review of 40 published studies that included some examination of father support and breastfeeding. One of these interventions was delivered via a website, but there were no mobile app-based interventions included in the review results. The one website initiative recruited fathers from antenatal classes (n=137) and offered them an additional information package that included a DVD, and tailored email support with links to appropriate websites (Fletcher, Vimpani, Russell, & Keatinge, 2008). Fletcher and colleagues found that fathers appreciated the information being made available and concluded that this may be a feasible approach to target fathers. Interestingly, the two least popular topics were breastfeeding, and resuming sex after birth with the authors suggesting that this may have been due to breastfeeding still not being seen as a role fathers can participate in.

Published in 2016, the SMS4Dads project is a mobile intervention targeted at new fathers (Fletcher et al., 2016). While not specifically designed to address breastfeeding, SMS4Dads aims to support the mental health of fathers who are either expecting a baby or have a baby under the age of three months. The small pilot intervention (n=40) ran for six weeks with text messages being sent via SMS five times in weeks one to four, and four in weeks five and six. The study found good acceptability of the approach and that fathers found it was useful in starting conversations with their partner.

A Canadian website designed to target breastfeeding information to mothers and fathers showed promising results from both parents in terms of being an acceptable approach, with participants liking the design and content (Abbass-Dick et al., 2017). The website included a specific section for fathers detailing their role and how they could help. Feedback showed 67% of fathers thought it was targeting both parents and that it was an excellent resource. Pre- and post-test results testing the efficacy of the website was carried out with 22 mothers and 23 fathers. Parents completed a pre-test questionnaire and were then given access to the website. After reviewing the website content, they then emailed the researchers to receive the link to the post-test questionnaire. No information was provided about the length of time parents spent reviewing the website information. Scores for mothers and fathers increased across the breastfeeding self-efficacy scale (Dennis, 2003), the Iowa infant feeding attitude scale (De la Mora, Russell, Dungy, Losch, & Dusdieker, 1999) as well as breastfeeding knowledge. There was no increase in the scores in the brief Co-parenting Relationship Scale (Feinberg, 2003). The authors stated that due to the exploratory stage of the research this was not conclusive and the website is currently undergoing testing in an RCT.

There is clearly an indication from the preceding examples of father-focussed, or father-inclusive interventions that more research is being conducted in this area and more comprehensive research is still needed. It also shows that targeting new and expecting fathers with information and support via digital means may be an effective way to reach them and to impact on behaviour change.

2.4.4 Using mHealth to engage participants

2.4.4.1 Introduction

Engagement is a vital component of mHealth interventions (Hartin et al., 2016; Perski et al., 2016; Yardley et al., 2016). If people are not engaged with an app, the potential of the intervention to achieve the desired impact is limited. Engagement is often subjective and what might motivate one user to keep returning to an app, might not work for another user, or might not work for them at that particular time. There are many different aspects of mobile development that can impact how a person uses and keeps returning to use an app (B. K. White, Burns, et al., 2016; Yardley et al., 2016). For example, an app could be attractively designed, have the exact information a person is looking for and be perfect for their needs, yet if the app has been designed in a way whereby the loading speed between pages is too long, a user will switch off.

2.4.4.2 Defining engagement

Perski et al. (2016) sought to conceptualise engagement in DBCI. They argued that before moving towards a more systematic method of evaluating engagement, the sector first needs a common definition of what engagement means and what contributes to it. They offer the following definition: *Engagement with DBCIs is (1) the extent (e.g. amount, frequency, duration, depth) of usage and (2) a subjective experience characterised by attention, interest and affect* (Perski et al., 2016, p. 1). Therefore, getting individuals to engage with an app needs careful consideration of factors that increase the extent people use it, for example how often they check in, how much they use the app and how many tasks they complete, as well creating relevant, interesting and usable systems.

In addition, the authors proposed a conceptual framework explaining how engagement with a DBCI influences the target behaviour (Perski et al., 2016). The framework describes the complex integration of factors that impact behaviour change. This includes individual factors (such as age and computer literacy), the setting (cultural and physical), intervention factors (such as content and delivery) and the mechanisms of change (attitudes and beliefs) on the target behaviour. In this model influence on engagement is highlighted from both evidence-based, and hypothesised influential factors. The framework is displayed in Figure 2.1.

Encouraging participants to use and engage with an app is a key consideration for mHealth researchers and mobile technology offer a range of unique methods that can be utilised to achieve the desired outcome (Hamari & Koivisto, 2015; Johnson et al., 2016). Some of these factors are discussed below and include the use of gamification, push notifications and social connectivity.

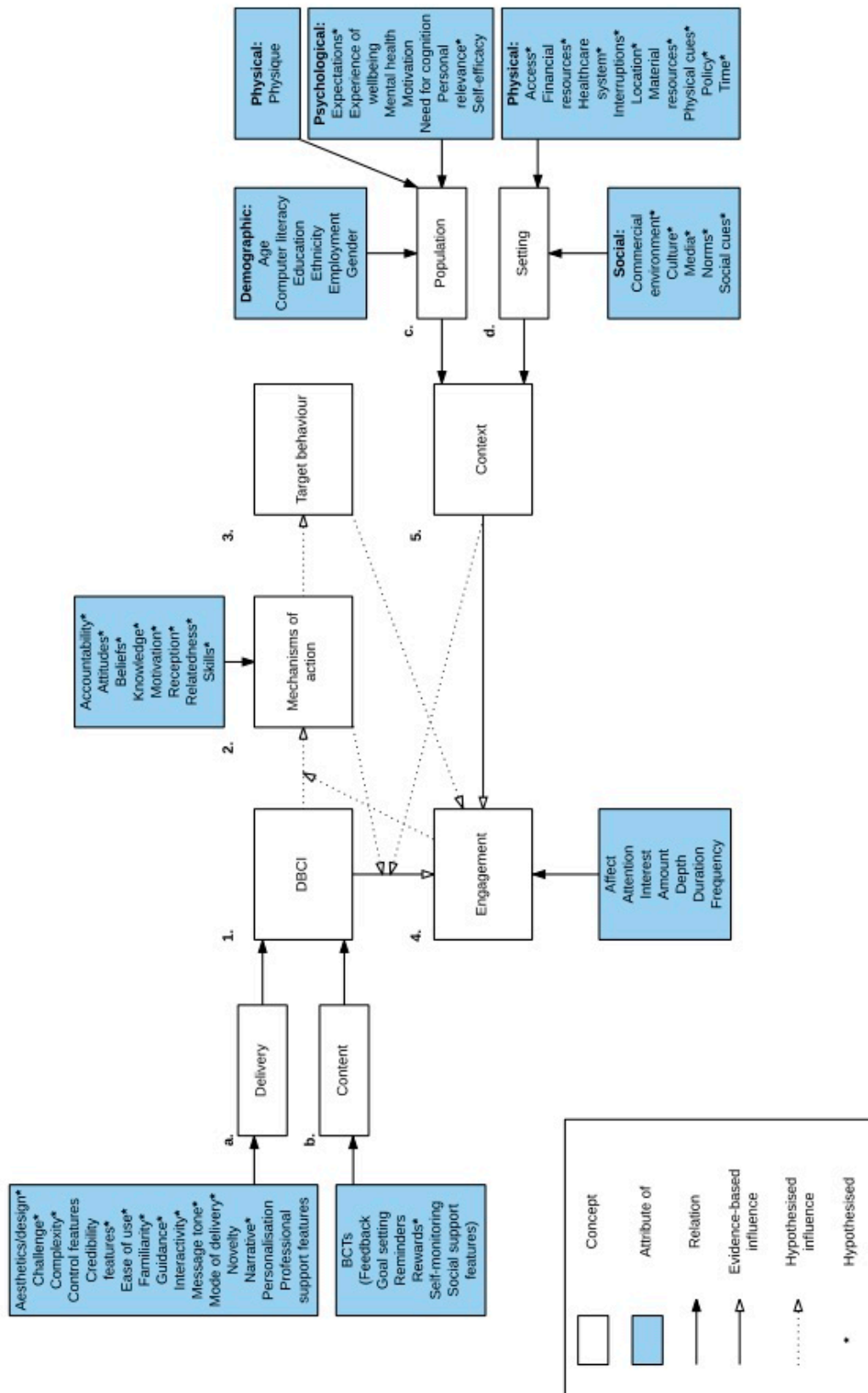


Figure 2.1. Conceptual framework of engagement and digital behaviour change interventions (Perski et al., 2016)

2.4.4.3 Gamification

Gamification is the practice of using game-like components to motivate and encourage people in non-game contexts (King, Greaves, Exeter, & Darzi, 2013). Some common gamification elements include badges, points, leaderboards and challenges (Zichermann & Cunningham, 2011). Gamification is an increasingly common strategy used in health and fitness apps and some of the most popular commercial health apps rely on gamification to motivate and engage users. MyFitnessPal (MyFitnessPal Inc, 2017), Runkeeper (Runkeeper, 2017), Zombie Run (Six to Start, 2015) and Superbetter (Superbetter Labs Inc, 2017) are just some examples of large-scale commercial apps utilising gamification elements as part of their core strategy.

Gamification is being used in intervention research for individuals of all ages and genders (Johnson et al., 2016). Despite the common assertion that gamification is suitable only for younger people, research has shown that age does not have a significant impact on the social, hedonic and utilitarian benefits users receive from gamification (Koivisto & Hamari, 2014). The only age-related disadvantage identified by Koivisto and Hamari (2014) was that the older people are, the less likely they are to experience ease of use. Conversely, a study from Korea found that gamification was more effective in increasing intention to use the app in young people (C. Lee, Lee, & Lee, 2017). There are interesting findings with regard to gamification and gender. Koivisto & Hamari (2014) found that women reported appreciating the social connectivity aspects of gamification more than men, while another study has found that men were more likely to be influenced by social factors than women (Y. Wang, Wu, & Wang, 2009). Australian mental health research with young men has suggested that gamification may be of value in enhancing engagement and enjoyment for that target group (Ellis et al., 2013).

Although a number of studies have examined how gamification is used in health apps (Lister, West, Cannon, Sax, & Brodegard, 2014; Miller, Cafazzo, & Seto, 2014), few have formally evaluated the impact on behaviour change. Physical activity is the behaviour most often targeted by gamification studies and the one for which there is the most evidence of its positive impact (Johnson et al., 2016). Evidence about the increasing use of gamified apps in health is emerging (Johnson et al., 2016; Lister et al., 2014; Miller et al., 2014; Payne HE, Moxley VB, & MacDonald E, 2015). A 2014 review of physical activity and nutrition apps found that the use of gamification was widespread, however behaviour change theory was not widely incorporated and there was no industry standard for developers (Lister et al., 2014). Several studies have noted the need for further investigation of the potential for gamified health apps to impact on behaviour change (Koivisto & Hamari, 2014; Lister et al., 2014; Miller et al., 2014; Payne HE et al., 2015).

A 2016 systematic review of research utilising gamification in health initiatives identified 19 papers and found that overall studies reported positive impact on behaviour, user experience and cognition (58%) (Johnson et al., 2016). Another 41% reported neutral or mixed effects, and no studies reported detrimental or negative effects. The gamification function most strongly associated with positive behaviour change was the use of rewards for physical activity interventions (including points, badges and leaderboards).

One debate about the use of gamification in mHealth revolves around motivation, and whether gamification can influence intrinsic or extrinsic motivation. Intrinsic motivation refers to a user doing something for their own sake, feeling self-motivated to complete a task or engage in a healthy behaviour. Extrinsic motivation refers to motivation being provided by an external source, for example receiving a reward or the act of competing (Seaborn & Fels, 2015). One reservation about gamification is that it increases extrinsic motivation only, which is likely only a short-term motivator. This could lead to a decrease in intrinsic motivation, which is essential for long-term behaviour change (Mekler, Brühlmann, Tuch, & Opwis, 2015; Seaborn & Fels, 2015). There is evidence, in relation to physical activity, that usefulness and enjoyment with gamification decline over time (Koivisto & Hamari, 2014). Others argue that well planned gamification can increase intrinsic motivation (Mekler et al., 2015; Pe-Than, Goh, & Lee, 2014; Peng, Lin, Pfeiffer, & Winn, 2012).

This issue of whether gamification can influence intrinsic motivation is particularly important in physical activity or nutrition interventions which seek to engage users over long periods to achieve sustained behaviour change. In comparison, breastfeeding is a relatively short-term behaviour, and seeking to change fathers' attitudes and knowledge about breastfeeding does not need a sustained engagement over a long period. Studies have shown that short, momentary interventions can have a positive impact on fathers (Maycock et al., 2013). It follows then that gamification may be an effective strategy to engage fathers in breastfeeding information, regardless of the type of motivation it inspires in participants.

2.4.4.4 Social support

The ability for digital technologies to connect people is arguably one of the greatest advantages of digital interventions (Chou, Prestin, Lyons, & Wen, 2013). Technology offers the ability to connect people who are far apart, or who share specific goals or interests (Latkin & Knowlton, 2015). It has the potential to remove barriers such as distance or time and may enable people to form meaningful friendships and support networks. Online social networks can also offer a level of anonymity which can make it easier for people to seek help, especially for issues they may not be comfortable talking about with people they know (Kauer, Mangan, & Sancu, 2014). The anonymity which can enable positive sharing, can also provide opportunity and impunity for people to attack and bully others (Kowalski, Giumetti, Schroeder, & Lattanner, 2014) It can also lead to misinformation being sourced and shared (Sudau et al., 2014).

The use of technology for information gathering has changed markedly over the last 20 years. Increasingly people want to interact with technology and use it to socially connect rather than simply using it passively to receive static information (Chou et al., 2013). Many people are socially connected throughout the day, and over a range of platforms. Australians are enthusiastic users of social media with approximately 79% of internet users having at least one social media profile (Sensis, 2017). Smartphones are the preferred medium to use social networks with 81% of social networking done via mobile. Facebook remains the most popular social network, with 94% of social media users having a Facebook profile. Australian Facebook users spend an average of 10 hours on the social media platform each week. While 59% of users check in daily, 35% use social media more than five times each day (Sensis, 2017).

There is potential that using technology to socially connect can encourage people to reach out to each other and build communities to support health behaviour change (Fukuoka, Kamitani, Bonnet, & Lindgren, 2011; Gay, Pollak, Adams, & Leonard, 2011; Kamal, Fels, & Fergusson, 2014; Proudfoot et al., 2010). Socially interactive features are increasingly common in mobile health interventions seeking to engage users (Johnson et al., 2016).

Findings from a focus group analysis investigating the feasibility of an app for overweight adults suggested that social support networks that create a virtual community could be the primary component in creating a successful healthy lifestyle app (Fukuoka et al., 2011). A study seeking to engage young people who were heavy drinkers in a treatment intervention found that adding social elements into the digital intervention resulted in an increased motivation to engage and increased aspects of user experience (Boendermaker, Boffo, & Wiers, 2015).

Social connectivity is intimately linked with gamification. Some of the key gamification elements, such as leaderboards and competition require that people are connected to each other. In their study, Hamari and Koivisto (2015) found that the social influence of receiving 'likes' or positive reinforcement from peers was a motivator for people to participate in physical activity. Furthermore, they found that the effect increased with the number of 'friends' a user had in the service.

While many studies report participants like social connectivity, whether socially connecting people to deliver support about a health issue actually has any impact on the health behavior, remains unclear. In 2012 a large weight loss study (n=8,112) investigated the online CSIRO Total Wellbeing Diet with overweight or obese participants (Brindal et al., 2012). Participants were randomised into groups that all received access to a website delivering the dietary information online, but differed in the levels of social support and personalisation they offered. The study found that while the social networking feature increased the length of time users engaged with the intervention, there was no associated demonstrated impact on weight loss. Similar results were found with a smoking cessation intervention that found that although participants liked the social support components, there was no association between use of these components and smoking cessation (Heffner, Vilardaga, Mercer, Kientz, & Bricker, 2015).

While there is conflicting evidence about the impact of social connectivity on health behaviors, most studies do report it being a popular inclusion that increases engagement with interventions.

2.4.4.5 Push Notifications

Another key advantage of mobile devices is the ability to send notifications. Notifications are a means by which mobile apps can send information or alerts to users (Mohr, Schueller, Montague, Burns, & Rashidi, 2014). Compared with other methods like email, notifications are immediate and quick to act upon; swiping the notification takes the users directly to the app, and even into the specific context referenced by the notification. Notifications remain in a list until they are acted upon or removed, meaning they can potentially act as triggers for later action. Use of notifications means that the onus is not solely on a participant to remember to engage with the service; to some extent the service comes to them.

There are two types of notifications, local notifications and push notifications (J. A. White, 2015). Local notifications are generated deterministically on the device in response to certain conditions being met - most commonly, on a specific time and date (e.g. a calendar app), a certain length of time after a user action (e.g. a timer app), or when the user enters a geographical area (e.g. a navigation app). Local notifications are not sent from a remote server, and require no internet connectivity on the device. Push notifications are sent from a remote server and require that the device is connected to the internet (J. A. White, 2015). They are used when it is not possible in advance to know when a notification might need to be triggered. For example, in a socially connected app, users might be notified when other users respond to their comments.

Notifications can be tailored to the user to contain personalised, timely content with the aim of encouraging users to think about the health behaviour and to visit the app. The Australian Government's Quit for You - Quit for Two app is a free app for pregnant women that aims to help them quit smoking (Australian Government, 2013). Quit for you - Quit for Two uses games, goal setting, and tailoring strategies to help women engage with the app and keep them coming back. One of the strategies the app uses is tailored notifications, sent out daily at a time specified by the user with reminders and words of encouragement. The app also uses intangible incentives by calculating the money saved from not smoking and applying it directly to baby related items. Figure 2.2 shows the Quit for You - Quit for Two app notification and the page incentivising users by calculating the cost savings.

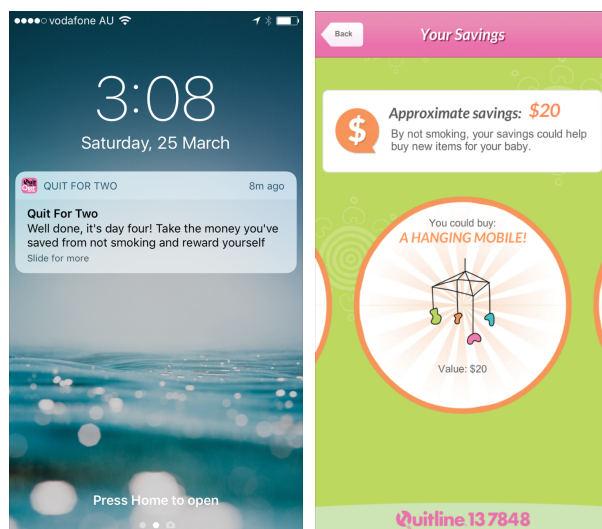


Figure 2.2. Quit for you - Quit for two app

2.4.4.6 Measuring engagement

How best to measure engagement is the subject of current debate and research. In their systematic review Perski et al. (2016) do not propose an engagement evaluation measure, however the definition and the framework they describe suggests that a multifaceted approach would be appropriate. Other studies have sought to measure engagement using a variety of different methods including analytics only approaches, questionnaire data only approaches, and a range of tools and engagement indexes that aim to standardise measurement.

The WYhealth due date app, for example, was developed by Wyoming Medicaid for pregnant women (Bush, Barlow, Echols, Wilkerson, & Bellevin, 2017). The app aimed to engage with pregnant women, identify women who were at increased pregnancy risk and refer them to appropriate health care providers. The authors measured engagement by examining app downloads and frequency of screen views and feature use within the app. Engagement was reported in the aggregate and participants were identified as either 'app users' or 'non-app users'. The authors reported an association between app use and lowered incidence of low birth weight and prenatal visit attendance.

A web based physical activity intervention also used website-collected metrics, including step log counts, average steps and last step log date, as engagement variables (Davies et al., 2012). The study reported better physical activity outcomes for participants who used virtual walking buddies and who participated in the individual challenges.

Another study by Han et al. (2012) described how they measured user engagement in an online health forum focussed on breast cancer. Their study sought to understand user behaviour by identifying characteristics that impacted on engagement. Users of the forum were categorised as either users (participants who wrote or read at least one message during the intervention period), non-users (those who did not read or write one message) lurkers (those who read the messages but never posted) and posters (people who wrote at least two messages during the study period). The authors then looked at how demographic factors predicted different levels of participation. They found posters had significantly lower levels of social support than lurkers and non-users and that posters had a higher need for information than lurkers and a lower competence in health information than posters. Their results suggested that people who posted in their forum, were at higher level of need than those who did not.

Sustained engagement however, is not always needed for effective behaviour change (Michie et al., 2017). Different users will have different needs from an intervention in terms of changing the desired behaviour (Yardley et al., 2016). Some users may use an app or a website just a few times, while others may need to utilise it over a much longer period. *Effective* engagement refers to the level of app engagement needed by an individual to achieve the outcomes (Yardley et al., 2016). Defining and understanding *effective* engagement will help researchers to better tailor interventions to the individual need.

Measuring engagement with complex gamified apps

Gamified apps can be more complex and offer different indicators for engagement than non-gamified apps. Baltierra et al. (2016) described the combination of components they used to measure engagement with their gamified online health promotion intervention for young black men and transgender women who have sex with men. Engagement was measured by total time users spent using the website (with automated logout at 10 minutes) and points received generated by the gamified system, as well as reported satisfaction with the intervention (Baltierra et al., 2016). The authors found strong correlations between time spend in the app and points received, as well as time spent in app and overall satisfaction.

Burgess, Cameron, Watt & Kimble (2016) developed a gamified injury prevention app that aimed to increase mothers knowledge about appropriate burns treatment. Their protocol paper described their plan to measure engagement with the intervention as a combination of frequency of app opens, intervention messages viewed, quizzes completed, and instances of photo sharing. Other studies based on a marketing perspective have used data gathered outside of the gamified app including perceived ease of use, usefulness, social influence and enjoyment to describe engagement intention in relation to measuring attitudes to brand (Y. Yang, Asaad, & Dwivedi, 2017).

Tools for measuring engagement

There have been numerous tools developed to help define and measure engagement. The User Engagement Scale (UES) was first developed by in 1997 and uses a number of measures, all asked of participants via a questionnaire (Webster & Ho, 1997). The UES is based on six factors perceived usability, aesthetics, focussed attention, felt involvement, novelty, and durability (O'Brien & Toms, 2013). While the scale has subsequently been developed further by others to be adaptable for digital interventions (O'Brien & Toms, 2010), one limitation is the reliance on self-reported answers, as opposed to being used in combination with usage analytics data. The UES has been used to measure engagement in game-play, but this was not mapped to outcomes (Wiebe, Lamb, Hardy, & Sharek, 2013).

Several commercial engagement indexes have been developed for mobile apps. One of these is the Forrester's App engagement index. This framework is purported to 'use behavioral tracking to measure engagement levels for media and communication apps' (Dvorak et al., 2014). Yet, there are no published reports of its application and evaluation in academic research. Another is the Mobile App Engagement Index (Liftoff, 2016). This index is based more on an economic model and tracks the costs of app installs, registrations, purchases, subscriptions, reservations, and in-app purchases.

Developed in 2008, The WebMatrix Visitor Engagement Measure was developed to measure engagement with a number of components (Peterson & Carrabis, 2008). The measure was developed primarily to aid businesses in decision making with regard to customer engagement via the web and can be used to calculate engagement on one website or to compare engagement over a number of websites. Seven different metrics were described are combined to give an overall engagement score. These are the:

- Click depth index - a measure of page views and events
- Duration index - length of time participants spent on the site
- Recency index - rate that visits return to the site over time
- Feedback index - qualitative feedback about site
- Brand index - users awareness of the brand
- Interaction index - how users interact with components of the app designed to engage them
- Loyalty index - long-term interaction with the site

The overall engagement score is calculated by finding the average across the indices. The authors stated one of the strengths of the framework is that it can be easily modified.

In 2017, the WebMatrix engagement calculation was modified and applied to measure engagement with an infant feeding app for Australian parents, the Growing Healthy app (Taki et al., 2017). This study used five of the seven metrics to calculate the Engagement Index (EI), which was then used to categorise users into three groups of those who were highly, moderately and poorly engaged. The study then conducted analyses to determine what demographic factors predicted engagement level, finding that participants were more highly engaged when they were recruited by health professionals, accessed both the app and the emails, signed up when their babies were younger and were having their first baby. The study did not report any behaviour change or health outcomes.

2.4.4.7 Summary

Mobile technology offers unique opportunities to use features such as gamification, social connectivity and push notifications to reach users and engage them in a mHealth intervention. Engagement is a key component in digital health interventions and there is a need to better understand how mHealth interventions can engage users, and how that engagement translates to behavior change. Reporting on engagement is occurring with an increasing number of mHealth interventions as they seek to clarify associations between patterns of engagement or app usage and health outcomes. There are a number of tools and methods researchers are using to measure engagement, and measures that use a multifaceted approach, combining both user feedback and app metrics, are becoming increasingly common. However, increased usage does not necessarily equate to increased behaviour change and finding ways to measure and understand *effective* engagement and how interventions can be better tailored to the individual's needs is a clear pathway for future research.

2.4.5 Conclusion

The field of mHealth research is one which shows much promise and potential. There are important studies being carried out over a range of health areas which will help to understand how mHealth initiatives can best be targeted. There remain significant challenges in the implementation and translation of these findings, not the least of which is that the need for more large sample sized RCTs evaluating health outcomes presents added complexity in testing mobile apps over a long period. More research is needed into how researchers can best shape and target interventions and better understand how different patterns of engagement translate to behaviour change.

As this field of research matures more interventions across diverse health areas are being developed and tested, including for breastfeeding. While there are still few digital breastfeeding interventions specifically targeting fathers, the field is active and agile and evidence is growing of the acceptability of these types of interventions for both parents. There is still a clear need to look at the impact of digital interventions on breastfeeding outcomes, which will be one of the many areas in which the Milk Man app intervention will be able to contribute to the evidence base.

2.5 Section 4: Theoretical framework underpinning Milk Man app development

The Ottawa Charter defines health promotion as *'the process of enabling people to increase control over, and to improve, their health'* (World Health Organization, 1986). Health promotion moves beyond a focus on individual behaviour towards consideration of a wide range of social, political and environmental factors. Health promotion takes a broad view of what contributes to health and wellbeing and this includes a focus on the social determinants of health. These determinants describe the circumstances that people live in and recognise the impact they can exert on an individual's health and health choices (World Health Organization, 2003). Some of these determinants are deeply rooted and very difficult to change (such as the social gradient and an individual's early life), while others are more amenable to influence (such as social support, stress and social exclusion).

The Social Cognitive Theory (SCT) is a social learning model that operates at the interpersonal level, assuming an interaction between the social environment, the psychosocial determinants of behaviour and the individual (Bandura, 1986; Luszczynska & Schwarzer, 2005). In seeking to understand and predict human behaviour, SCT can help to inform strategies for interventions to motivate and enable people to adopt healthier behaviours (Bandura, 2004, 2009).

Reciprocal determinism is a key principle of SCT, describing the influence both personal factors and the social environment have on a person's behaviour. The two key constructs that influence behaviour according to the model are self-efficacy and outcome expectations (Luszczynska & Schwarzer, 2005). Self-efficacy refers to the belief a person holds that they are able to complete a task and that it will lead to a desired outcome. Outcome expectations are what people believe will be the outcome of completing that action, be it positive or negative. The other constructs included in the theory are goals and socio-structural factors. Goals can lead to behaviour change because to make any change, the individual must first set a goal, and try to work towards it. Socio-structural factors are the barriers or facilitators that can impact the individual. The relationship between these constructs is not linear, and they interact and impact on each other at different points. Figure 2.3, from Bandura's work describes SCT and the interaction of the constructs (Bandura, 2009).

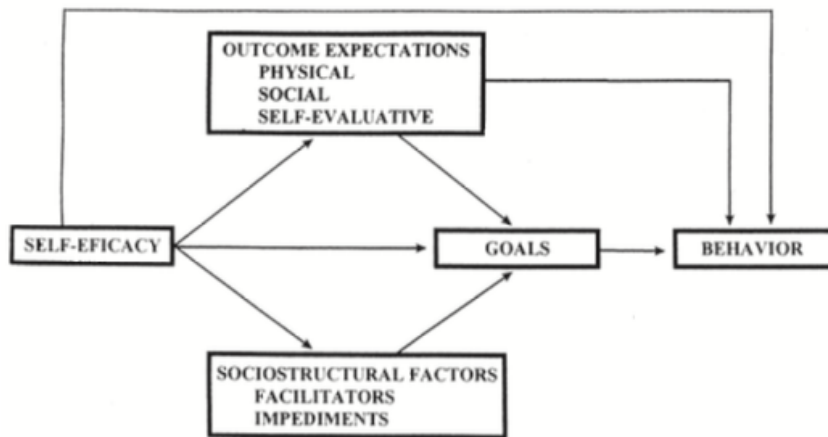


Figure 2.3. Bandura's Social Cognitive Theory

SCT is especially well-suited to app-based interventions which aim to connect individuals together via a technological medium. In his paper, *Health Promotion by Social Cognitive Means*, Bandura (2004) describes how interactive technologies can be applied to enhance health promotion projects using SCT. Providing individualised interactivity and facilitating social support interventions designed to increase self-efficacy can be ways of enhancing health promotion interventions. He described how 'social mediated pathways', using media to link participants up to social support networks can provide guidance, motivation and the social support needed to achieve the change. The paper highlights a number of specifically designed gamified programs that have been successful in increasing self-efficacy in health promotion interventions.

The factors that impact on fathers' decisions and capacity to support breastfeeding are broad and include a combination of environmental and personal influences. Two specific social environmental factors that have been identified in the literature for this target group are: the sometimes complex issues related to public breastfeeding, and the role that health professionals can have (Brown & Davies, 2014). SCT acknowledges the impact these influences can have, rather than simply focussing on the individual.

Other key SCT constructs include self-efficacy, outcome expectations, observational learning, goal setting and self-regulation. In developing self-efficacy with breastfeeding Sharma & Petosa (1997) stated that fathers need to overcome barriers which may limit their support, including feeling left out and feelings of inadequacy, as well as finding ways to spend time with, and bond with their baby which do not involve feeding. Outcome expectation management and self-regulation is important with new fathers and interventions can seek to include information about the realities of life with a newborn including breastfeeding, sleep, relationship changes and resuming intimacy. Observational learning, including peer-based models can offer opportunities for fathers to learn, and for the normalisation of different behaviours (Mitchell-Box & Braun, 2012).

In recognition of these factors, SCT has been recommended in the literature as a useful framework for breastfeeding interventions that target fathers (Mitchell-Box & Braun, 2012; Sharma & Petosa, 1997). It was used as the basis for the FIFI study, particularly in designing the male-facilitated antenatal sessions, which considered the constructs of self-efficacy and observational learning. It also helped researchers to understand the potential interrelation of different factors, including the overestimation of parental capacity and the underestimation of potential problems with breastfeeding. SCT was also used in Mitchell-Box & Braun's (2013) study of breastfeeding education interventions for fathers in which they state:

[SCT] may be a promising theory upon which to base male targeted breast feeding interventions, as it calls for promotion of knowledge, skills, self-efficacy, observational learning, goal setting, and reinforcements (Mitchell-Box & Braun, 2013, p. 477).

Based on the literature describing the relevance of SCT to both technological interventions as well as breastfeeding interventions targeted at fathers, SCT was chosen as the theoretical framework to guide the development and implementation of the Milk Man app intervention described in this thesis.

Chapter 3 Methods

3.1 Introduction

The Milk Man app was developed as an intervention in the Parent Infant Feeding Initiative (PIFI). The PIFI was a four-armed, factorial randomised control trial that tested two interventions, the Milk Man app and a male-facilitated antenatal class, both separately and in combination to determine their relative effect on breastfeeding (Maycock et al., 2015). The PIFI followed a translational research approach (Spoth et al., 2013) building on many years of research, and directly followed from the findings of the FIFI described in Section 2.3.3.1 that was carried out by many members of the same team (Maycock et al., 2013). The PIFI was registered with the Australian New Zealand Clinical Trials Registry on 6th June 2014 (ACTRN12614000605695). The PIFI has been described in detail elsewhere (Maycock et al., 2015), and this section briefly outlines the methodology underpinning the study design for the PIFI, which includes the Milk Man app intervention. The methods specifically related to the Milk Man app intervention are also described.

3.2 Parent Infant Feeding Initiative

The PIFI was a four armed, factorial design RCT. It aimed to test the impact on breastfeeding duration of two interventions of differing intensity targeted at the father. There was one control group, two medium intensity groups and one high intensity group. Of the two medium intensity groups, one received a male-facilitated antenatal class (M1) and the other the social support intervention (Milk Man app) (M2). The high intensity group received both the Milk Man app and the antenatal class. Figure 3.1 shows the four arms of the trial. The control group received usual care from their hospital provider (hospital provided antenatal classes).

		Milk Man intervention	
		Yes	No
Male facilitated antenatal class	Yes	HI (high)	M1 (medium 1)
	No	M2 (medium 2)	Control (C)

Figure 3.1. PIFI intervention study design

The main study objective was to measure the effectiveness of each intervention with a key outcome of increasing breastfeeding duration. The secondary objective was to determine the cost-effectiveness of each intervention.

3.2.1 Aims of PIFI study

The PIFI study hypothesises that:

There will be a 10% or greater difference between the interventions and control groups in the proportion of mothers who are breastfeeding at six weeks and at six months and;

There will be a 10% or greater difference between the interventions and control groups in the proportion of mothers who introduce infant formula and complementary food during the first six months after birth.

3.2.2 Sample size and recruitment

A sample size of 300 fathers in each group was deemed necessary to enable detection of a 10% difference in breastfeeding at 80% power and at a 5% level of significance using a log-rank survival test. The recruitment aim was set at 400 in each group to account for a 25% attrition rate. As survival analysis was used to calculate the time to breastfeeding cessation, the sample size was calculated in terms of the hazard ratio taking into account the censoring of data.

Parents were recruited from antenatal classes at public and private hospitals in Perth, Western Australia. Antenatal classes were either run as a weekly two-hour evening class conducted over four consecutive weeks, or as a full day class. A researcher attended each antenatal class and described the study to parents. Parents were eligible to participate if they were expecting one child, lived in Western Australia, had internet access and an iOS or Android smartphone, and if both parents were intending on participating in the rearing of their child. Exclusion criteria were if there was an existing medical condition which would inhibit breastfeeding, and if the baby was born before 36 weeks' gestation.

After having the study explained to them, participants were given an information sheet and provided the opportunity to ask any questions about the study. If they agreed to participate, they then completed a consent form, with both parents giving consent to participate.

Randomisation was by cluster (antenatal class) as opposed to the individual. Groups were randomly assigned by a computer program which was overseen by the study statistician.

3.2.3 Procedures

After signing up to the study, couples were informed of their group allocation by the researcher. Couples who were randomised into a group where the fathers had access to the Milk Man app were provided with an information sheet detailing how they could download and sign into the app. Fathers were provided with a code, which matched their PIFI identification number to enable data matching. Participants were asked to download the app soon after signing up to the study and use it as they would any other app. There was no prescribed usage pattern. Two email reminders were sent out automatically if fathers had not downloaded the app within one, and then two weeks. One final follow-up reminder phone call was carried out by the researcher if participants had still not downloaded the app after three weeks.

Couples randomised into a group where the fathers had access to the male-facilitated antenatal class had the details of the class explained to them. The antenatal classes were all facilitated by trained peer volunteers. All the volunteers were fathers of children under the age of two, whose children had been breastfed for a minimum of three months. The volunteers attended the antenatal session at another time (usually the week after for weekly evening classes, or later in the day for the full day classes) and ran a session which lasted for between 45 mins and one hour. The sessions were held while the midwives were facilitating a breastfeeding session with the mothers. The fathers' sessions covered breastfeeding, and a range of other topics including preparing to be a father, bonding, managing expectations in the early days and how fathers can best support their partner.

3.2.4 Data collection and management

Data were collected both by questionnaires that were administered to all participants, and from a customised analytics framework embedded in the app for app users. Both parents were asked to complete a study questionnaire at three time points. Once at recruitment, a second when their baby was six weeks old and a third when their baby was 26 weeks of age. The questionnaires collected data about participant demographics and breastfeeding duration as well as attitudes, breastfeeding self-efficacy, mental health and partner support. This thesis reports results to six weeks postpartum.

All data were managed in accordance with the National Health and Medical Research Council's (2007) guidelines, the *Australian Code for the Responsible Conduct of Research*. Data collection and management was overseen by an experienced project manager. Data collected electronically were stored on a password secured server, accessible only by the research team. Data from the remote server was regularly backed up, encrypted and stored securely. Personally identifiable information and de-identified questionnaire data will be retained separately at Curtin University for seven years in locked storage.

3.2.5 Ethics approval

The PIFI study was approved by the Curtin University Human Research Ethics Committee (Approval No. HR 82/2014). Site specific ethical approval was also provided by The Sir Charles Gairdner Group Human Research Ethics Committee (Reference No. 2014-111), the Women and Newborn Health Service Human Research Ethics Committee (Reference No. 2016037EW) and the St John of God Health Care Human Research Ethics Committee (Ref No:777). In addition, the study received Clinical Governance approval from all participating hospitals.

3.3 Milk Man app intervention

The development of the Milk Man app is described in detail in Chapter 6 and is the focus of this thesis. The intervention development was informed by SCT and adopted a mixed methods approach to evaluation. The Milk Man app aimed to engage fathers with information and conversation about breastfeeding with a view to increasing the support for their breastfeeding partners. Participants had access to the app from recruitment (at approximately 30 weeks gestational age) until 26 weeks postpartum.

3.3.1 Aims

This study aimed to develop and evaluate the impact a socially connected, gamified app about breastfeeding that was targeted at fathers, had on exclusive breastfeeding duration. Breastfeeding duration was measured at six week postpartum.

3.3.2 Objectives

As well as the overall aim of the study, the research involved discrete yet connected phases with accompanying objectives.

1. To review the evidence of the use of mobile technology in health promotion initiatives in general, and with the target group.
2. To develop an engaging breastfeeding app for fathers, informed by the literature and marketing audit and with input from stakeholders and members of the target group, that would provide them with the information and support they need to effectively support their breastfeeding partners.
3. To conduct comprehensive process evaluation investigating which of the app engagement strategies were effective in motivating and engaging users.
4. To determine the effect of the Milk Man app on breastfeeding behaviour and whether level of app engagement was associated with breastfeeding outcomes.

3.3.3 Procedures

Participants were given information on how to access the Milk Man app in their antenatal classes. After they had logged in to the app and created a profile, they were manually placed into a group by the researcher depending on when their baby was due. This enabled the information that was pushed out to fathers through the conversation to be time-relevant to them, and enable conversation with other fathers at roughly the same perinatal stage. Details of the app and the intervention management, including the notification schedule and protocols developed to guide the research project are described in Chapter 6.

3.3.4 Study design

The development of the Milk Man app was based on SCT. The evaluation plan developed for the intervention is detailed in Chapter 4. The app development process is described in Chapter 5 and Chapter 6. The stages of the study are outlined below.

Milk Man study phases

1. Literature review focusing on mobile technology and health promotion, and factors impacting on paternal support for breastfeeding.
2. Focus groups and input from members of the target group and health professionals.
3. A marketing audit of current advertising and campaigns targeting men in the 20-44 year age group, and an audit of breastfeeding apps.
4. App design concept and content development informed by SCT. Input and feedback from research team on app design concept, content and development.
5. Beta testing and user testing of the prototype.

6. Milk Man app intervention trial and data collection.
7. Data analysis and reporting.

3.3.5 Data collection and analysis

The study used a mixed methods research approach collecting both qualitative and quantitative data at different phases. Mixed methods research has been defined as:

...research that involves collecting, analyzing, and interpreting quantitative and qualitative data in a single study or in a series of studies that investigate the same underlying phenomenon (Leech & Onwuegbuzie, 2009, p. 265).

In mixed methods studies, a combination of techniques is used to explore and describe the research. It involves the intentional collection of different types of data, and then integrating both in the results and discussion to gain a deeper understanding of the study implementation and findings (Creswell, Klassen, Plano Clark, & Smith, 2011). With such a broad focus on evaluating different phases in the implementation of the Milk Man app trial, combination of both types of data from multiple sources was integral in understanding user involvement in the study and how that impacted on outcomes.

The two sources of data were the six week questionnaire and the app analytics framework. The analytics framework was embedded in the Milk Man app and recorded user actions performed in the app over time. A link to the online six week questionnaire was emailed to mothers and fathers when their baby was approximately six weeks of age. The questionnaires were made available using Qualtrics software (Qualtrics, 2017). The PIFI questionnaire contained a range of questions for parents outside of the scope of this thesis and the relevant questions are included in Appendix A for fathers and Appendix B for mothers.

3.3.5.1 Quantitative data

In evaluating this study quantitative data were collected from several sources at different phases of the study. These include:

- Demographic data from focus group and user-testing participants
- Demographic data from the baseline questionnaire from both parents
- Breastfeeding outcome data and process evaluation data from the six week questionnaire from both parents
- App usage data from the app analytics framework

Quantitative data were analysed in SPSS version 23 (IBM Corp, 2015) and the individual tests used are described in detail in Chapter 7. The breastfeeding data of the two groups were compared using Pearson chi-squared tests of association. Association between process evaluation variables were examined using Spearman's rank correlation. Both intention-to-treat (ITT) protocol and per-protocol were used to investigate the impact of the Milk Man app intervention on breastfeeding outcomes. Time to breastfeeding cessation was analysed using survival analyses. Association between Milk Man app engagement levels and breastfeeding outcomes was evaluated using a Pearson chi-squared test. Statistical significance was achieved if $p < 0.05$.

3.3.5.2 Qualitative data

Qualitative data were also collected from different sources throughout the study. These included:

- Focus groups with fathers and health professionals (interview guide development and focus group procedures detailed in Chapter 5)
- Think-aloud walkthrough studies in the user testing phase (think-aloud walkthrough and procedures detailed in Chapter 6)
- Open text answers given in the six week questionnaire (procedures and results described in Chapter 7)
- Comments posted by fathers in the app-based conversation forum (method and procedure described in Chapter 8)

NVivo 11 (QSR International, 2015) was used to organise all qualitative data. The data were analysed using a thematic analysis which involves coding the data into patterns or themes to enable organisation and understanding of data (Braun & Clarke, 2006). Words and phrases were examined and themes developed from shared meanings. Thematic analysis of qualitative data involves a six-step process, these steps are:

1. Data familiarisation
2. Initial generation of codes
3. Searching and identifying themes
4. Reviewing themes
5. Defining and naming the theme
6. Final analysis and report production (Bryman, 2004)

A sentiment analysis was also carried out with the open text responses given by mothers regarding their thoughts on the Milk Man app, to enable investigation of the appropriateness of the method for mothers. This type of analysis can be useful in determining overall sentiment across a large amount of qualitative data (Mäntylä, Graziotin, & Kuutila, 2016). Analysis involved initially coding a participant's response to a top-level sentiment node of positive, negative or neutral and then to a number of child nodes, or categories (for example - *good for dads, helpful / informative*) as per the content of the response.

As qualitative research is inherently subjective, there are additional considerations in terms of verifying the process and trustworthiness of analysis. These include determining:

- Dependability (reliability - proper qualitative processes have been followed)
- Credibility (internal validity - findings would be credible from the perspective of the participant)
- Confirmability (objectivity - analysis is not subject to the researcher's bias)
- Transferability (generalisability - degree that the results can be transferred to other settings) (Bryman, 2004; Shenton, 2004)
- Authenticity (findings have transformative potential and are useful) (Bryman, 2004)

Qualitative data were transcribed verbatim, coded manually and the coding was then checked by another researcher trained in qualitative analysis to ensure dependability (Bryman, 2004). Confirmability was enhanced by ensuring the codes and themes were analysed by the research group. Credibility was also achieved by ensuring the focus groups process was consistent with good practice. Transferability was achieved by ensuring the data were as rich as possible (Bryman, 2004). Authenticity of the data was achieved as the focus group data and user-testing data were reviewed by the immediate researcher and key findings discussed with the wider team to inform the development and refinement of the app. Qualitative data were then combined with the quantitative findings to triangulate the data and further explore people's experiences with the app use.

3.3.6 Milk Man engagement index

An engagement index (EI) was developed for the Milk Man intervention to enable users to be grouped into differing levels of app engagement. This enabled examination of the impact different patterns of use had on breastfeeding outcomes, and to determine if any specific demographic factors predicted engagement level. The engagement measure used for Milk Man was informed by other measures used in this field, in particular by the WebMatrix Visitor Index (Peterson & Carrabis, 2008) that was adapted for the Growing Healthy study (Taki et al., 2017) and the approach adopted in a gamified health promotion intervention (Baltierra et al., 2016). While the Milk Man EI is informed by previous work in this area, the model described by Taki et al. (2017) was adapted to create an EI specifically for the needs of this intervention.

The EI developed for Milk Man aimed to rank and organise participants from within the cohort to identify those who were higher and lower app users. The EI used for Milk Man is described in Table 3.1. In this index, users were benchmarked to the highest score achieved by a participant in the cohort to give a possible range of engagement score from 0-100 for each subindex. The index was calculated over the period from participant sign up (approximately 30 weeks' gestation) to six weeks postpartum. All subindices were considered equal. The EI was calculated for participants who had both downloaded the app, and had completed the six week questionnaire.

Reading subindex (Rei):

This subindex was adapted from the Web Matrix click-depth subindex, and was designed to measure only articles read in the app library, rather than page-view taps. The Rei measured the number of library articles a participant viewed, which was benchmarked to the highest number read by any Milk Man participant - 117 articles read.

Loyalty subindex (Li):

This subindex measured how often a participant had accessed the app over the recording period. App access was calculated using unique days the app was opened, regardless of how many times an app was opened on a particular day. This was benchmarked to the highest number of app open days by any participant in this study – 62 days.

Interaction subindex (Ii):

Web Matrix defined this subindex as seeking to '*capture visitor interaction with content or functionality designed to increase level of attention the visitor is paying to the app*' (Peterson & Carrabis, 2008, p. 6). In the case of Milk Man, the gamification framework awarded points to users based on their interaction with the different app functions. Therefore, a participant's points score was used as a measure of interaction. The Ii was defined by the number of points scored by an individual user, benchmarked to the highest number of points scored by any participant in this study – 153 points.

Recency subindex (Ri):

The recency subindex was described by Web Matrix as '*...the rate at which they return to the site. The calculation is very simple for any given session: $R_i = 1/\text{Number of days elapsed since the most recent session}$* ' (Peterson & Carrabis, 2008, p. 24). This was adapted for Milk Man to measure the last week each participant visited the app in weeks prior to six weeks postpartum.

Feedback subindex (Fi):

The feedback subindex used information collected in the six week questionnaire to measure participant satisfaction with the app. Fathers indicated how strongly they agreed or disagreed with specific statements about different components of the app. For this subindex, the six general statements about the participant's overall perspectives of the app were used. Questions were answered using a Likert scale, and a positive response was recorded if the participant answered strongly agree, or agree to any of the questions. The number of positive responses was divided by six and then multiplied by 100. The six statements included were:

- The app was easy to use
- The visual design was appealing
- I would recommend the app to other dads
- The app was interesting / fun to use
- The app made me more aware of how I can help with breastfeeding
- The app has led to discussions with my partner

The formula for each subindex is detailed in Table 3.1. The overall EI score for each user was calculated by averaging the five subindices. Participants were then placed into three groups: poorly engaged, moderately engaged and highly engaged. A Pearson chi-square test was conducted to explore the association between the different levels of engagement and exclusive breastfeeding at six weeks postpartum (yes or no). This was then repeated with the three engagement levels and the control group. Chapter 7 describes the results of the EI and how the EI was then used to explore the association of app engagement and breastfeeding outcomes.

Table 3.1. Milk Man engagement index

Subindices	Milk Man description	Formula
Reading subindex	Interaction with library contents	$Rei = 100 \times \left(\frac{\text{Total library articles read}}{117 \text{ (highest no of articles read)}} \right)$
Loyalty subindex	Total number of times person has accessed the app	$Li = 100 \times \left(\frac{\text{Total unique days where the app was opened}}{62 \text{ (highest no of days app was open)}} \right)$
Interaction subindex	Gamification points percentage	$Ii = 100 \times \left(\frac{\text{users points score}}{153 \text{ (highest point score)}} \right)$
Recency subindex	Time of last visit prior to six weeks post birth	$Ri = 100 \times \left(\frac{1}{\text{No of weeks elapsed since most recent session (17 – week last open)}} \right)$
Feedback subindex	Subjective measure - Includes a measure of satisfaction with the program	$Fi = 100 \times \left(\frac{\text{No of positive responses to general MM questions (SA or A)}}{\text{All questions (6)}} \right)$


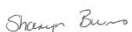


Chapter 4 Milk Man evaluation plan

4.1 Introduction

Chapter four is a peer reviewed journal article that investigated four mHealth evaluation models and tools and described the evaluation plan that was developed for the Milk Man app. This article was published in the Health Promotion Journal of Australia (B. K. White, Burns, et al., 2016).

White, B. K., Burns, S. K., Giglia, R. C., & Scott, J. A. (2016). Designing evaluation plans for health promotion mHealth interventions: a case study of the Milk Man mobile app. Health Promotion Journal of Australia, 27(3), 198-203. doi: <http://dx.doi.org/10.1071/HE16041> [Impact Factor 1.097]

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Permission:

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Designing evaluation plans for health promotion mHealth interventions: a case study of the *Milk Man* mobile app

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Abstract. Evaluating complex health promotion interventions that use mobile apps requires comprehensive and adaptive evaluation plans. As mobile usage becomes increasingly sophisticated and personalised, broad evaluation plans are important in determining the impact and efficacy of a mobile health (mHealth) app. Evaluation should consider user feedback and outcome measures, as well as examine elements such as the robustness of the technology, the intervention principles and engagement strategies, and the interaction of the user with the technology. This paper introduces four mHealth evaluation models and tools and describes the evaluation plan that has been developed for *Milk Man*, a breastfeeding app targeting new and expectant fathers. *Milk Man* is a socially connected, gamified app that is being tested in a large Randomised Control Trial (RCT). While there is a need for mobile apps to be evaluated in adequately powered RCTs, trialling mobile apps over a long period of time presents challenges. Incorporating robust evaluation design will help ensure that technological performance, app intervention principles, as well as health and behavioural outcomes are measured. The detail and scope of the *Milk Man* app evaluation plan will ensure the findings add to the evidence base and have broad relevance to health promotion practitioners.

So what? Evidence about the efficacy of mHealth interventions is an emerging area and appropriate evaluation skills are needed. This paper illustrates an evaluation planning approach for mHealth interventions that could be adapted for use by health promotion practitioners and researchers.

Key words: breastfeeding, evaluation methods, evidence-based practice, information and communication technology.

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Introduction

In 2014 there were over 100 000 health and fitness apps available in the app stores of the two major mobile platforms (iOS and Android),¹ yet despite the proliferation of mobile health (mHealth) apps, there remains a lack of definitive evidence of the efficacy and impact mHealth apps can have in terms of reach, behaviour change and, ultimately, health outcomes. This paper discusses the need for comprehensive evaluation plans for mHealth interventions, highlights four evaluation models and tools and describes the evaluation plan of a socially connected, gamified breastfeeding app targeted at fathers – the *Milk Man* mobile app.

Mobile apps and health promotion

Mobile devices offer unique opportunities for health promotion professionals to design tailored interventions that make use of innovative technology to reach populations.^{2–4} Physical activity

interventions, for example, utilise inbuilt pedometers and accelerometers to accurately record exercise and movement,⁵ and nutrition interventions seeking to utilise food diaries can benefit from non-textual data entry, including the use of photos.⁶ Other mHealth apps incorporate strategies such as gamification, social connectivity and push notifications to reach people as they go about their daily lives.⁷

This concept of reaching people throughout their daily life is described as an Ecological Momentary Intervention (EMI).⁸ Mobile devices are a perfect fit with EMIs because peoples' relationships with their smartphones are often intimate and constant, with almost 50% of Australians reaching for their phone within 15 min of waking.⁹ This connection to devices continues throughout the day with the average person checking in with their phone twice every hour.⁹ People rely on their devices for an increasing number of everyday tasks – banking, scheduling, connecting with friends and

checking emails can all be coordinated from the one device. One UK study found smartphones were used to perform an average of 221 tasks daily, equating to 3 h and 16 min of device use every day.¹⁰ With such a strong connection, there are genuine opportunities for health behaviour-changing EMLs to reach individuals, groups and populations through their mobile device. Encouraging results have been reported for mHealth interventions designed for breastfeeding mothers,¹¹ promoting positive mental health to adolescents¹² and nutrition for adults.¹³

While apps for health appear to have great potential in reaching populations,²⁻⁴ there remains a lack of evidence in terms of the efficacy of their use, particularly in terms of the impact on health outcomes.¹⁴⁻¹⁶ The need for more evidence of the effectiveness of health apps is a common recommendation in the literature,^{2,17} yet there are significant challenges in designing and implementing Randomised Control Trials (RCT) for mHealth apps. In particular, the difficulty in trialling an app over the period of time typically needed for adequately powered trials, and the potential for either changes to the technology or the technological expectations from the user over this time.¹⁸ The World Bank states mHealth services have the potential to deliver better public health outcomes at a lower cost than traditional programs, yet also states there is a lack of evidence of positive behaviour change.¹⁶ There is a need to evaluate the cost effectiveness of mHealth interventions delivered via mobile apps in comparison to other ways of reaching specific populations and motivating positive behaviour change.

An individual's usage and engagement with apps is complex and sophisticated. Many factors can impact on the success of an mHealth intervention; to determine its success, evaluation should examine user feedback and outcome measures, as well as the robustness of the technology, the intervention principles, engagement strategies and the interaction of the user with the technology.

Evaluation is an integral part of health promotion planning and implementation¹⁹ and more knowledge and evidence is needed about what works with targeted mHealth interventions. To generate evidence to improve health promotion practice, evaluation needs to be conducted throughout the implementation of an intervention not only at the conclusion.²⁰ A multifaceted evaluation plan is required to assess the complex web of components that could impact on the success of an mHealth intervention.

Evaluating mHealth initiatives

As the number of mHealth initiatives has increased, researchers have developed several models and tools to guide evaluation. This paper describes four different approaches from the published literature. Two approaches described, the Collaborative Adaptive and Interactive Technologies framework and the Mobile Application Rating Scale, were incorporated into the development of the evaluation plan for the *Milk Man* app. More recent examples are the Trial of Intervention Principles framework and the WHO mHealth

Evidence Reporting and Assessment Checklist. These did not form part of the *Milk Man* evaluation plan; however, the overlap in approaches is a confirmation of the growing consensus in reporting on mHealth interventions.

Collaborative Adaptive Interactive Technology framework

The Collaborative Adaptive and Interactive Technologies framework was developed by O'Grady *et al.* in 2009.²¹ The authors define 'collaborative adaptive and interactive technologies' as those technologies that facilitate collaboration between users, support adaption of content according to users' needs and enable user interaction with the technology.²¹ This type of approach is particularly relevant for interventions that connect people, groups and populations through technology. The framework organises formative, process and impact evaluation over five key areas:

1. People – the users and stakeholders
2. Content – information or content
3. Technology – the technology used to develop and maintain the intervention
4. Computer-mediated interaction – the interactions between the user and the technology, and how the technology supports interactions between users
5. Health systems integration – how the intervention interacts with and impacts on the broader health system.

While developed with web-based interventions as the focus, the framework is comprehensive and has broad relevance to mobile apps, particularly socially connected apps that are to be trialled over a long period of time, such as *Milk Man*.

Mobile Application Rating Scale (MARS)

The MARS was developed by a multidisciplinary team as a reliable tool to assess the quality of health apps and was released in 2015.²² The scale comprises five categories, including four that measure:

1. Aesthetics – graphics, layout, visual appeal
2. Engagement – entertainment, customisation, fit to target group
3. Functionality – performance, navigation, gestural design
4. Information – quality, quantity, visual information, credibility.

The fifth category is a subjective 'quality' scale and asks users their opinions including if they would recommend the app to others and if they would pay for it.^{22,23} The categories covered by the MARS are designed to measure a range of factors important in mobile apps and give health professionals a valid, reliable and easy-to-use tool to help them assess quality.

Trial of Intervention Principles framework

Mohr *et al.* suggest that traditional RCTs are not ideal for testing Behavioural Intervention Technologies (BIT).¹⁸ This is due to the extended time periods required for adequately powered trials that can be in direct conflict with changing technology. The Trial of Intervention Principles framework¹⁸ focuses on defining and testing the intervention principles (actual intervention aims and strategies) as opposed to a static version of the BIT that cannot be altered. By focusing on testing the intervention principles (for example, in

the case of *Milk Man*, testing the delivery of a social support intervention for fathers via a mobile app) the model allows for some modifications to the actual BIT (improving usability and functionality, for example) as long as any changes are reported.

WHO mHealth evidence reporting and assessment checklist

In 2016, the WHO mHealth Technical Evidence Review group released a checklist detailing 16 key criteria for reporting and assessing mHealth interventions.²⁴ The checklist identifies criteria needed to define the content of the intervention (what it is), the context (where it is being implemented) and the technical features (how it is being implemented). It includes criteria such as usability, cost assessment, interoperability, content and data security. The checklist was developed to help researchers develop and assess the evidence in mHealth interventions by providing a checklist for reporting the quality of the intervention (as opposed to actually evaluating the quality of the intervention).²⁴

Summary

The four approaches described are different in their intent, focus and scope yet there are distinct similarities in that they all focus on taking a multifaceted approach to evaluating mHealth interventions. Both the Trial of Intervention Principles framework and the Collaborative Adaptive Interactive Technology framework are comprehensive in scope and could be adapted for longer- or shorter-term interventions. The MARS is an easy-to-use, validated tool that can be incorporated into app development to strengthen the development process by identifying areas of weakness or strength or to rate already existing apps. The WHO mHealth example offers a concise checklist to refer to throughout the implementation of a project.

Evaluation needs and constraints will differ for each intervention. Health promotion practitioners are encouraged to consider the above approaches and design plans that incorporate components that focus on what is important and feasible for their own programs.

The *Milk Man* app

Milk Man is a socially connected breastfeeding app designed specifically for fathers that was developed as a strategy for use in the Parent Infant Feeding Initiative (PIFI) study.⁷ The PIFI study is a four-armed RCT that aims to increase the duration and/or exclusivity of breastfeeding.²⁵ The study involves testing two different interventions designed to increase fathers' support for breastfeeding: a male-facilitated antenatal class and the *Milk Man* mobile app.

Milk Man utilises several engagement techniques including gamification (the process of embedding game-like elements in things that are not games, in the case of *Milk Man*, leaderboards, points and badges) and push notifications (notifications sent to users that appear on the home screen of their phone alerting them to new content).⁷ *Milk Man* has an extensive, searchable,

evidence-based information library and a guided user-to-user conversation forum. Fathers are placed into groups depending on when their baby is due enabling age-relevant information to be pushed out twice a week through the conversation forum and fathers to be able to interact with peers with similar aged babies. The aim of the app intervention is to increase the support new and expectant fathers provide their breastfeeding partners, which we hypothesise will lead to an increase in breastfeeding duration, and in particular an increase in the duration of exclusive breastfeeding.

Milk Man evaluation plan

In developing the evaluation plan for the *Milk Man* app, there was a focus on planning for ongoing evaluation throughout the development of the app and through the trial. This encompassed three stages of evaluation: formative (takes place while planning interventions), process (takes place during the implementation) and impact (assesses the outcomes of the intervention) evaluation.^{20,26}

Milk Man is the first breastfeeding app we are aware of that targets fathers. The development of the app included formative evaluation with input from the target group and health professionals, and a user-testing phase encompassing a think-aloud walkthrough and completion of the MARS.⁷ PIFI study data are collected from participants via self-administered questionnaires at recruitment and at six and 26 weeks post-birth. Additionally data from the *Milk Man* app are collected via a customised analytics framework and through content analysis of the conversation forum.

The *Milk Man* evaluation plan is detailed in Appendix 1, and focuses broadly on evaluating the delivery of a social support intervention through a mobile app. The comprehensive plan is based on the Collaborative Adaptive Interactive Technology framework developed by O'Grady et al.²¹ and is designed to measure indicators for the formative, process and impact evaluation of the app across the five different areas – people, content, technology, computer-mediated interaction and health systems integration. As the trial is currently underway, the formative evaluation phase has been completed, with process and impact evaluation still being conducted. The five areas of evaluative focus are described below.

People

In the case of *Milk Man* 'people' refers to end-users (fathers) and stakeholders (health professionals). The formative evaluation phase informed the development of *Milk Man* and sought to identify end-users' and stakeholders' needs. This included an extensive literature review, focus groups and user-testing involving a think-aloud walkthrough of the app and completion of the MARS.⁷ Think-aloud walkthroughs are a common way of testing health apps where the user is observed using the app while verbalising their thought processes as they do so.²⁷ This can help to highlight issues with usability and navigation. Focus groups were conducted with end-users and stakeholders. Stakeholders were important to include at this stage as the health professionals we spoke with had

direct and ongoing contact with new and expectant parents and were able to offer insight into emerging trends and how to engage fathers. The end-user groups focused on the acceptability of the proposed engagement strategies, the framing of the app and the appropriateness of the approach and content. Indicators of user perspectives were included at both the formative and process level along with individual's intentions and motivations to use the app. Stakeholder groups focused more on the content of the library and on how best to engage the target group.

Data were gathered by the completion of the think-aloud walkthrough studies and the MARS,^{22,23} and ongoing process data are being collected via questionnaires collected at six weeks postpartum as part of the RCT. The impact assessment includes examination of data gathered from the six- and 26-week study questionnaires including breastfeeding outcomes,²⁵ as well as several other constructs such as partner support²⁸ and breastfeeding self-efficacy.²⁹

Content

The 'content' in the case of *Milk Man* refers to the static informational content, or 'library', contained within the app, as well as the dynamic, ever-changing, user-generated content in the conversation forum. In developing the app, formative evaluation sought to test the quality and credibility of the app content through focus groups. Understandability, functionality and usability were measured at the process stage via the think-aloud walkthrough studies, the MARS²³ and the six-week study questionnaires.

The app contains a socially connected forum for fathers to interact with each other and the impact assessment will focus on examination of the conversation content that was generated. This will begin with an assessment of the role that this forum appears to have played for users; for example, has it been of assistance for seeking advice? Has it offered emotional support? It will also examine the positioning of this forum within the app. For example, investigating if the forum was the central function that users returned to repeatedly, and used as a gateway to library information, or if they tended to find information directly in the library section, perhaps via the search function.

Technology

Technology refers to the software used to create and run the app. In this case, the formative phase included indicators such as the robustness of the system in terms of performance and speed of loading, including how it performed with multiple users. It also involved examining the two different operating systems employed by the study (iOS and Android) and examining the similarities and differences. Privacy of users was an important consideration including how data were stored and coded to maintain research integrity and confidentiality. This included the development of a robust set of management protocols for the app. Process evaluation will involve an examination of the analytics framework embedded within the app to answer questions such as, how people are using the

app, which sections are the most popular and at what age of their child, or developmental milestones, are fathers most often seeking information and support. The impact assessment will involve looking at the dynamic evolution of the app (how it responds to new technologies or social trends) over time, which is particularly important in this study as the app is being trialled over a two-year period. By examining how the app responds to operating system updates and other technological changes the robustness of the technology over time can be monitored, and the impact this may have on implementation can be considered.

Computer-mediated technology

Computer-mediated technology describes the interaction of users with the technological interface. Formative evaluation primarily included the think-aloud walkthrough studies that measure the usability of the app, how the information is organised and how intuitive this is for the user. Further information is sought from users about their perspectives on the usability, findability and sociability of the app through the app-specific questions included in the six- and 26-week study questionnaires. The impact assessment will use app analytics and content analysis of the forum to explore the 'community development', how the app has supported the interaction of the 'community' or the users on the study over time, and how users have engaged with each other and with the technology.

Health systems integration

Health systems integration represents the larger system in which the intervention may be implemented.²¹ In this case the formative evaluation involved the development of a comprehensive evaluation framework, and consideration of ethical issues. Process evaluation will assess the impact of the app on participants' usage of other health services. This will include examining visits to external websites from within the app, and data collected via the study questionnaires that asks participants about the health professionals they have consulted in relation to breastfeeding. The impact assessment of the *Milk Man* app will include consideration of its sustainability and how it can be embedded into existing health services. Finally, the PIFI study includes an economic analysis of the cost effectiveness of the two different interventions being trialled.²⁵

Discussion

As mobile technologies continue to become integrated into the daily lives of individuals and populations, health promotion practitioners will increasingly require the ability to plan effective mHealth interventions. Challenges remain in the development of mHealth interventions, including privacy and data security considerations, the need for more evidence about their efficacy and demonstrated pathways for sustainability beyond funded projects. Incorporating comprehensive evaluation into program planning will help ensure the evidence base continues to grow.

The *Milk Man* case study describes a comprehensive evaluation approach that will provide evidence from an adequately powered RCT to inform future mHealth interventions. While this detailed approach will not be practical for every intervention, if practitioners and researchers continue to think broadly about how they can incorporate ongoing evaluation across a range of factors, the sector will be best placed to grow the evidence.

Conclusion

The technology sector moves and iterates quickly. As more health promotion practitioners and researchers seek to incorporate mHealth into interventions, there is a need to ensure the skills and knowledge of the workforce remain up-to-date with new technologies. The tools and case study described here can help guide health promotion practitioners working in mHealth to develop effective and thorough evaluation plans. Developing comprehensive plans, such as the one described in this paper for the *Milk Man* app, will help ensure that the knowledge is transferable and relevant across disciplines and move health promotion research towards a greater understanding of how mHealth can be best used.

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Appendix 1. Milk Man app evaluation plan

	Formative evaluation		Process evaluation		Outcome Impact assessment	
	Indicator	Measurement	Indicator	Measurement	Indicator	Measurement
People (app users and stakeholders)	User traits: – Identification of key characteristics of target group to inform app User perspectives: – Identification of target group needs	Focus groups Literature review	User Perspectives: – Intentions to use – Satisfaction – Motivation for use – Awareness, knowledge, attitudes	MARS Questionnaires	Health outcomes: – Impact on breastfeeding outcomes Constructs that mediate breastfeeding behaviour: – Knowledge – Attitudes – Social support – Partner support – Breastfeeding self-efficacy	Multivariable analysis, correlations between app usage and specific determinants Questionnaires
Content (all content contained with the app)	Quality and credibility of app content: – Understandability – Relevance – Completeness of content	Focus groups	– Quality and credibility – Usefulness – Level of personalisation	MARS Questionnaires	User-generated content produced: – Nature (advice, opinion, emotional support etc.) – Positioning of content	App analytics Content analysis of user comments
Technology (technology used to create and run app)	System robustness: – Performance – Loading speed – Performance with multiple users – Privacy of data Platforms: – Interoperability	Beta testing Research team testing	Usage stats: – Page hits and usage – Patterns of usage System reliability: – Speed – Interoperability	App analytics Questionnaires	Dynamic evolution: – Response to software updates – Ongoing nature of app	Response to updates Recommendations from findings
Computer-Mediated Interaction (user interactions with interface)	Usability Information architecture: – Organised to support user Sociability	Beta testing User testing (think-aloud walkthroughs)	User perspectives on: – Usability – Accessibility – Sociability (mechanisms to support community) – Findability (could people find what they were looking for?)	Questionnaires	Community development: – How app has supported community interaction Evidence of collaboration: – How community has responded over time – Nature of collaboration	App analytics Content analysis of user comments
Health Systems Integration (refers to the broader health system processes)	Evaluation metrics incorporated Ethical issues	Evaluative framework All necessary ethical clearances	Service Utilisation: – Ways in which the site may be affecting delivery of health services (impact on other service utilisation)	Questionnaires	Public impact: – Effect on the wider community – Appropriateness of methods Effectiveness in terms of reaching health outcome goals Cost effectiveness	Statistical analysis Questionnaires Recommendations from findings Economic analysis

Chapter 5 Formative evaluation

5.1 Introduction

The important role fathers play in supporting their partners with breastfeeding provides compelling evidence for their inclusion in antenatal education. Beyond this though, increasing opportunities for fathers to be included in perinatal education and social support initiatives is likely to impact on their own self-efficacy, mental health and parenting skills. Despite the wide reach of mobile devices, Section 2.4 demonstrated that there are few mHealth interventions that have focused on breastfeeding and targeted fathers.

Due to the paucity of research available to inform the development of a father-focussed breastfeeding app, including a consultation with fathers and key stakeholders was imperative in the development of this research project. This formative evaluation was carried out via focus groups with members of the target group (new or expecting fathers) and hospital-based health professionals involved in the perinatal care of families. A multidisciplinary research team at Curtin University consisting of breastfeeding researchers, health promotion professionals, dietitians, a midwife and an app designer and developer were also consulted at various stages with this team acting as a steering committee.

The formative evaluation consisted of two phases:

- Focus groups with members of the target group
- Consultative sessions with health professionals

A semi-structured interview guide was developed for the focus groups informed by SCT. The questions within the interview guide were designed to investigate the mobile device usage behaviour of participants, as well as their experiences with using apps and their needs as new fathers. Feedback from these sessions provided information to help the researcher better understand how best to engage fathers with the intervention. A summary of the information in this chapter, and the following chapter was published in the JMIR mHealth and uHealth in 2016 (B. K. White, Martin, et al., 2016) Appendix C.

5.2 Focus groups with fathers

5.2.1 Aims

The focus groups with fathers aimed to:

- Determine framing for the intervention
- Investigate the acceptability of the engagement strategies
- Ensure content was appropriate and credible
- Ensure that the approach was appropriate.

5.2.2 Recruitment

A purposeful sampling method was used to recruit participants (n=18) to the focus groups through existing networks, the Curtin university staff and student body, a local playgroup and the researcher's own networks. Men were eligible to participate if they owned a smartphone, and were expecting a baby, or had a new baby aged under six months of age. Three focus groups were conducted at three different locations in the Perth metropolitan area over a one-month period in February 2015. Focus group one was held in the northern suburbs of Perth, at Wanneroo Playgroup, and recruitment focussed on local community message boards on Facebook and the researcher's own networks. Focus group two was held in the southern Perth suburb of Bentley at Curtin University, and recruitment was facilitated via a staff broadcast email. Focus group three was held in the western suburb of Shenton Park at another Curtin University campus and recruitment focussed on the researcher's local networks. The recruitment poster is included at Appendix D.1.

5.2.3 Procedures

When participants arrived at the session, they were given an information sheet explaining the study, as well as a consent form. The researcher outlined the study to them individually, highlighted that the session was to be audio-recorded and provided the opportunity to ask questions. Once participants had signed the consent form, they completed a brief demographic questionnaire asking their age, marital status, number of children and if each previous child had received any breastmilk. Refreshments were served to participants and each participant was given a \$25 Target shopping voucher as a thank you for their time.

This sub-study of the PIFI project was approved as a protocol amendment by the Curtin University HREC on the 3rd of December 2014 (HR82/2014). The focus group information sheet, consent form and demographic questionnaire are included in Appendix D.2.

5.2.4 Interview Guide development

The semi-structured interview guide for the focus groups was informed by SCT and developed to address the aims described above. SCT highlights a number of constructs that can impact health behaviour, which are pertinent to breastfeeding. The focus groups were designed to elicit information about smartphone use and expectations about breastfeeding and parenting. Questions addressing breastfeeding self-efficacy, observational learning and social support were included to examine how the proposed app could best positively impact these specific areas. The questions were grouped into two main sections:

- Section one: Smartphone use and behaviours
- Section two: Breastfeeding attitudes and support pathways

Section one sought to better understand smartphone ownership and usage patterns of participants as well as identify apps and engagement techniques that were appealing. Questions were framed around understanding what kinds of apps participants used, what it was about the apps they liked, or didn't like, and what motivated their use of those apps. Participants use of parenting and health apps were also explored.

Section two focussed more specifically on breastfeeding, fathering and how an app for fathers could best be targeted. Participants were asked their thoughts about social support opportunities including through an online forum. The questions also explored infant feeding attitudes, information provision and environmental factors.

The interview guide is included at Appendix D.3. For each sub-section, the aim is articulated, and in Section two the SCT constructs being investigated are also listed. The semi-structured interview guide was used to guide the conversation in the sessions. Due to the nature and flow of the conversation, there was overlap in some sections and not all questions were necessarily asked in order, or asked at all if they had been covered in a different section.

5.2.4.1 Data collection and analysis

Each focus group was facilitated by the same researcher and observer who both kept notes throughout the session. The two facilitators debriefed after each session and compared and discussed the main points, including how the session had been received by the participants.

The recordings from the sessions were transcribed verbatim and reviewed by the researcher alongside notes to maintain dependability and determine credibility (Bryman, 2004). Data were coded manually and categories and themes created to help group the data and aid analysis and understanding. Coding was independently verified by another researcher trained in qualitative analysis to reduce bias and enhance confirmability (that the themes were shaped by participants rather than researcher) (Bryman, 2004). NVivo 11 (QSR International, 2015) was used to manage the data.

5.2.5 Results

A total of 18 men attended the three focus groups. Participants were aged between 30 and 43 years. Most were married (n=14), just under half were expecting a baby (n=8), and the remainder had a new baby aged under six months (n=10). Table 5.1 provides a summary of participant characteristics.

Table 5.1 Demographic summary of focus group participants (n=18)

Age in years	
30-34	10
35-39	7
40-44	1
Marital status	
Married	14
Defacto	2
No answer	2
Children	
Expecting a baby	8
Baby aged under 6 months	10

The thematic analysis revealed four main themes:

- Mobiles are used throughout the day for a variety of reasons
- App engagement should be carefully considered
- App should be targeted and funny
- Fathers need support and information about breastfeeding and parenting

Mobiles are used throughout the day for a variety of reasons

All men owned either an iPhone or Android smartphone and all said that they kept their phone close at hand and referred to it throughout the day. All participants had some apps on their smartphone.

Every day most of the [day], I'll run through, quickly through Facebook, AFL, cricket, banking. Thursdays I normally do the banking at home so I'm on that Thursday nights, but, every day. (Focus group 3)

Most participants were encouraging of the concept of apps for new fathers. The use of the internet, including mobile apps and YouTube, as a source of parenting information was common, yet participants reported mixed experiences with sourcing, and trusting information online. Most participants stated they were more likely to trust information that came from a government source, or that of a recognised peak body (such as the Australian Breastfeeding Association)

We use the WA Health website sometimes for baby things. So you're searching like coughs or any kind of rashes and stuff like that and you type in the symptom and WA and [you're looking for] not local but regional advice. (Focus group 2)

We stopped trusting anything that wasn't from a doctor 'cause we got 50 different opinions and my wife ended up freaking out, got told 20 different things from 20 different people and one person's kid had a bad reaction to milk after something and that kid died. (Focus group 1)

If there was some sort of endorsement by or in association with or something like that then I'd be more likely to trust an app as well. (Focus group 1)

Or watching the YouTubes I mean they have some instructional kind of video clips then it's easier to believe because you're seeing it and how they do it. (Focus group 1)

Many fathers referred to their partners using pregnancy apps including 'Sprout' (Med ART Studios, 2016) and the 'BabyCentre' (2016). Although fathers reported reading information and watching videos from apps their partners had for pregnancy, few fathers reported sourcing pregnancy apps themselves. The only father-focussed parenting app specifically discussed was the Australian 'Who's your Daddy?' (2017) app. One participant described why he liked that app.

It was just kind of a bit of fun. It had a contraction counter on it and it had sort of a hospital, what to pack the hospital bag and things and that was yeah sort of your weekly updates were quite succinct but they were just interesting sort of facts that were happening and things. (Focus group 1)

Several fathers discussed using the Google search engine as their primary way of sourcing information, with some then going on to describe the different filtering processes they used to decide which website to choose to view.

I'd come home from work and we'd just Google, you know what can we do to sort this out. Even when we'd seen all these allergy specialists and he spent a couple of nights in hospitals and I don't know, in the end I think he just outgrew it. (Focus group 3)

I found the Victoria Health website is a common Google search and then I'll generally trust that one... (Focus group 1)

We typed in hand, foot and mouth WA and went to the government website which provides information on what it is, what the symptoms are, what to look for, what to expect. So I would definitely use the web, like as a first, first base because then you can ring the help line or the information line. (Focus group 2)

More internet like Google sort of thing, not necessarily like an app. (Focus group 3)

App engagement should be carefully considered

There was a mixed response to the idea of a discussion forum for men to connect to each other. Some participants were positive about the idea, while others stated they would not use it. Some of the reasons participants gave for stating they would not use a forum within an app included not trusting the information, preferring to talk to people in real-life, and that information on forums can be alarmist and cause unnecessary concern.

I don't know, I wouldn't talk to a stranger for starters on an app... we go to barbeques and friends house and their kids are ratbags or this and that and you can't tell your mate how to look after their kid, it's their kid. You don't know what they've been through the night before, you don't know what they've eaten the night before, so I wouldn't ask someone for advice on my child in that sense. (Focus group 3)

Somewhere you could post a question and then dads reply to that but you still, you've got to be able to filter all the crap that comes along with it ... and you'll get all these different answers from all these different dads and you can make your own judgement on what you want to go sort of that sort of way, which way you want to take it. That's sort of probably what I'd be more inclined to do than yeah just have like a one on one chat with another dad or something that you don't know. (Focus group 3)

Fathers who were positive about the idea of talking to other fathers through an app-based forum reflected on their own parenting in describing how they would have used it.

I think other dads, well my opinion would have been directly after the baby was born, maybe in the first sort of six weeks or you know two months, three months whatever would be a better time to have that because it's actually happening then... that's when I would have I think we probably talked more about that sort of stuff in those first few weeks 'cause it's there, you're doing it, you're living it. (Focus group 1)

[support from other dads] Yeah that would [be] alright. (Focus group 3)

Most of the comments about the use of push notifications were positive, as long as they were used judiciously and the content was relevant.

I think the lesson really is notification fatigue. You know some people like them, some people don't. I suppose if you got far too many you just become disinterested and that can actually be more dangerous than not getting a notification. (Focus group 1)

Just from my experience I'd definitely respond better to maybe like a once a week sort of summary or a bit of an update rather than like every few seconds... Almost like a once a week, hey this is what's new sort of thing or this is what's just been happening or like just the top things or something you know. I found that much better and actually then wanted to go in and check that update. (Focus group 1)

Several fathers specifically described parenting-related apps that they either used or knew of which used push notifications. The ability to personalise the settings so the information was tailored and relevant was also discussed by several fathers.

I think it was one which was the weekly, each time the baby hit a milestone which was the weekly thing, you get your week, once a week update. (Focus group 1)

It depends on the validity of the information you're provided in the first stage when you sign up to this app. You ask a bunch of questions you know to set up your profile and get a pattern right and then you know it is the back-end job to really analyse where the baby is or to send out customised information rather than a group send like that sort of notification. That would be more personal and that would be more interesting to watch, to read. (Focus group 1)

Sometimes if it's like on the milestones... it gives you a pop up. (Focus group 2)

Would it be useful to get like notifications of updated information about it? So like 'here's a new way to deal with colic'. Yeah, yeah. (Focus group 1)

One father described his reluctance to allow push notifications to be sent with any of his apps as he resented the intrusion, yet he discussed how he had allowed push notifications from a parenting app due to the relevance of the information.

I don't have a voice mail, voice box, voice mail I don't have, I never had it [with] any phones and I don't have push notifications stuff like that. I did that with that [a parenting] app and maybe two others... stuff that really impressed me, but the rest not. (Focus group 2)

Apps should be targeted and funny

In terms of the tone of the app the use of humour, a light-hearted approach and the app being quick and easy to use were common suggestions from men.

For me light-hearted would be better. Even the best baby I think that first period is probably strap in and get through it kind of time. So if I have to read a text book of really... dry text I'm probably not going to do it. But if it's something quick and easy that ... tells me that what I'm seeing in front of me is correct [I'm more likely to use it]. (Focus group 1)

Push notifications can add that element to the humour. (Focus group 2)

That app's [discussing 'Who's your Daddy' a pregnancy app for fathers] quite unique in how it's written. Like the language is very light-hearted... It said you know like your baby's the size of a hammer and the weight of a, like I don't, coconut or something you know. It was kind of just, related it to beer or something which was you know always, it was just interesting. (Focus group 1)

Dads need support and information

As previously discussed, fathers used the internet and apps to access information about parenting and had strategies for doing so. Reinforcing findings from the literature, men were clear on wanting practical tips for helping their partner, with information ideally delivered in short, summarised formats including bullet points and checklists. Access to more detailed information could be provided via links.

I want bullet points and if I want to read into it more I'll look into it more if I've got the time. (Focus group 2)

Checklists, perhaps a list of [reasons why] my baby won't stop crying and then people could maybe leave suggestions. Doing an up-voting, down-voting vetted type system. Say "try this top answer, this worked really well" [or] "that didn't work, give me another thing on the list to try". (Focus group 1)

Some participants also reported a lack of support for fathers from antenatal and other information service providers. This reinforces the need for father-focussed interventions and that the app may help to fill a void in information provision at this crucial time.

So I did everything but all the support is focussed on her and that sucks.
(Focus group 1)

The information for dads [in the antenatal class] was pretty light on. It was like 'oh ok so I'm just here to rub your belly is that it?' (Focus group 1)

Other participants reflected on an antenatal class they had attended at a hospital which facilitated a short activity where the mothers and fathers were separated to discuss issues independently. This was well received by the participants who had attended, and reinforces the high value placed on peer-support in the perinatal period. This was an important consideration in planning the app.

We did [a class] where the women went to another room and the dads stayed in the room and we did like a joys and challenges sort of thing, all of us together which was quite good... But it was good to have a discussion and everyone sort of 'oh yeah you're going through the same sort of, all the shit moments as what I am'. (Focus group 2)

[The dad-only session] just gives you a sort of a breathe out a little bit and share a few worries and stuff or concerns, it was nice. Well, we didn't hug it out or anything. (Focus group 2)

Public breastfeeding has been identified in the literature as a behaviour some fathers can be uncomfortable with and need more information about. Attitudes to public breastfeeding from the fathers in the focus groups were mixed. Most participants reported feeling comfortable with their partner breastfeeding in public and some even reported feeling a protective instinct towards all breastfeeding mothers. However, others expressed feelings indicating some level of discomfort. This highlights the importance of including information and support that helps normalise public breastfeeding.

It's the most natural thing in the world. Every human being should be able to understand that in my opinion. (Focus group 2)

It is more of a protective instinct for anyone that wants to breastfeed. Like if I see a woman breastfeeding I'm actually like looking around to see if there's anyone [objecting] and I'm actually prepared to confront them and say if you don't like it go off you know she has a right to feed her child. So that's just me.
(Focus group 1)

I really don't see why we need to breastfeed next to a table of people eating. You can go and sit over there. (Focus group 2)

5.2.6 Summary

The SCT provided a useful framework with which to structure the focus group discussion guide and make sense of the findings. Participants' experiences with using apps were varied, as were responses to the proposed engagement strategies. Some participants had experience sourcing and using apps for parenting and pregnancy while others identified specific barriers to their use including issues around trusting information and the preference for face-to-face interaction. Most apps that participants discussed were ones sourced by their partners, which they either then used themselves, or were given the information by their partners. Only one father-focussed app about pregnancy was mentioned by participants.

Peer support was valued, and some participants felt incorporating a conversation-like function within the app could be good for social support. Discussion around information provision flow were consistent with previous research in that short, summarised points with links to more information, was of preference. A lack of support and information for fathers was reported, both from antenatal education classes and the variety of available apps and websites. Discussion around breastfeeding in public was mixed, reinforcing the need to include information and strategies in the app for normalising this. The SCT emphasises the interaction of behavioural, environmental and personal factors to impact on behaviour. Fathers participating in the focus group identified factors from all three of these domains which provided guidance for the development of the app intervention. These findings provided useful insight into how fathers use their smartphones, and how an app for fathers could best be made appropriate and engaging.

5.3 Consultative sessions with health professionals

5.3.1 Aim

The consultative sessions with health professionals aimed to:

- Ensure content was relevant and appropriate
- Ensure any emerging or current issues were included.

5.3.2 Recruitment

Two separate consultative sessions were held with health professionals from two of the maternity hospital sites participating in the PIFI study (one public hospital and one private hospital). The researcher requested an hour of time to talk to a number of staff members working directly with new and expecting parents. Both sites arranged a meeting for the researchers to attend at a time that was convenient for their staff.

5.3.3 Procedures

Upon arriving at the session, all participants were given an information sheet explaining the PIFI study, as well as a consent form. The information sheet and consent form are included in Appendix D.4. The researcher explained the study to participants individually, highlighted that the session was to be recorded and provided the opportunity to ask any questions. Each session was facilitated by the lead student researcher and the same observer. Refreshments were served to participants.

5.3.4 Discussion development

Feedback was sought from participants about the proposed content to be included within the library section of the app, as well as the design and engagement strategies. The library content was based on topics relevant to early parenting and included breastfeeding, parenting and fathering, with a focus on managing expectations and encouraging couples to work together to solve problems. An outline of the content to be included within the app was developed prior to the session, and this outline formed the basis for the discussion. Each content section was briefly described and participants were then given the opportunity to discuss the content and comment on anything that was included. Specific questions were designed to elicit more information and participants' views or input about the relevance of the content to their patients. The health professional consultation discussion guide is shown in Table 5.2. The guide included the proposed different content areas, what each area was designed to describe and the prompting questions for participants.

Table 5.2. Health professional discussion guide

Proposed content areas of app library	Aim	Discussion questions
<p>Planning for fatherhood and healthy pregnancy.</p> <ol style="list-style-type: none"> 1. Planning for fatherhood 2. Support networks 3. Healthy pregnancy 4. Managing work and home life 	<p>To introduce pregnancy and birth and get men thinking about their role as a father, and how they might parent their child.</p>	<p>What else might expecting fathers want to know in the early pregnancy period to prepare them for their role?</p> <p>What are parents asking you?</p>
<p>Breastfeeding benefits</p> <ol style="list-style-type: none"> 1. Health benefits of breastfeeding 2. Formula 3. Every breastfeed is a success 	<p>To introduce and reinforce benefits of breastfeeding including health and economic. Reinforce that every breastfeed is a win.</p>	<p>Any specific benefits that really appeal to your patients, or the fathers in particular?</p>
<p>Planning for breastfeeding</p> <ol style="list-style-type: none"> 1. Fathers role 2. Breastfeeding plan 3. Antenatal breastfeeding support 	<p>To start men thinking about their role in planning for breastfeeding success from before baby is even born.</p>	<p>What other things do fathers say they are doing or do you think could be good to consider?</p>
<p>Getting breastfeeding established</p> <ol style="list-style-type: none"> 1. How can father help 2. Milk coming in 3. Common questions (how often should baby feed, baby losing weight, are they getting enough milk?) 4. Using dummies and bottles 	<p>To provide tips and information for getting breastfeeding going including tackling common issues such as baby losing weight, how often they should feed and are they getting enough?</p>	<p>Any omissions in common issues?</p>
<p>Anticipating change</p> <ol style="list-style-type: none"> 1. Relationship changes 2. Mental health 3. Baby milestones 4. Baby crying, sleep, poo 	<p>To start to manage expectations about early parenthood and prepare men to expect change and provide practical advice.</p>	<p>Any other expectations that people talk to you about postpartum?</p>
<p>Practical paternal support</p>	<p>To provide practical solutions to help partner.</p>	<p>Any further suggestions or comments?</p>

Proposed content areas of app library	Aim	Discussion questions
<p>Troubleshooting</p> <ol style="list-style-type: none"> 1. Breastfeeding problems are common 2. Attachment 3. Mastitis 4. Engorgement 5. Nipple care 6. Biting 	<p>To normalise breastfeeding problems, provide information and advice to manage expectations.</p>	<p>What are the main problems you see in your practice?</p>
<p>Bonding</p> <ol style="list-style-type: none"> 1. Dads skin-to-skin 2. Encourage bonding without feeding 	<p>To provide practical bonding solutions for men.</p>	<p>Any further suggestions or comments?</p>
<p>Breastfeeding in public</p> <ol style="list-style-type: none"> 1. Information about legislation 2. Information about why babies may need to feed in public 3. Tips and strategies for breastfeeding in public 	<p>To inform about legislation and normalise breastfeeding in public.</p>	<p>Any further suggestions or comments?</p>
<p>Paternal role in breastfeeding</p> <ol style="list-style-type: none"> 1. Information about the importance of fathers 2. Comments from previous research about paternal support 	<p>To reinforce that men do have a role to play and that they can help.</p>	<p>Any further suggestions or comments?</p>
<p>Service providers for father</p> <ol style="list-style-type: none"> 1. DadsWA –Ngala 2. Mensline 3. How Is Dad Going (HIDG)? 4. Man 	<p>To inform about male-specific support services.</p>	<p>Are there any others we have missed?</p>
<p>General parenting and health service provision</p> <ol style="list-style-type: none"> 1. Australian Breastfeeding Association 2. Lactation consultants 3. Pregnancy, Birth and Baby Helpline 4. Child health nurse 5. Health direct 6. Ngala 7. PANDA 8. Lifeline 	<p>To provide a range of early parenting and pregnancy information for the family.</p>	<p>Are there any others we have missed?</p>

Proposed content areas of app library	Aim	Discussion questions
Additional information 1. Alcohol and breastfeeding 2. Going back to work 3. Expressing and storing 4. Mix feeding 5. Introducing solids 6. Smoking and breastfeeding 7. Drugs and breastfeeding	To introduce a range of other topics to parents.	Are there any other stand out areas that we have missed?

Following discussion of the proposed content areas for the app, the following questions aimed to ensure any emerging or current issues were included and to encourage a sense of ownership of the project with hospital staff.

- Are there any emerging issues that have not been captured or other things that may need to be considered?
- What post-natal support does your hospital offer?
- Are there any services specific to your patients that you would like included?
- Do you have any further suggestions or considerations for working with fathers?
- Is there anything else you would like to tell us?

5.3.4.1 Data collection and analysis

Both the lead student researcher and observer kept notes throughout the session and each session was audio-recorded. The two researchers debriefed after each session and compared and discussed the main points, including how the session had been received by the participants. The lead student researcher reviewed the recordings of the sessions several times, summarised feedback in consultation with the session notes and identified key ideas and themes.

5.3.5 Results

A total of 16 health professionals attended one of two sessions to provide input about the content and engagement strategies of the proposed app. All participants were hospital-based midwives working with new and expecting parents, with some having additional, specialist roles including being lactation consultants, parent educators, or being in charge of discharge and follow up of patients. In addition, there were specialist midwives working with Aboriginal and Torres Strait Islander families, with families requiring complex care (e.g. those experiencing alcohol and other drug-related issues, or mental health problems) and with young families.

Overall, health professionals were enthusiastic about the app, and in particular about having fathers as the focus of the intervention.

Knowing the success of the woman's breastfeeding experience is single-handedly influenced more by the support that [partners] give at home, than any other factor...makes [partners] feel like, 'hey, I can do something to help'.
(Group 1)

They want to help, but they don't know how they can help. (Group 1)

Participants offered views that reinforced those from the focus groups about keeping the tone of the app light-hearted and ensuring the information provided was short and to the point.

Light-hearted and informative, because otherwise you'll lose them, and they won't come back if they're finding it too heavy and judgmental. (Group 1)

Are you using dot form? Because I just find, they won't read a whole big [article]. You just need dot points [and] key words. (Group 2)

Pictures and dot points will work well. (Group 2)

Overall, the health professionals offered confirmation that the content to be included in the app was relevant and appropriate. Specific advice was offered about tailoring information for each of the sections including websites and online videos they typically used with new parents. They further advised the need to include information about postnatal depression for fathers and to focus on the message that every breastfeed is a success. A summary of the feedback provided by participants for each of the different sections is provided in Table 5.3.

Table 5.3. Summary of feedback from health professionals

Section 1: Planning for fatherhood and healthy pregnancy
<ul style="list-style-type: none">• Childbirth is life altering, but for many it is not real until the baby is born. Very few couples think beyond the birth.• Need to consider that asking people to reflect on how they were fathered may raise issues. It is a good idea to include links to support services in app.• App should encourage fathers to think of the men around them, and think of three things they want to emulate, and three things they don't.• Lots of parents think antenatal and/or breastfeeding classes are not for fathers.• Women report wanting to be more socially connected. Need to consider that fathers may want to as well.• Regardless of knowledge, some people will be more motivated to learn more than others.
Section 2: Breastfeeding benefits
<ul style="list-style-type: none">• App should include specific breastfeeding benefits for fathers. Cost benefits are a good, relevant example.• Empower fathers by including information about just how important they are in supporting their partner with breastfeeding.• Bottle-feeding can be seen to offer more opportunity for fathers to bond with babies. Information needs to encourage other ways for fathers to bond.• Ask fathers to consider other males around them, and just because their father did something, doesn't mean they need to do it that way too.• Encourage couples to keep open the lines of communication between them before the baby comes.
Section 3 - Planning for breastfeeding
<ul style="list-style-type: none">• Provide practical solutions for fathers to support their partner with breastfeeding. Women also need to know what fathers can do to help.• Include information about postnatal depression in both fathers and mothers.• Include the five S's checklist (swaddle, suck, swing, side or stomach, shush).

- Women can become resentful of breastfeeding if they feel like their partner is not doing anything, app could suggest ways they can help.
- Include positioning checklist and information about biological nurturing.

Section 4 – Getting breastfeeding established

- It is important to emphasise breastfeeding establishment can take time. If mothers are stressed, fathers can be the cheerleader, 'let's see if we can get to three weeks', then they can suggest four, then five.
- Make fathers aware there is a link between breastfeeding experience and postnatal depression.
- Provide education and information about feeding frequency. A baby that feeds often does not mean a low milk supply. Babies feed for many reasons aside from hunger including for comfort, thirst or being tired.
- Encourage fathers to think about skin-to-skin contact and managing the early visits. Father can be gatekeeper in the room. The early days shouldn't be a constant stream of visitors. Fathers need to be aware that mother and baby need time to establish breastfeeding.
- Encourage fathers to sit down with their partner while they are breastfeeding and spend quality time together as a family while baby is being fed.

Section 5: Anticipating change

- The app should include information on how to deal with family and cultural differences in relation to breastfeeding and other postpartum related issues.
- Many people have different thoughts about infant feeding than their families and considering this beforehand may help prevent difficulties arising.
- It is important for people to understand that people can bring a lot of personal experience to discussions about breastfeeding and new parents should be encouraged to find their own path.
- Reinforce breastfeeding on demand as opposed to scheduling feeds.
- Partners can feel a bit ignored in the early days, app can include information for fathers about how to be involved.
- Younger women are breastfeeding less and need to be specially targeted with information and support.

- It is important to emphasise that every breastfeed is a success.
- Encourage parents to expect relationship changes and find new activities they can do together as a family of three, such as going for a walk.

Section 6: Practical paternal support

- Provide practical solutions for fathers to support their partners, including making time to do things together.
- Encourage communication, every mother has different needs. Sometimes making dinner can be a break for mums while dads take the baby.
- Reinforce that it can take time for breastfeeding establishment.

Section 7: Troubleshooting

- Emphasise that breastfeeding is a learnt skill.
- Include information about low supply (perceived and not). Often people can start with a mindset that they may not be able to do it saying 'Oh I'll give it a try but my friend, my sister couldn't do it'.
- Include information about how often babies need to breastfeed, particularly in early days.
- Provide simple solutions to sore nipples such as bra-free time and cabbage leaves.
- Participants contributed differing views on including information about expressing, with some participants saying to include information about expressing, and others saying there can be too much focus on expressing, and that it is often never needed.

Section 8: Bonding

- Encourage other ways of bonding rather than bottle-feeding. Suggestions included: father skin-to-skin, bathing, showering, massage and tummy time.
- Make fathers aware about how things can impact on others. So if the baby is more happy and relaxed then the mother may find breastfeeding easier.
- Encourage dads to make time to play, including active play and age appropriate rough and tumble play.

Section 9: Breastfeeding in public

- Younger fathers may feel more uncomfortable with public breastfeeding than older fathers.
- Encourage strategies to help couples feel more comfortable with public breastfeeding, such as planning to go out together the first time the mother will need to breastfeed in a public place.
- App should help to normalise public breastfeeding. Women need to feel that they can sit in their own home and breastfeed in front of others. Fathers need to help them feel comfortable.

Section 10: Paternal role in breastfeeding

- Emphasise the importance of fathers in supporting partners with breastfeeding, and in playing with their babies.
- One midwife discussed recent research with working fathers which showed they were not playing with new babies enough as were getting home late and leaving for work early. Need to suggest ways fathers can engage in play.

Section 11: Service providers for fathers

- Add in the WA based Fathering Project.
- Some local councils do localised activities for fathers.

Section 12: General parenting and health service provision

- Suggestions to include the following services:
 - The Bump WA
 - Bellybelly.com.au
 - Beyond blue
 - WA breastfeeding centre at King Edward Memorial Hospital
 - Aboriginal pregnancy and labour sites
 - Child health nurse contacts
 - Beer and Bubs for antenatal classes

Section 13: Additional information

- Include information about not pushing to drop the night feed. Feeding through the night is important in maintaining milk supply. Supply can be the highest at night, so encourage parents not to drop night feeds.
- Suggestion: If someone does smoke, encourage them to use a 'smoking jacket' while outside that they can take off so the scent of smoking doesn't stick to clothing when coming back inside.
- Have information about resuming intimacy and the time it may take.

Other

- Content as described is comprehensive.
- Women can feel that if they can't breastfeed they are a failure. App should emphasise that there is no such thing as a failure and include the 'every breastfeed is a success' message.
- Include a recipe book for easy to prepare, lactation friendly meals.
- App will be a useful resource as people want all the information in one place.
- Use pictures and keep the information concise and in dot point format.
- Include information about breastfeeding not being a reliable form of contraception.

5.3.6 Summary

Researchers spoke to health professionals at two different maternity hospital sites participating in the PIFI project, one public and one private. The health professionals had a diverse range of roles in working with new and expecting parents. All participants were enthusiastic about the development of an app for breastfeeding support and all were encouraging of targeting fathers. Health professionals used their current clinical practice and experience to offer insight and specific suggestions on how to strengthen the proposed content. Ideas and suggestions were incorporated into the content to be included in the library section of the app prior to the start of the trial.

5.4 Conclusion

Qualitative data from this formative evaluation phase including focus groups with new and expecting fathers provided insight into the use of mobile technology by members of the target group and into what engagement strategies might be most effective. Fathers discussed their use of apps and the web for information gathering and their experiences with supporting their partner with pregnancy and early parenthood. While this was not intended to be an exhaustive qualitative study to thematic saturation, there were many overlapping themes and participants provided rich insight to help guide the app development. The SCT was a useful framework to guide the focus groups, allowing for identification and discussion of a broad range of interrelated factors that can impact on fathers' views about breastfeeding. The discussions with health professionals offered confirmation of the appropriateness of the content and some good suggestions for inclusions to strengthen the information. Given the dearth of information about targeting fathers with breastfeeding information through mobile technology, these focus groups were an important phase in planning the app development and the approach to targeting fathers.

Chapter 6 **Developing the Milk Man app**

6.1 Introduction

The Milk Man app aimed to reach fathers with information and support about breastfeeding and early parenting, with the hypothesis that this increased support would have a positive impact on maternal breastfeeding duration. This chapter details the development of the app. A summary of the information in this chapter, and the preceding chapter, was published in the JMIR mHealth and uHealth in 2016 (B. K. White, Martin, et al., 2016) Appendix C.

6.2 App design process

The Milk Man app was developed as a socially connected information and support resource for fathers. It was focussed on breastfeeding, but included broader information on topics including early parenting, being a supportive partner and local service providers. It was based on evidence about the main factors impacting fathers' support of their breastfeeding partners, and was informed by SCT. As part of the planning process, a marketing audit of current advertising campaigns was completed to investigate how health messages, products and services were being designed for the target group. This information helped guide the design of the app. Breastfeeding interventions are typically targeted at the mother, resulting in fathers reportedly feeling excluded from family support programs (Brown & Davies, 2014; Rempel & Rempel, 2011; Tohotoa et al., 2009). Milk Man was explicitly designed for, and targeted towards, fathers and this was a key consideration in encouraging men to access and use the information.

As described in Chapter 5, Milk Man was informed by focus groups with fathers in the target group and by consultation with health professionals. It was refined through a testing phase comprising beta testing and user testing with new or expecting fathers. User-testing involved participants completing a think-aloud walkthrough, as well as completing the Mobile App Rating Scale (MARS) (Stoyanov et al., 2015). Figure 6.1 illustrates the Milk Man development process.

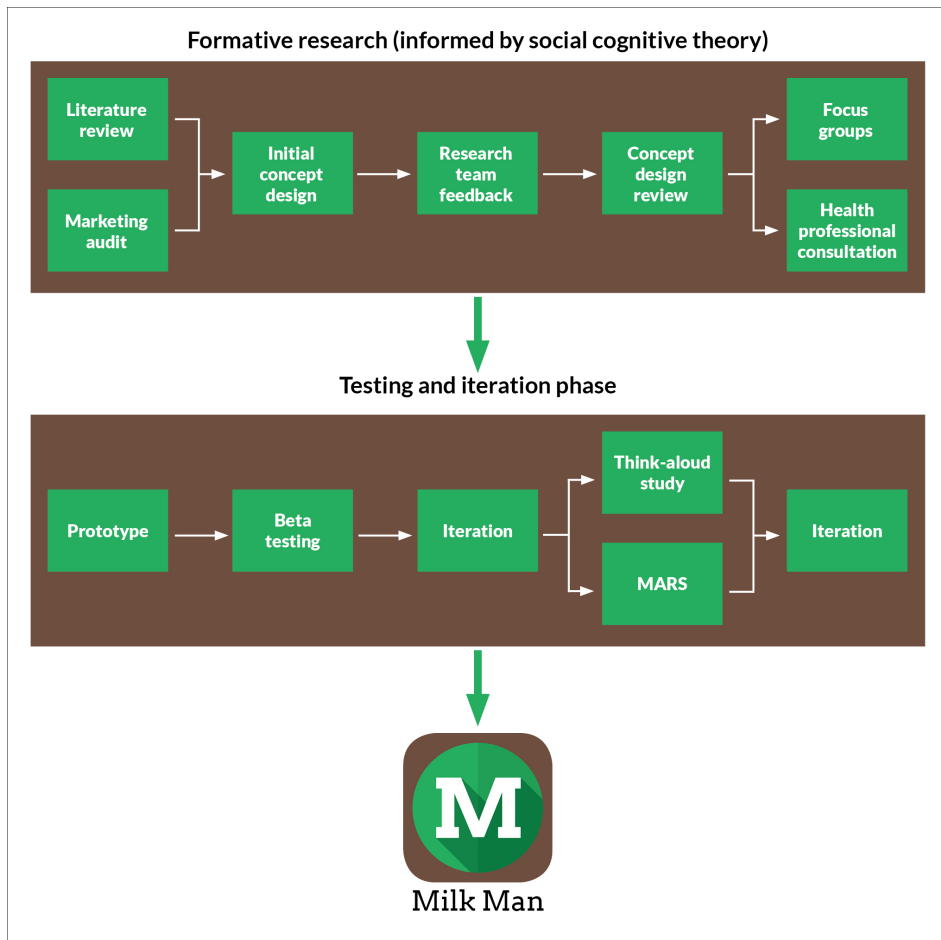


Figure 6.1. Milk Man development process

6.2.1 Theory-based design

The design of the Milk Man app and its engagement model were based on SCT constructs to address the key issues impacting fathers' support for their breastfeeding partners. The specific constructs of observational learning and goal setting were key components. The app based forum was designed to encourage opportunities for fathers to share and learn from each other and the content had a focus on planning for success and realistic expectations in a goal setting capacity. In seeking to address self-efficacy, the app encouraged problem-solving by couples. Table 6.1 describes how the SCT underpinned the Milk Man app. This table highlights the key factors that were identified in the literature as impacting fathers' support with specific SCT constructs. These constructs then informed the app development with the corresponding engagement techniques mapped to the SCT constructs.

Table 6.1. Milk Man engagement techniques mapped to social cognitive theory

Key factors	SCT constructs	Engagement technique in Milk Man app
<p>Social support</p> <p>Men feel they do not receive enough social support with pregnancy and early parenting.</p>	<p>Observational learning</p> <p>Goal setting</p> <p>Self-efficacy</p>	<p>Connected social support function via the guided “conversation” feature.</p> <p>App was specifically designed for, and targeted towards, men.</p> <p>Gamification functions to encourage inclusion, engagement and positive feedback.</p>
<p>Knowledge</p> <p>Gaps in knowledge around breastfeeding, pregnancy and early parenthood.</p>	<p>Outcome expectations</p> <p>Goal setting</p> <p>Self-efficacy</p>	<p>Provision of information via the library including practical solutions and support service contact details.</p> <p>Regular, age-relevant topics sent out via push notifications.</p>
<p>Empowerment</p> <p>A reported lack of recognition of paternal role and understanding of their supportive role.</p>	<p>Self-efficacy</p> <p>Self-regulation</p> <p>Outcome expectations</p>	<p>Focus on empowering men to understand their role through the library and the conversation.</p> <p>Provision of practical advice.</p> <p>Encouragement to discuss issues with partner.</p>
<p>Overcoming barriers</p> <p>Specific barriers including bonding postponement, public breastfeeding and feeling left out.</p>	<p>Self-regulation</p> <p>Self-efficacy</p> <p>Observational learning</p> <p>Outcome expectations</p> <p>Goal setting</p>	<p>Forum for men to share information and an opportunity for discussion around solutions to barriers.</p> <p>Provision of information and strategies on public breastfeeding.</p> <p>Provision of information on specific barriers and solutions with the aim of establishing realistic outcome expectations.</p>

6.2.2 Marketing audit

In planning the design of the app, a marketing audit was completed, and a design brief was written to guide the development. The researcher examined a range of health campaigns, websites and apps investigating how health messages, products and services were being designed for the target group. The search specifically focussed on marketing campaigns and products developed for men in the 18 - 44 year age range, and on products developed for new and expecting fathers.

The only one of these campaigns that had conducted any evaluation that was publically available was the Beyond Blue *Man Therapy* campaign. The evaluation report revealed the campaign had an unprompted reach (participants able to recall the campaign without being shown campaign materials) of 11% of the target group (men aged 30-54 years) and a prompted reach (participants able to recall the campaign when shown campaign materials) of 43% (Ipsos Social Research Institute, 2014). Important to this research, 80% of participants felt that the *Man Therapy* campaign was relevant to them. The report noted the number of men who remarked on the tone of the campaign in that it appeared to be coming from a peer, rather than a health professional. Some users however, reported finding the use of humour for an important health issue inappropriate. There was no difference in social stigma reported pre-and post-campaign.

As the other campaigns reviewed were a variety of ventures, including commercial and independent, it is not surprising that there was limited evaluation. This did however reinforce the importance of including comprehensive evaluation indicators in the Milk Man app intervention in order to better understand what works with targeting fathers. A summary of campaigns reviewed is provided below in Table 6.2.

Table 6.2. Marketing audit

Name / Source	Platform	Description
Who's your Daddy? (2017) Commercial app (Australia)	Mobile app - iOS	This app was targeted at Australian men who were expecting a baby. It was light hearted, funny, used high quality images that were male relevant. Language was colloquial, and male-specific.
Quick tips for new dads (2017) Commercial app (United Kingdom)	Mobile app – iOS Supported by website and social media	Early parenting information broken into different categories and presented as comments and advice from real fathers. App designed specifically for men with lots of imagery that included fathers. Included a range of How-to video guides. Fathers could submit their own tips. Design was minimal, images high quality, language was colloquial and targeted.
Man therapy campaign (Beyond Blue, 2015) Beyond Blue (Australia)	Website	This website was part of a mental health campaign targeted at men. It was clearly designed for men. It included a number of high quality videos featuring quirky imagery and colloquial, male-targeted language.
Project breastfeed (Cruz, 2015) (US)	Website	Project Breastfeed was a photographic campaign designed to reduce stigma about breastfeeding and educate men about how important breastfeeding was, and their role is. Many of the photos feature men bare chested, holding a child as though breastfeeding with the slogan <i>"If I could, I would"</i> . Design was minimal and simple.
New dads' survival guide (Bounty UK, 2012) Commercial - Bounty UK (UK)	Website	This website produced by Bounty UK was targeted directly at men. The website was simple and sparse, with images of men throughout. The language was colloquial and male-targeted. There was a 'real dads' section with tips and stories from real fathers.
How to be a dad (2017) (US)	Website	Blog featuring regular posts written by two fathers. Topics were broad and wide-ranging. Information was written in a peer-to-peer fashion.

Name / Source	Platform	Description
24 hr cribside assistance (Father Involvement Initiative - Ontario Network, n.d.) Father Involvement Initiative (Canada)	Website	This website covered a wide range of newborn baby information, all delivered as if through a car manual. The site featured a range of videos featuring men, high quality imagery and colloquial language.

App audit

A search of the iOS App Store, and Google Play was conducted on the 22nd September 2014. The search term applied was 'breastfeeding' and the top 100 results on both stores were reviewed. Results covered a range of apps for different functions such as breastfeeding timer apps, baby care apps, and breastfeeding information apps. Information apps included those regarding medication and alcohol consumption during lactation. Apps were not downloaded, and review was based on the title, image, app description and screen shots.

By far the most common type of apps available were record keeping apps. This included apps that only focussed on recording breastfeeding times, as well as those that also recorded formula feeds, nappy changes, and sleep times, amongst other activities. The next most common category was breastfeeding information apps, which were a mixture of those produced by health bodies or agencies, and other commercial apps. None of the apps viewed were specifically targeted at fathers. There was greater variability in the apps available on the iOS store. The audit demonstrated the large number of apps available to parents, the number of apps that parents would need to review and evaluate to find an evidence based product, and that father-focussed apps were unavailable. Furthermore, an earlier systematic review of websites and apps about infant feeding examined apps over a range of characteristics and found most apps (78%) to be of poor quality (Taki et al., 2015). Apps from each store were reviewed and categorised depending on the main intent. The number of apps in each category in each store is listed in Table 6.3.

Table 6.3. Categories of breastfeeding apps on iOS and Google Play stores.

Category	Google Play Store	iOS App store
Breastfeeding tracker apps (including other trackers such as formula, sleep, nappies etc)	65	54
Breastfeeding information apps	28	20
Lactation and drugs	3	1
Breastfeeding location finder app	2	1
Magazine apps (parenting / breastfeeding)	1	7
Nutrition apps (for babies or mums)	0	4
Baby development tracker	0	3
Breastfeeding conference app	1	1
Alcohol and breastfeeding	0	1
Other		
Parents To do list	0	1
Fertility tracker	0	1
Pregnancy guide	0	1
Breastfeeding podcast app	0	1
Diapers Game	0	1
Mums chat room	0	1
Breastfeeding podcast	0	1
Understanding baby sounds	0	1

Design brief

The formative qualitative data described in Chapter 5 and the audit detailed above helped to inform the development of an app design brief document. This document was discussed and refined within the research team and with the app designer and developer to better inform the design of the Milk Man app. The aim of the design brief was to provide context around the apps' purpose, use and target group. The research group were able to provide some parameters for the graphic designer to consider when coming up with a 'brand' for the app. The app design brief is available in Appendix E.1.

6.2.3 Engagement strategies

The app was specifically designed to be contemporary, attractive and engaging to the target group. The approach to engagement was considered and thorough, and informed by careful research and consultation. It delivered important information in a fun and light-hearted manner and contained high quality imagery throughout. Milk Man contained engagement strategies that aimed to keep fathers interested in using the app. The main engagement strategies included the use of push notifications, social connectivity via a guided conversation, an information library and gamification (B. K. White, Martin, et al., 2016). The implementation of each of these is detailed in Section 6.3.

6.2.4 Software platform

Informed by the research team and the previously described development processes, the app developer prepared a specification document and provisional data model for the app. This was reviewed and approved by the research team. The specification document is provided in Appendix E.2.

Milk Man was developed as two native apps, one for iOS and one for Android. The iOS app was written in the Objective C programming language and the Android version written in Java.

There are a number of advantages to developing native apps over other types of apps. Native apps are built specifically for one platform and using the platform's provided Software Development Kit (SDK) (J. A. White, 2015). These SDKs are libraries of code for developers to utilise to ensure consistency and help ensure that apps maintain the intuitiveness that people expect with apps on their choice of device. Native apps generally use less data than non-native apps, and can best enable full optimisation of the phone's features (J. A. White, 2013). Another significant benefit of native apps is the ability for some, or all of the app, to be functional off-line. Native apps allow data to be embedded into the app so that when the app is downloaded onto a user's mobile device, the content comes with it. This offers several benefits to users. Use of the app, or that section of the app, does not require internet access, so is not using data. This can be a significant consideration for people in lower SES populations or areas of low-connectivity. Users do not need to wait for pages or content to load, and the information is always available, including if people are in areas with limited internet access available, or if the website went down.

The Milk Man library was embedded into the app so that when users downloaded the app, the information was then contained on their device allowing for access at any time. Due to the shared connectivity functions, the conversation relied on internet access. This combination approach ensured that participants always had access to the advice and information from the library, while the conversation forum allowed for the connectivity and new content generation.

The apps were made available on the iOS App Store and Google Play and users could access and download the app directly from these stores. Study participants were given a sign-up sheet at recruitment explaining how they could find the app and download it and provided with their personal access code which was required to enable access to the app.

For data storage and access, the app used the Parse Backend as a Service (BaaS) (Parse, 2016). A BaaS, is an off-the-shelf, customisable tool for providing database functionality for an app or website. The Parse BaaS comprised two components: database infrastructure (for facilitating user sign up, group management, content management and push notifications) and hosting of those data.

In January 2016 it was announced that the hosting component of the service would be retired after a 12 month grace period, and that the database component would be open sourced (Lacker K, 2016). This means that the entire codebase was provided openly, and turned over to interested developers to maintain and extend. This necessitated finding a new hosting component, and in July 2016 the app was migrated to the Sashido Parse hosting platform (SashiDo, 2016), via updates submitted to both app versions.

Migrating an app database while the app is in active use is a non-trivial exercise, and these changes had some ramifications for data continuity for some users. These issues are documented in Section 7.3.3. However, these impacts were limited, and the transition was well managed.

6.2.5 App Management Protocols

A series of protocols were developed to govern the management of the app throughout the study. These protocols were established to ensure thorough risk management approaches were planned for and to ensure app management was consistent throughout the study and agreement was in place as to how to respond quickly, should the need arise.

The protocols covered the following areas:

1. Downloading the app
1. Moderation protocol
2. Managing user exit
3. High risk behaviour
4. Ad hoc topic protocol
5. Peer responder protocol

Each protocol included a statement of intent including the scope of what it would address, and then a corresponding procedure to manage the issue. The full protocol documentation is attached as Appendix E.3. Minor revisions were made to the document at several points as the trial progressed.

6.2.5.1 Moderation

The role of moderators in Online Health Communities (OHC) has been the subject of extensive research (Cole, Watkins, & Kleine, 2016; Edwards, 2002; Huh, Marmor, & Jiang, 2016; Matzat & Rooks, 2014) yet a consensus about the role of moderators in online health forums has yet to be reached (Huh et al., 2016). Some participants of OHCs feel moderators can be beneficial in enforcing community rules, and can contribute to discussions and encourage interactivity, while others feel moderators limit free speech (Edwards, 2002). While there are sometimes concerns about the quality of health information contained in OHCs, research has demonstrated that a community moderated OHC can maintain a high quality of health information (Cole et al., 2016). Other research has shown that when participants in an OHC have developed a rapport, external moderation may not be needed (Maloney-Krichmar & Preece, 2005).

WebMD is an accredited health and medical website that provides health information written by health professionals (WebMD, 2017). It also has a number of popular OHCs. In 2013 WebMD made the decision to remove staff moderators from their forums and Huh et al. (2016) conducted a study in the period immediately afterwards seeking to understand the reaction of the community to this decision. They found mixed results, with some participants feeling the moderators played critical roles in the OHC, and some even reporting feeling a personal rapport with the moderators. Conversely, others reportedly felt the approach to moderation had been overzealous and constrained communication.

In recognition of the complexity of moderation and the need to manage risk, the app management protocols developed for Milk Man included a statement on moderation. The app employed a post-moderation approach in that content submitted was immediately made visible on the app, and was viewed by researchers for any potential issues after being posted. The protocols describe the hands-off approach to moderation chosen for the Milk Man app and the role of a peer responder, a role filled by a member of the research team who was a father of two young children. The research team only intervened and posted in the app when certain criteria were reached, for example a user providing misinformation. The decision to respond was made by the lead student researcher, in consultation with the research team and a log was kept of all interactions. Any responses by the peer responder were kept in the tone of the app, as in being from another father, and were published only after consultation with two other appropriate research team members.

The responder posted under the username 'MacDaddy' participants were introduced to the existence of MacDaddy through the information page within the app, which states:

You might notice MacDaddy in the comments. He is an experienced dad there to provide clarification on anything if needed. You probably won't see him much, as he has two young kids

The peer-dad responder was identifiable through his avatar (the Milk Man app logo) and username (MacDaddy), to ensure it was clear to participants that he was connected with the study, and not another father participating in the trial.

6.3 The Milk Man app

While the planning and development of Milk Man was detailed and complex, the app was designed to be simple, easy-to-use and easy for participants to use and understand. The different components of the app were clearly laid out over four tabs and a detailed tutorial was presented to users when they first signed up which demonstrated the app's features. This section describes the Milk Man app, including the structure of the conversation, the content of the library and the engagement features.

6.3.1 Login and onboarding

Participants randomised into a group that had access to the app were provided with a document informing them of how to download the app in the respective app stores, and given a user ID. In order to make it as straight-forward as possible for participants to find the apps, they were made publically available on the iOS App Store and Google Play. While anyone could download the app, a participant ID number was needed to create an account. As part of the signup process, participants were required to choose their own avatar. The signup screen is shown in Figure 6.2, and the list of avatars available for participants to choose from is shown in Figure 6.3.

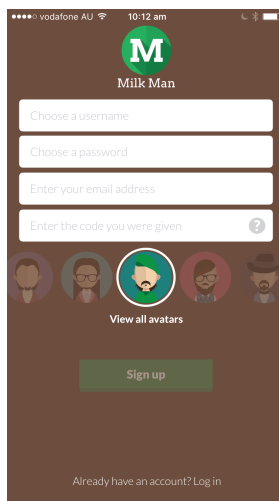


Figure 6.2. Signup screen



Figure 6.3. Avatars

When users first logged into the app they were shown a series of images describing the functionality of the app, and highlighting the content. This onboarding sequence was shown only once, immediately after login, but was available for reviewing at any time through the information tab. The onboarding screens walked users through the app, describing the different tabs and functionality. Figure 6.4 shows the onboarding screens introducing the conversation tab and informing fathers of the grouping system. Figure 6.5 shows the screens introducing the library, and Figure 6.6 shows the screens introducing the gamification elements.

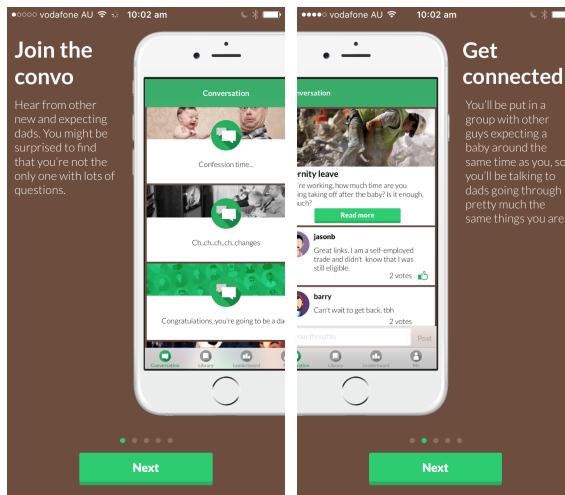


Figure 6.4. Onboarding screens – Conversation

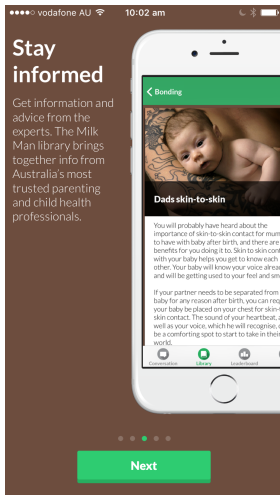


Figure 6.5. Onboarding screens - Library

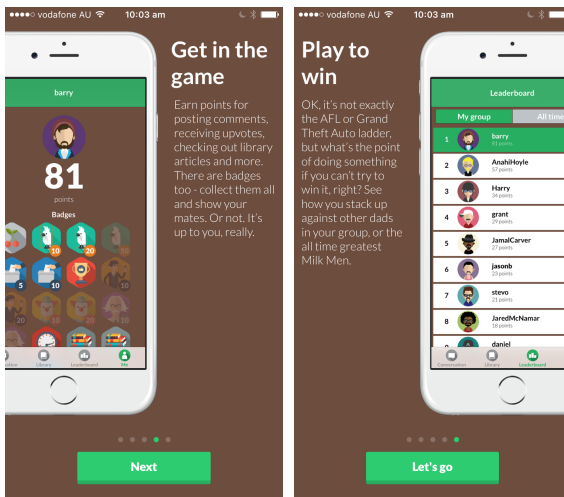


Figure 6.6. Onboarding screens - Gamification

6.3.2 Conversation

Milk Man aimed to socially connect fathers by engaging them in a guided conversation. Upon signing up to the app, participants were placed into a group depending on the month their baby was due, enabling time-relevant information to be targeted to them. The conversation consisted of a series of topics posted by the research team twice a week. Participants received a push notification alerting them to new topics and inviting them to participate in the conversation. On swiping the notification they were taken directly to that conversation within the app. Topics were either posts or polls. A post, shown in Figure 6.7, consisted of a question, usually with a link to a static information article in the library component of the app, with space underneath for users to add their own comment if they chose to.

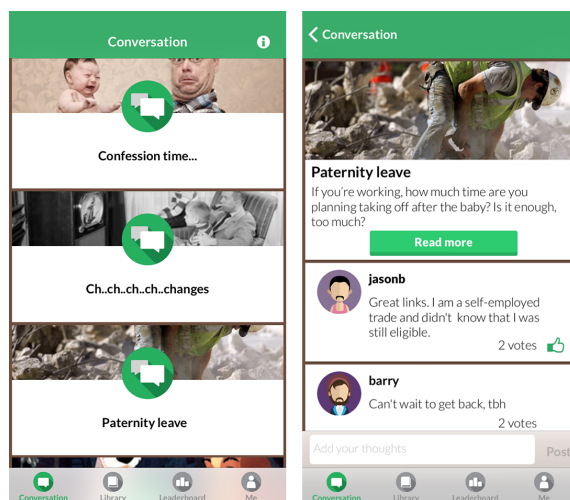


Figure 6.7. Milk Man conversation topic

A series of conversation topics were developed to cover the perinatal period. The purpose of these topics was to deliver small pieces of time-relevant information to participants in an engaging manner, and to encourage them to share information and support their peers by participating in the conversation. Most of these topics linked back into the relevant section in the library, to encourage participants to keep reading evidence-based health information as they progressed through their pregnancy and into the first six months of their baby's life. The topics were designed to either be of relevance to milestones in the perinatal stage or to focus on community building, that is, providing light content designed to encourage fathers to communicate with each other. The information for the content areas, including the timing of content delivery was established using expertise within the PIFI research team and informed by other relevant sources including the Raising Children's Network (2017), the Australian Breastfeeding Association (2017), and Beyond Blue (2016). The topic content areas are listed below in Table 6.4.

Table 6.4. Topic content areas

Time	Content areas
<u>Antenatal</u> Approximately 30 weeks of pregnancy to birth	Expectation management, practical solutions Preparation for breastfeeding and fatherhood Healthy pregnancy, birth and early parenthood
Postnatal	
Month one	Baby blues Father's role / how is dad feeling Bonding Supporting partner Breastfeeding benefits / reinforcements
Month two	Back to work Bonding Managing expectations Practical solutions Fatherhood
Month three	Public breastfeeding and breastfeeding establishment Post-natal depression Delaying introduction of solids Bonding Managing expectations, practical solutions

Time	Content areas
Month four	Breastfeeding benefits / reinforcement Delaying introduction of solids Bonding Practical solutions Public breastfeeding
Month five	Bonding Managing expectations Breastfeeding benefits / reinforcement and expressing Alcohol and breastfeeding Post-natal depression
Month six	Breastfeeding, reinforcement of benefits Introduction of solids Fatherhood, managing expectations Bonding

The conversation was the default tab - that is, the tab that was open each time the user launched the app and Figure 6.7 shows the main conversation screen. Users could then tap on a topic title to see the rest of the information, and if any fathers had commented on the post. An information page was accessible from the conversation tab. By tapping the small *i* icon on the top right of the page, the user could see the study information, contact details for researchers, replay the onboarding screens and report any problems they were having.

Users could add comments to the conversation, and upvote (that is, like or recommend) other users' comments. The upvoting options are displayed in Figure 6.8, users could choose from *Good banter*, *Smart idea* and *I just like it, ok?* When a user upvoted another user's comment, the poster received a notification stating "[upvoter's username] liked your comment". Users could choose to have conversation topics displayed either by the newest post, or by those with the most votes.

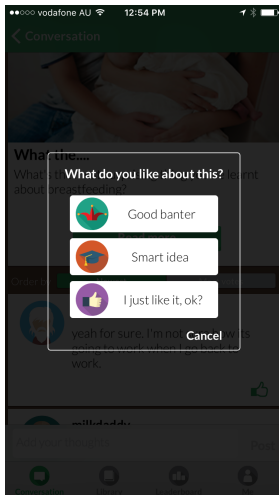


Figure 6.8. Upvoting in the conversation

A poll was a multiple choice question, where users could chose an answer and view the aggregated responses of other users. An example of what was seen both before, and after choosing an option is displayed in Figure 6.9. Many of the polls also contained links back into the library section via the “read more” button.

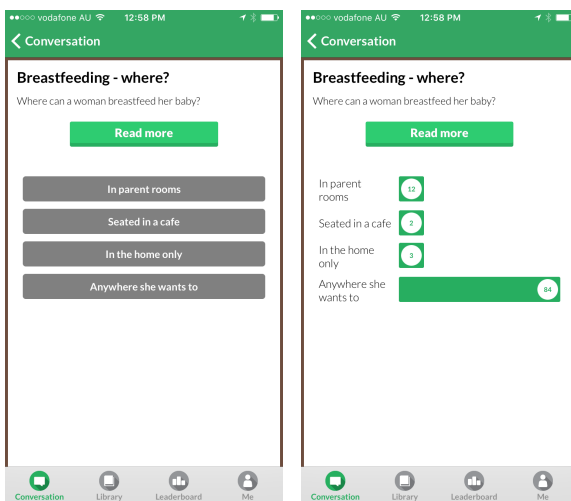


Figure 6.9. Poll view. Before (left), and after (right) choosing an answer

6.3.3 Push notifications

The Milk Man app had new content added in the form of conversation topics twice a week. Push notifications were used to alert users to new discussion topics. Once the new conversation topics were added to the app, a push notification was sent out to all current users. The notification read *'There's a new conversation starting'* and popped up on the lockscreen of the user's device if it was not in use at the time, or at the screen top, if it was. The user could choose to swipe into the notification, which then opened the app to the conversation page. Figure 6.10 shows the push notification appearance on an iPhone lockscreen.

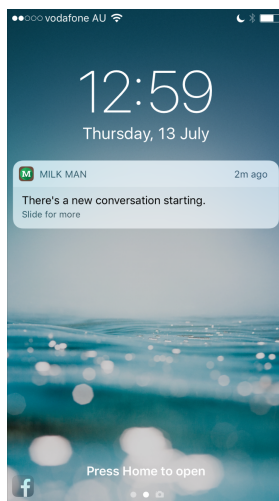


Figure 6.10. Milk Man push notification

6.3.4 Information library

The information library was the second information delivery method used in the app. The library was a static, evidence-based information source tailored specifically to fathers. The information had a focus on breastfeeding information, but also covered a range of other topics associated with early parenthood and becoming a father, including managing expectations, support networks, mental health and co-parenting. The content was compiled by the researcher and was then reviewed for accuracy and clinical correctness by the wider research team. The research team included professionals with a wide variety of expertise including breastfeeding researchers, a midwife and health promotion professionals. On request by a team member, one item was referred to clinicians at the tertiary women's hospital in Perth to ensure information was up-to-date and in-line with current advice.

The topics to be included within the library were developed based on research about what information parents, and fathers in particular, want in their transition from pregnancy to parenthood. It was further informed by the consultation with health professionals. The topics were then grouped into content areas to keep the information easy to find. A summary of the information provided in the library is displayed in Table 6.5.

Table 6.5. Library contents

Content headings	Description
<p><u>So, you're having a baby!</u> Now what???</p> <p>Preparing for fatherhood What kind of dad will you be? How to be a dad Assemble the squad Time off work Supporting new dads Healthy pregnancy Smoking and alcohol in pregnancy</p>	<p>This section aimed to introduce pregnancy and birth and encourage men to think about their role as a father, and how they might parent their child. It asked fathers to reflect on how they were parented and what they would like to do differently or the same. It also covered support networks, practical advice about paternity leave and supporting their partner with a healthy pregnancy.</p>
<p><u>Breast is best – why?</u> Why is breastmilk good for babies? Why is breastmilk good for mums? What about formula? Breastmilk is more than just food Every breastfeed is a success Cost benefits</p>	<p>Introduction of benefits of breastfeeding including health benefits for mothers and babies and the economic benefits to families. This section discussed the difference between formula and breastmilk and also reinforced that whether for a day, or two years, every breastfeed is a success</p>
<p><u>Planning for Breastfeeding</u> Do men need to worry about breastfeeding? Consider a breastfeeding plan Look into breastfeeding antenatal classes Practically speaking...</p>	<p>This section encouraged fathers-to-be to start thinking about planning for breastfeeding, similarly to how they are planning for the birth. It contained links to breastfeeding groups and antenatal classes. It aimed to encourage men to start thinking about their role and how they could help with planning for breastfeeding success from even before their baby was born.</p>

Content headings	Description
<p><u>Getting it off to the breast start</u> What can I do to help it get off to a good start? Where is the milk!?! Hindmilk / foremilk How big is my baby's stomach? Help, my baby is losing weight! How often should the baby feed? Is he getting enough? What about dummies and bottles?</p>	<p>The early days are vital in breastfeeding establishment and are when couples can experience the most problems. This section provided tips and information for getting breastfeeding going. This included tackling common issues such as early weight loss, how often babies may need to feed and breastmilk supply.</p>
<p><u>What to expect</u> Relationship changes Why is my baby crying? Ahem, what about sex? Feeling low? Will I ever sleep again? What is with that poo? What's baby doing now? Say what now!?!</p>	<p>Parenthood bring many changes and when couples are expecting them, they can fare better. This section aimed to start managing expectations about early parenthood and prepare men to expect change. There was a strong focus on communication in this section with articles encouraging fathers to have a conversation with their partners about a specific issue.</p>
<p><u>What can I do to help?</u> My partner is in pain – Why? What can I do? Tips for helpful dads</p>	<p>Practical solutions to help their partner is one of the most common requests from fathers and this section contained many such tips. This sat alongside advice that every family is different and that the best way to know how to help, is to ask their partner.</p>
<p><u>Troubleshooting</u> Breastfeeding problems Attachment Insufficient supply Nipple care Breast and nipple thrush Mastitis Engorgement Biting</p>	<p>Breastfeeding problems are common and this section aimed to normalise this, and to provide information and advice to manage expectations. It covered a range of common breastfeeding problems such as mastitis, insufficient supply and engorgement.</p>
<p><u>Bonding</u> Dads skin-to-skin How can I bond without feeding?</p>	<p>Using bottles as a way of bonding with baby can be detrimental to breastfeeding. This section aimed to provide practical bonding solutions for men, that did not involve bottle-feeding.</p>
<p><u>Breastfeeding in public</u> What's the deal, can you breastfeed in public? Can't she just do it at home? Tips and strategies</p>	<p>This section provided information about the legislation regarding breastfeeding in public and aimed to normalise public breastfeeding. It had some specific strategies families could try if mothers were feeling a little unsure.</p>

Content headings	Description
<p><u>Do I really matter?</u> Think you can't help with breastfeeding? Feeling a bit on the outer?</p>	<p>This section aimed to reinforce the important role men play in supporting their partner with breastfeeding. It contained statements from mothers in the research teams' previous qualitative research where they described the vital support they had received from their partners and the impact that had had on breastfeeding.</p>
<p><u>Support just for dads</u> DadsWA –Ngala Mensline How Is Dad Going? Man The Fathering Project</p>	<p>This section contained a range of support services specifically for fathers or men.</p>
<p><u>Support for families</u> Australian Breastfeeding Association Child Health Nurse Breastfeeding Centre of WA Pregnancy, Birth and Baby Helpline Lactation consultants The Bump WA The Raising Children Network Health Direct Ngala Beyond Blue PANDA Lifeline</p>	<p>This section contained a range of support services about breastfeeding and parenting for families.</p>
<p><u>Additional information</u> Alcohol and breastfeeding Going back to work Expressing and storing Mix feeding When breastfeeding doesn't work out Don't rush to mush How to start with solids Smoking and breastfeeding Medication and breastfeeding</p>	<p>This section contained information about starting solids, alcohol consumption and smoking during lactation, and supporting their partners if breastfeeding doesn't work out.</p>
<p><u>10 Strange but true Breastfeeding facts....</u></p>	<p>This random selection of facts about breastfeeding was included mainly for entertainment but contained important advice about not relying on breastfeeding as a contraceptive.</p>

The library used the progressive disclosure technique (Spillers F, n.d) where information is sequenced so the initial information presented is concise with options to read more. The content then gets progressively more detailed as the user seeks further information. External links provided further information from service providers including the Australian Breastfeeding Association (2017) and the Raising Children Network (2017). The length of the library articles was restricted to approximately 150 words to ensure content was succinct, and minimal scrolling was required to see the whole article. A search function was added so that information could be sourced quickly. Users could change from list view, to the search view by tapping the magnifying glass icon in the top right-hand corner of the screen. The language was kept colloquial and light, and humorous imagery was used. Care was taken to ensure the images used represented Australia's multicultural community. The following images displayed from Figure 6.11 to Figure 6.23 demonstrate the library content, how it was displayed and some of the imagery used throughout. Each figure shows the contents page, the sub-contents page for each heading, and an example of one article from within each section.

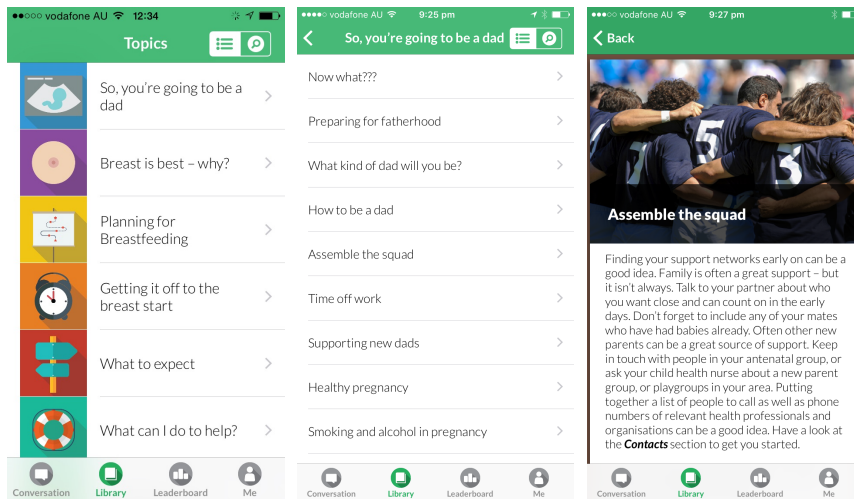


Figure 6.11. Library - So you're going to be a dad

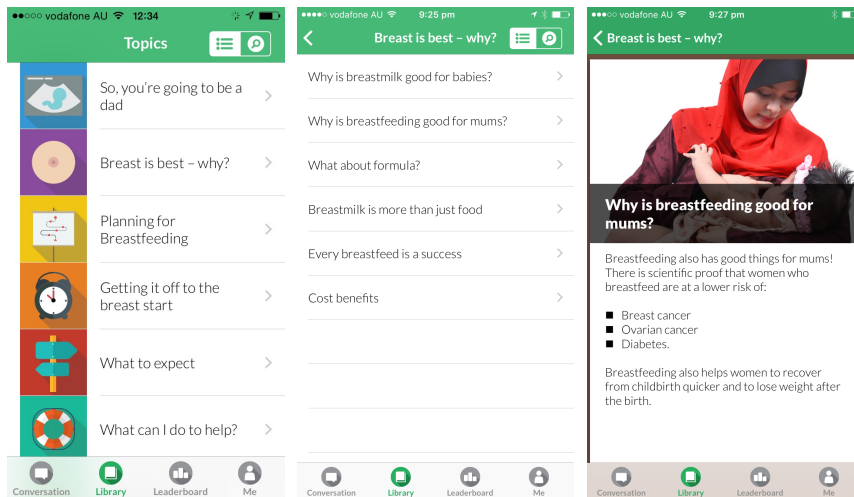


Figure 6.12. Library - Breast is best - why?

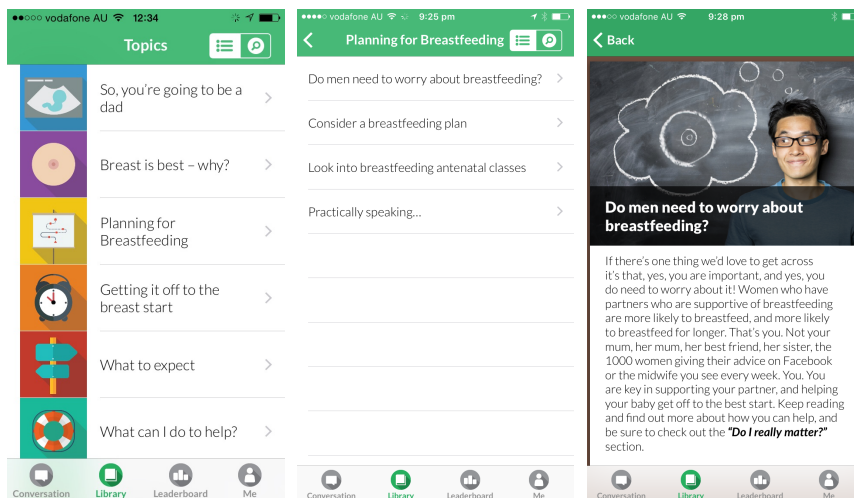


Figure 6.13. Library - Planning for breastfeeding

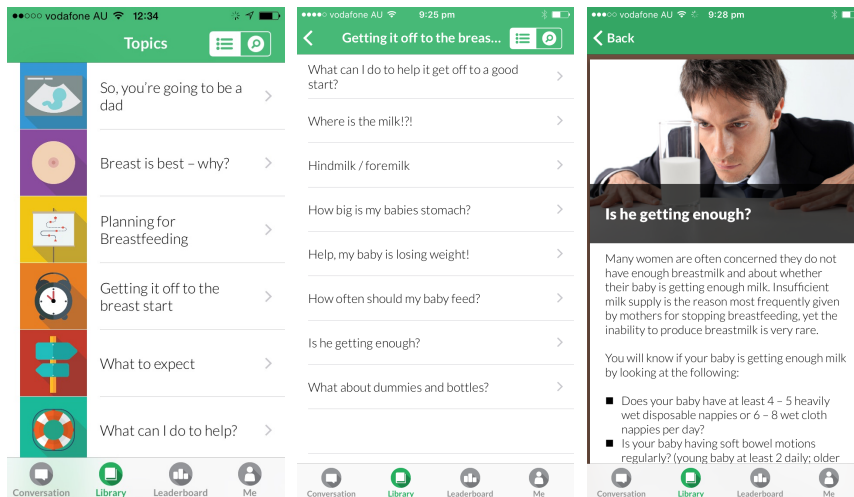


Figure 6.14. Library - Getting it off to the breast start

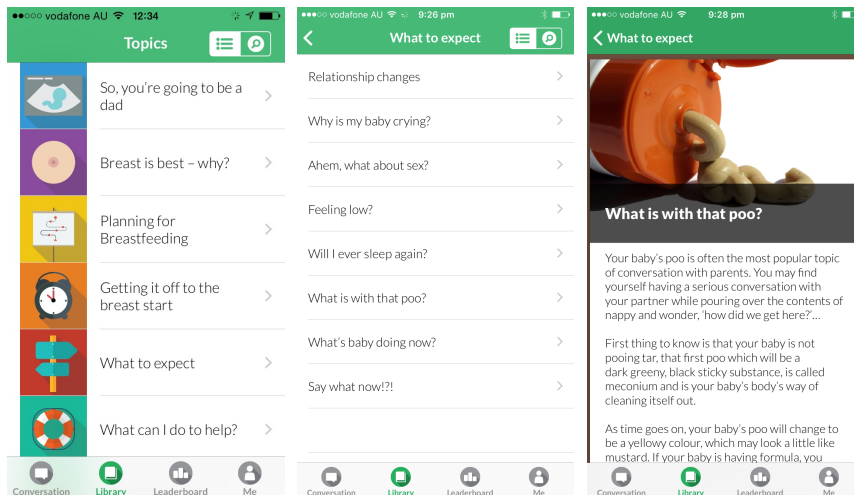


Figure 6.15. Library - What to expect

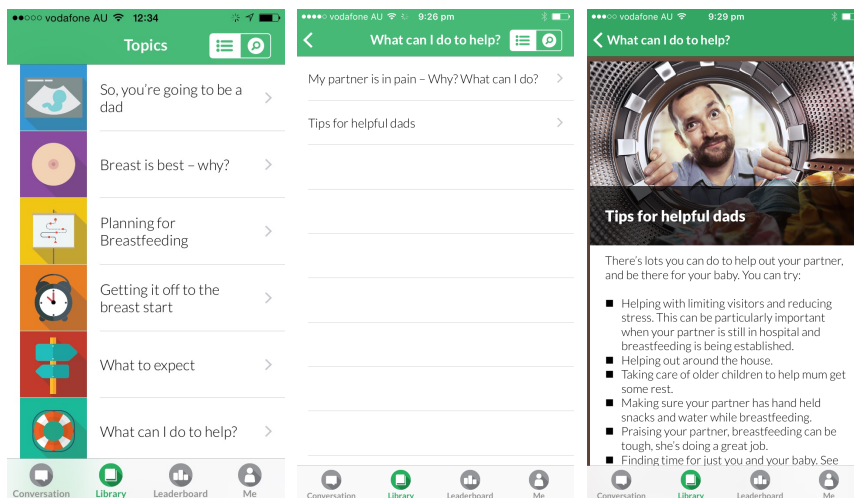


Figure 6.16. Library - What can I do to help?

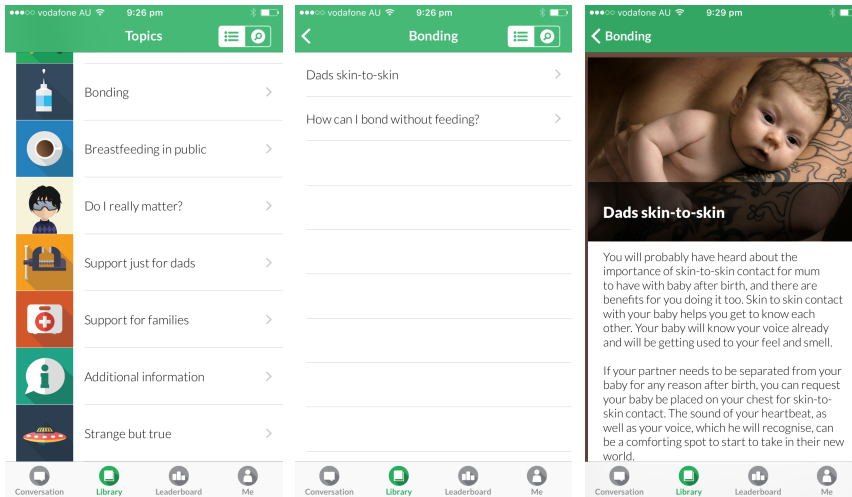


Figure 6.17. Library - Bonding

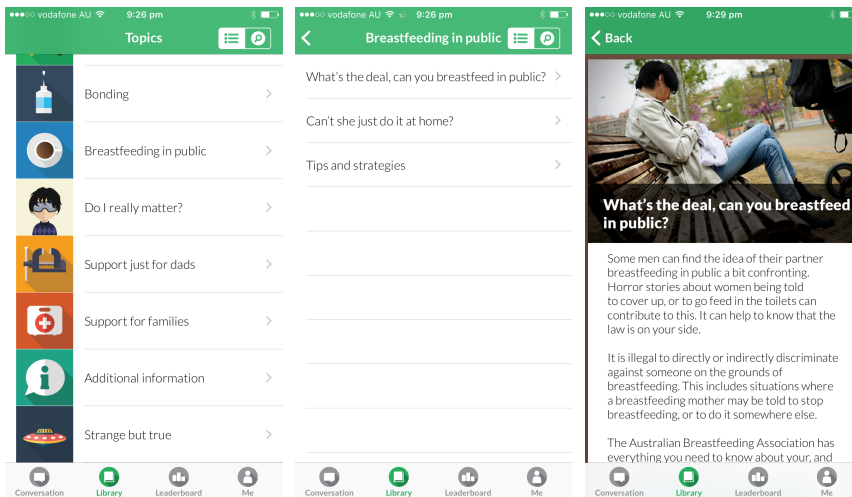


Figure 6.18. Library - Breastfeeding in public

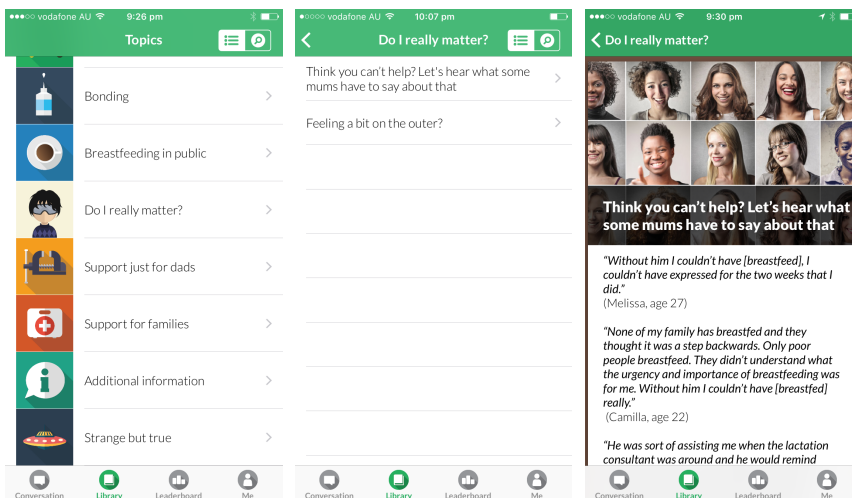


Figure 6.19. Library - Do I really matter?

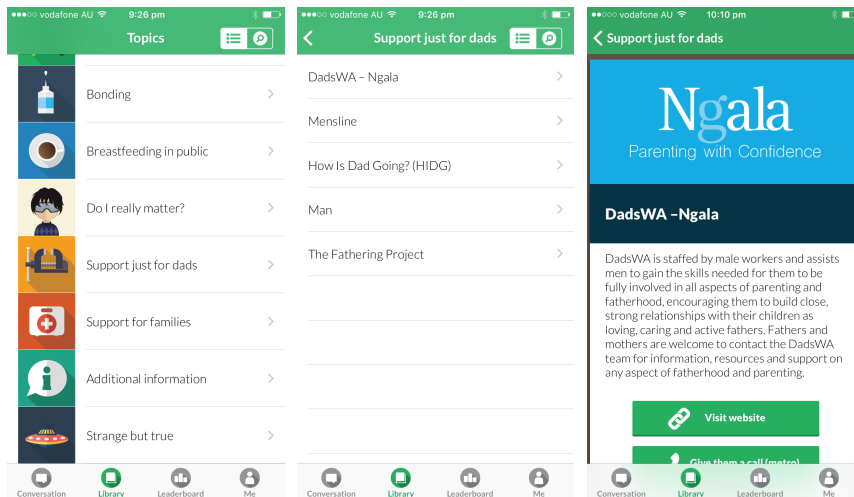


Figure 6.20. Library - Support just for dads

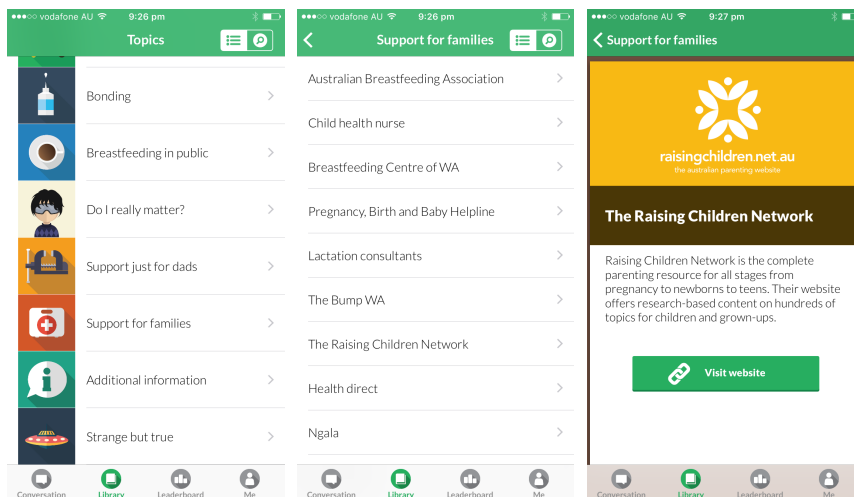


Figure 6.21. Library - Support for families

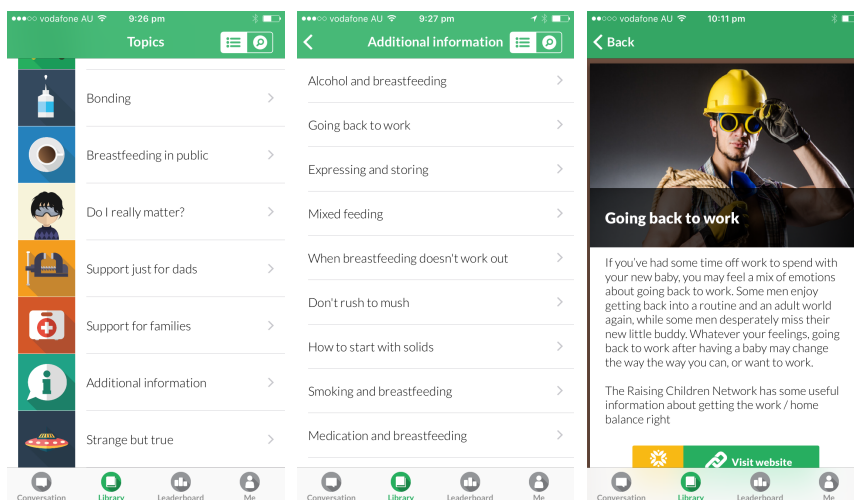


Figure 6.22. Library - Additional information

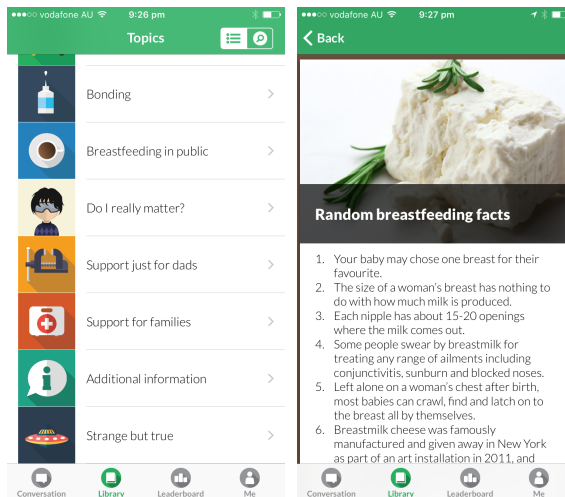


Figure 6.23. Library - Strange but true

6.3.5 Gamification

The app employed a number of gamification elements such as leaderboards, badges, and points to encourage engagement with both the social conversation and library of information. Utilising gamification mechanisms such as these has the potential to better motivate use of health apps (Miller et al., 2014). Users were awarded points for actions that demonstrated engagement. One point was awarded for each comment posted and each poll vote. In addition, users were awarded five points for each badge they achieved. Badges were awarded for achieving the following milestones:

- Making their first comment
- Posting 10 comments
- Posting 20 comments
- Posting 50 comments
- Voting on five polls
- Voting on 10 polls
- Receiving their first upvote
- Receiving 10 upvotes
- Receiving 20 upvotes
- Receiving 10 'good banter' upvotes
- Receiving 20 'good banter' upvotes
- Receiving 10 'smart idea' upvotes
- Receiving 20 'smart idea' upvotes
- Being the first person to comment on a post
- Reading 10 library articles
- Reading 20 library articles
- Following 10 links to external websites
- Opening the app for five consecutive weeks
- Swiping into the app 10 times from the notification

Users could tap on the badge icon to reveal the user requirements in order to achieve each badge. Figure 6.24 shows the 'Me' tab with the badge icons, and examples of the descriptors of two badges. Unachieved badges were shown in a low alpha state (that is, faded out), with achieved badges at full alpha.

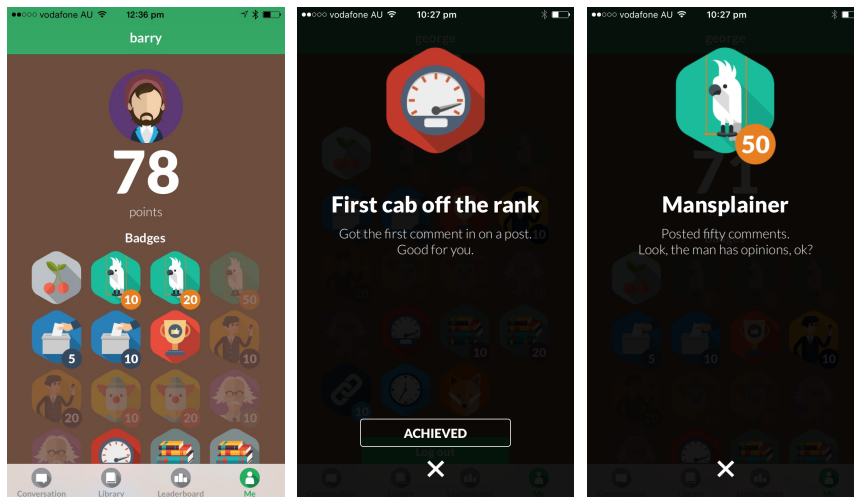


Figure 6.24. Milk Man badges

A user could see their score and rank on the leaderboard. The leaderboard had the option of being listed either by their own group, or with the whole cohort (all time). Figure 6.25 shows the leaderboard.

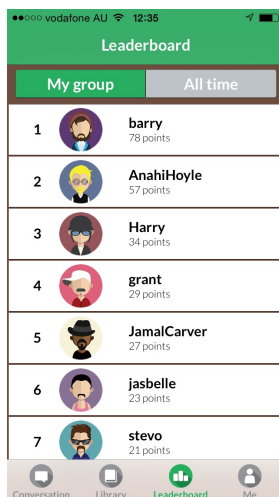


Figure 6.25. Milk Man leaderboard

6.4 Testing and iteration

6.4.1 Introduction

App testing is a vital part of the development process. As well as testing for bugs and software errors, user testing is imperative in identifying functionality and usability issues. Testing of Milk Man included two phases – beta testing and user testing. The beta testing involved providing early versions of the app to four experienced app testers, who examined it for errors, crashes, layout issues, software bugs, or other problems. The app was also beta tested by members of the research team. Feedback was incorporated into successive iterations of the app. Members of the target group were not used for beta testing, as design and functionality feedback was not being sought at this stage.

The second phase of testing, user testing, involved obtaining feedback on the app's functionality, design and usability. It was important that this phase of testing was carried out by members of the target group, as the objective was to gain an indication of the way in which the app was likely to be used and received by those for whom it was intended.

6.4.2 User testing methods

Fathers who were either expecting a baby or had a baby under the age of six months were eligible to take part in the user testing. Participants were recruited from a pool of people who had expressed interest in attending one of the focus groups, but had not been able to attend. The testing sessions were conducted one-to-one with the lead student researcher and participants were invited to come to Curtin University at a time that suited them. Upon arrival at the session, participants were briefed on the process, given an information sheet and asked to sign a consent form (included as Appendix E.4). Once they had provided consent they were asked to complete a brief demographic questionnaire before commencing the user testing. This sub-study of the PIFI project was approved as a protocol amendment by the Curtin University HREC (HR82/2014/AR3, 12 March 2015). Table 6.6 summarises the participant demographic information.

Users were initially asked to undertake a think-aloud walkthrough of the app, and then to complete the Mobile App Rating Scale (MARS) (Stoyanov, Hides, Kavanagh, & Wilson H, 2016). Instructions issued to users are included in Appendix E.5. Four users were recruited to this testing phase. Four to five test users is generally sufficient to identify up to 75% of usability issues, with the value of additional participants decreasing after this number (Nielsen, 1994).

Table 6.6. Demographic summary of user testing participants (n=4)

Age in years	
30-34	1
35-39	1
40-44	2
Marital status	
Married	3
Defacto	1
Children	
Expecting	1
Baby under six months	3

6.4.2.1 Think-aloud walkthrough

Think-aloud walkthroughs are an industry standard approach in software development, and a well-recognised way of testing mobile health apps (Al Ayubi, Parmanto, Branch, & Ding, 2014; Atwal, Money, & Harvey, 2014; Boushey et al., 2015; Lim et al., 2015; Nikolaus et al., 2014). In this study, after observing a researcher-led example using a different health app, participants were asked to spend a minimum of 10 minutes using Milk Man, and to verbalise their thought processes as they navigated through the app. As the researcher wanted to observe the natural flow of app use and observe organic navigation, the initial instruction was simply for users to *'Use and open the app as you would exploring any app for the first time'*.

A checklist of 10 tasks was compiled by the researcher and a log was kept of tasks completed by users. At the completion of the walkthrough users were specifically asked to complete tasks on the checklist that they had not completed independently. In keeping with best practise in conducting think-aloud studies, the researcher remained quiet throughout the study, speaking only to remind the participant to keep talking aloud, and to issue tasks at the end (Jaspers, 2009). The think-aloud sessions were recorded and transcribed.

The tasks each user was required to perform included:

1. Log on
2. Go to the library and read an article
3. Follow a link within a library article
4. Find an article on 'expressing'
5. Find your position on the leaderboard
6. Enter a comment for last week's conversation
7. Complete a poll
8. Read the information page
9. Find out what three of the different badges mean
10. Upvote a post

6.4.2.2 Mobile App Rating Scale

The MARS is a comprehensive questionnaire used for rating mobile health apps. It identifies five key criteria for evaluating health apps. The first four of these give a measure of *aesthetics, engagement, functionality* and *information*, while the fifth criterion is a subjective *quality* scale and seeks users' views on whether they would recommend the app, how often they would use it and asks for an overall rating (Stoyanov et al., 2015). The MARS comprises two different scales, one for professionals, and one for 'app users', both of which have been validated (Stoyanov et al., 2016; Stoyanov et al., 2015). The 'app user' scale comprises twenty questions over the five sections, with a final section asking six questions designed to describe the potential for impact on a user's knowledge, attitudes and intention to change (Stoyanov et al., 2016). After completing the think-aloud study, users were asked to independently complete the 'app user' version of this scale.

6.4.3 Results - Testing and iteration

6.4.3.1 Think-aloud walkthrough

User testing via the think-aloud walkthrough identified six issues related to usability and functionality. Usability issues included text in the comments section being too small, a lack of clarity about how the points system worked, and the need for the information icon to be more prominent. In terms of functionality, three additional features were suggested: the ability for users to post their own questions, the inclusion of a tutorial or walkthrough to explain the different sections of the app, and the ability to change the avatar they had selected on creation of a user profile.

The majority of participants completed the 10 tasks on the walkthrough checklist while independently using the app, without needing to be prompted. In each case, the remaining items were all able to be completed when prompted.

6.4.3.2 Mobile App Rating Scale

The MARS scores from each user were averaged and are listed in Table 6.7. All four participants said they would recommend the app, and all gave the app a four or five star rating.

Table 6.7 MARS Scores for each category

Criterion	Average (out of 5)
Aesthetics	4.3
Engagement	3.8
Functionality	4.6
Information	4.5
TOTAL Average score	4.3

6.4.4 Discussion

The think-aloud walkthroughs showed good navigability and understanding of the app layout and usage. All of the six issues identified in the user-testing phase were addressed in the next round of iteration with the exception of the ability for users to post their own questions. This issue was discussed within the research team and a decision was made not to include this added functionality. The reason for this was that the scope of the project was very much focussed on the dissemination of breastfeeding and infant feeding information, with a secondary focus on early parenthood and fatherhood. The team identified a potential risk of topics being introduced by users with misleading or poorly informed informational content, as well as the potential for the content focus of the app to be shifted away from the study aims.

The MARS scores were high, indicating good user acceptability, usability, and functionality. While still high, the engagement score was slightly lower. The lowest score for this section was in response to a question about the level of customisation in the app. This appeared to relate to participants' stated need for further instructions, explanations, and the ability to change avatars to better customise their user account, all issues that were addressed in the next iteration of the app. The testing phase was useful in identifying issues that were able to be addressed in iteration and prior to the deployment of the app in the PIFI study.

6.5 Conclusion

The Milk Man app was developed using a best practice approach which included being grounded in behaviour change theory, involving end users throughout and being developed by a multidisciplinary team. The app had a considered approach to engagement which included a thorough scoping and design process, inclusion of targeted content and a range of engagement strategies used within the app. The different components of the app were directly informed by the literature and mapped to relevant SCT constructs. The SCT provided a useful and thorough base to guide the structure of the intervention. Push notifications, gamification and social connectivity were all strategies designed to encourage engagement. A comprehensive information library was developed and embedded in the app and robust procedures were developed to manage the implementation. Milk Man scored highly with users in the testing phase and underwent several rounds of iteration following feedback at various stages prior to the start of the trial.

Chapter 7 Process and impact evaluation results

7.1 Participant demographics

A total of 1,426 couples were recruited to the PIFI study. Demographic information was available for 1,093 fathers who returned the baseline questionnaire. The demographic summary of fathers participating in the study is presented in Table 7.1. Fathers were randomised into either the control group (C), a medium intensity group receiving the male facilitated antenatal class (M1), a medium intensity group receiving the Milk Man app intervention (M2) or the high intensity (HI) group receiving both the antenatal class and the Milk Man app intervention.

A total of 271 fathers (24.8%) were randomised into the control group, 259 (23.7%) in the HI group, 263 (24.1%) into the M1 group and 300 (27.4%) into the M2 group. A chi-square test of association demonstrated there was no statistically significant difference between study groups for any demographic factor. Most of the fathers were aged over 30 years (81.5%), had some university education (61.8%), lived in an area identified as the least disadvantaged by the Index of Relative Socio-economic Disadvantage (IRSD) (50.1%) and were born in Australia (67.4%).

Table 7.1. Participant demographics

Group	C	HI	M1	M2	Total	P-value^a
	(N= 271)	(N=259)	(N=263)	(N=300)	(N=1093)	
Age						
<30 yrs	63 (23.2%)	46 (17.8%)	42 (16%)	51 (17%)	202 (18.5)	0.065
30-34 yrs	115 (42.4%)	102 (39.4%)	116 (44.1%)	147 (49%)	480 (43.9)	
35 yrs plus	93 (34.3%)	111 (42.9%)	105 (39.9%)	102 (34%)	411 (37.6%)	

Group	C	HI	M1	M2	Total	P-value^a
	(N= 271)	(N=259)	(N=263)	(N=300)	(N=1093)	
Education						
High school / trade	109 (41%)	95 (37.5%)	99 (38.7%)	106 (35.8%)	409 (38.2%)	0.642
Some university	157 (59%)	159 (62.6%)	157 (61.3%)	190 (64.2%)	663 (61.8%)	
IRSD						
1 (most disadv)	8 (3%)	6 (2.3%)	7 (2.7%)	7 (2.3%)	28 (2.6%)	0.818
2	7 (2.6%)	9 (3.5%)	8 (3%)	10 (3.3%)	34 (3.1%)	
3	62 (22.9%)	58 (22.4%)	44 (16.7%)	59 (19.7%)	223 (20.4%)	
4	53 (19.6%)	65 (25.1%)	67 (25.5%)	75 (25%)	260 (23.8%)	
5 (least disadv)	141 (52%)	121 (46.7%)	137 (52.1%)	149 (49.7%)	548 (50.1%)	
Country of birth						
Aust / NZ	187 (70%)	166 (65.1%)	172 (67.2%)	199 (67.2%)	724 (67.4%)	0.925
UK / Eire	27 (10.1%)	31 (12.2%)	33 (12.9%)	38 (12.8%)	129 (12%)	
Africa / Middle East	14 (5.2%)	19 (7.5%)	12 (4.7%)	20 (6.8%)	65 (6.1%)	
Asia	23 (8.6%)	18 (7.1%)	22 (8.6%)	21 (7.1%)	84 (7.8%)	
Other	16 (6%)	21 (8.2%)	17 (6.6%)	18 (6.1%)	72 (6.7%)	

^a Pearson chi square

7.2 Process evaluation

Process evaluation conducted in this study describes how participants were using the app and user perspectives on the app. Process evaluation was carried out via a mixed methods approach using a combination of qualitative and quantitative data including app analytics data and data collected from the questionnaires participants completed when their baby was six weeks old. The results from the process evaluation are described here, structured according to the evaluation plan detailed in Chapter 4 which included the five areas of: people, content, technology, computer-mediated technology, and health systems integration. Data in this section address objective three: *to conduct comprehensive process evaluation investigating which of the app engagement strategies were effective in motivating and engaging users.*

A flowchart of participant inclusion is shown in Figure 7.1. A total of 681 participants were randomised into a group that had access to the Milk Man app (M2 or HI) and from these, a total of 586 people downloaded the app (86%). Of the 586 participants who signed up to the app, 513 provided a date of birth for their babies. The date of birth was required to trigger the six week questionnaire and to enable comparison of analytics over time. Four of these participants signed up to the app, but never opened it and hence were excluded as no data were available. Therefore, the app analytics data are provided for 509 participants.

Of the 681 participants who were randomised into an app group, 439 completed the six week questionnaire. A total of 400 participants completed both the six week questionnaire and had downloaded the app and opened it at least once. Completing both of these actions was required for inclusion in the engagement measure.

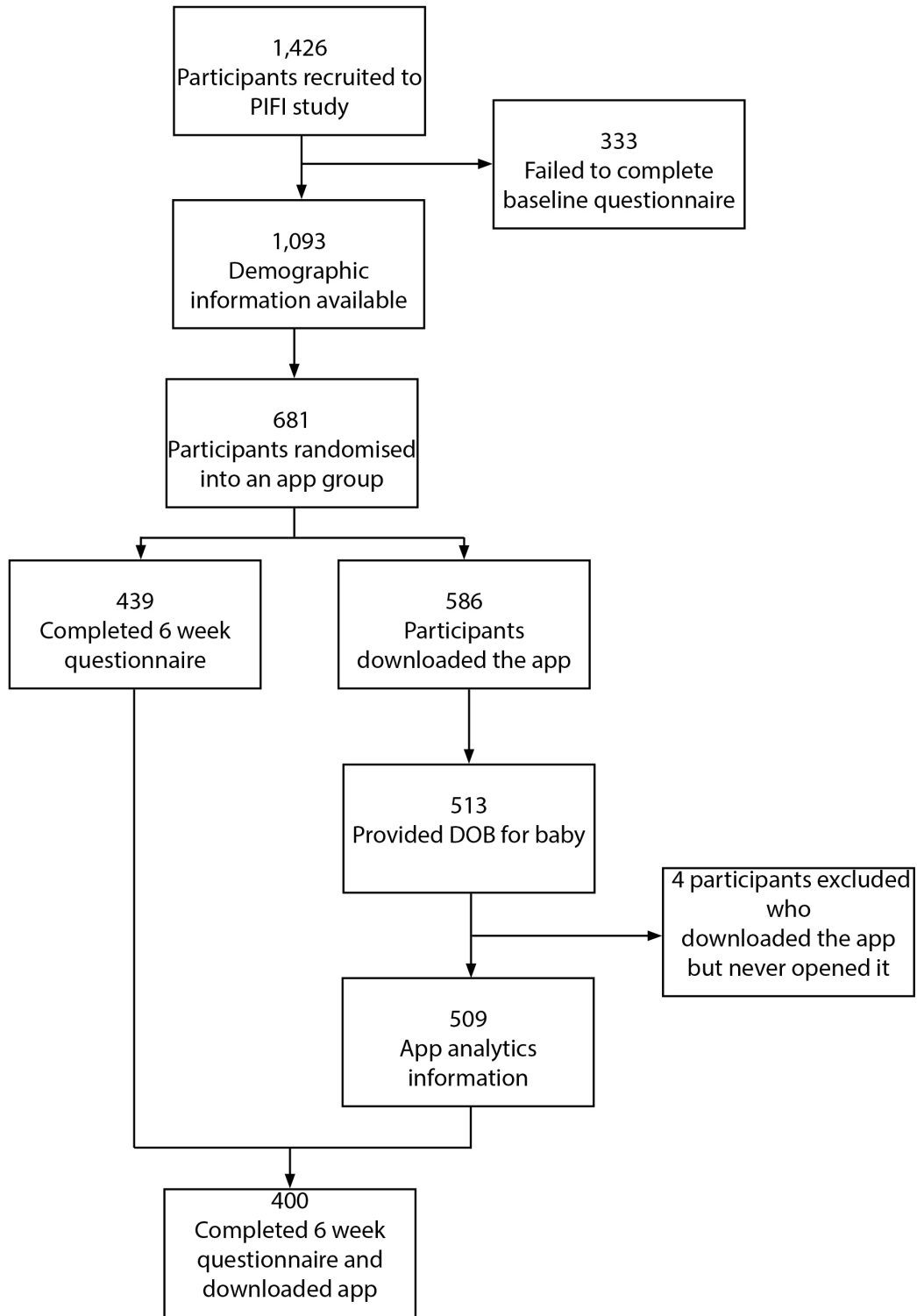


Figure 7.1. Flowchart of participants

7.2.1 People

The 'people' section of the process evaluation includes intentions to use and users' perspectives, including motivations for use. Data were derived from the quantitative and open text (qualitative) questions in the six week questionnaires. Of those who completed the questionnaire (n=439), most (84%, n=367) indicated that they had downloaded the app. Those who said they had not installed Milk Man (n=23) were asked why and their responses are below in. Participants could choose more than one response. The most common reasons given for not downloading the app were either being too busy, or just having not gotten around to it.

Table 7.2. Reasons given for not installing app (n=23)

Answer	Number of responses^a
I'm too busy	8
I haven't gotten around to it	7
Had problems downloading	6
I can't be bothered looking at it	4
I don't use apps	4
Partner not breastfeeding	1
Other	5

^a Multiple response – could indicate more than one reason

The *other* option contained an open text box asking participants to identify reasons for not installing the app. The responses given to this were: 'I could not install it on my phone', 'I found support and advice from friends instead', 'I lost the code', 'The software it runs off was not supported on my phone' and 'Windows phone'.

7.2.1.1 Motivators

Participants were asked (via a multiple-choice question) what motivated them to visit the Milk Man app. Figure 7.2 describes participant responses, participants could chose more than one answer. Push notifications were the highest reported motivating factor (n=164). This was followed by liking seeing what other dads had written (n=129) and needing to find information (n=109).

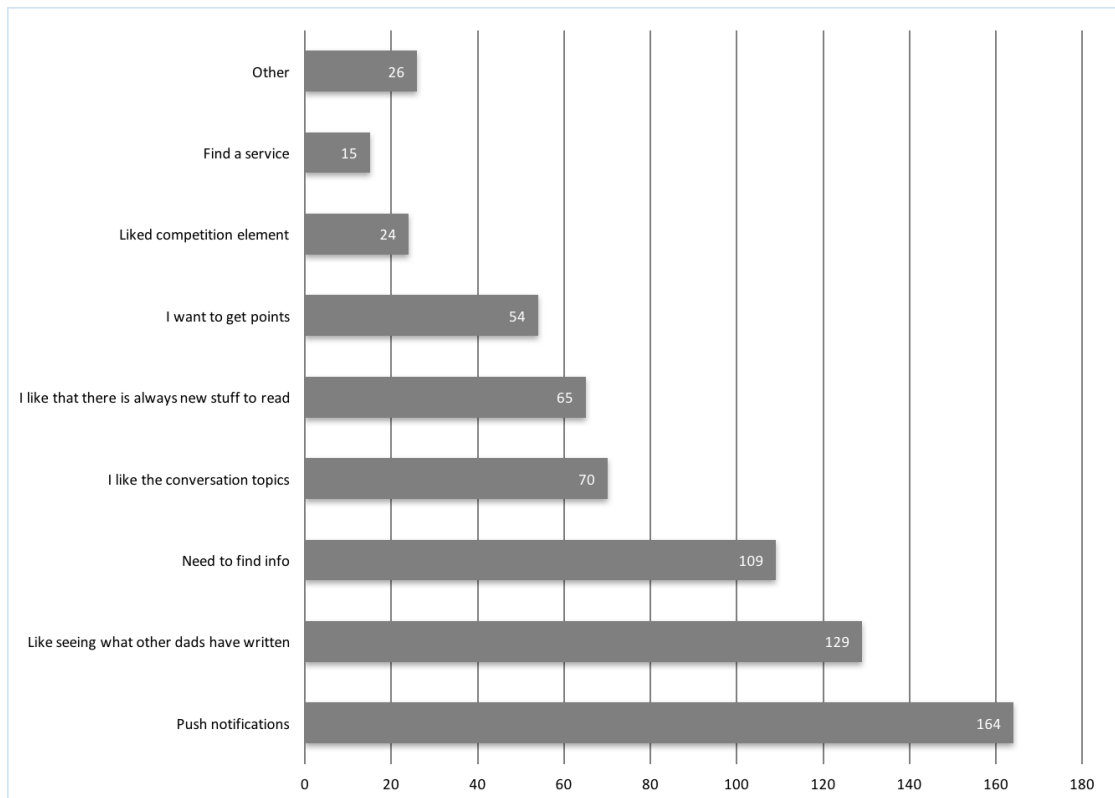


Figure 7.2. Motivators to use app

Twenty-four free text responses were recorded underneath the 'other' option in response to asking what motivated use. The most common response recorded was feeling obliged to as part of the study (n=9), followed by curiosity (n=5) and 'just checked it out once' (n=3). Other comments entered in this section (n=7) included:

I wanted to support other dads, and support an app that does so,

*I feel the need to win at everything. For this reason I have dominated the app.
#1.*

That I'm participating in this study so want to see what it offer.

It's a useful on hand trustworthy source without having to sift through information.

Boredom.

Just having it there was cool as you could get information if you wanted, gave me a little freedom.

What competition?

7.2.2 Content

Content refers to the library content built into the app, as well as the dynamic user-generated content in the conversation forum. Users' perspectives on the key engagement strategies are also included in this section. Data were derived from both the app analytics framework and from the quantitative and open text (qualitative) questions in the six week questionnaires.

A total of 139 comments were posted in the open-ended question asking fathers what they liked about the app, and many of these were in relation to the app's content. Twenty-five fathers posted comments about how they liked the general concept of the app. Simply the fact that the app existed and was targeted at fathers appeared to be a perceived as a positive to fathers.

[I] like the idea and the potential of it.

I like the concept.

Was good to see that there was something out there for the Dads.

[I liked that] It exists.

[I liked] It being there.

Although the majority of comments were positive, one comment identified a potential harm in relation to the app causing increased stress.

While the app may prove to be useful for some people, it didn't appeal to me, nor did it provide me with anything extra I needed. I felt at times the app, through conversations, encouraged over thinking and unnecessary stress. The more I used the app the more I felt stressed to do more and more even though what I was doing was enough. I felt like I would research and use the app to feel like a better parent when I was missing out on working through things with my partner.

Two fathers reported that having the app introduced earlier on in pregnancy would have been beneficial.

Earlier access / direction - i.e., if the app was presented to me at, say, our 12 or 16 week scan, I may have had more time to become used to it or built it in to our routine. As it was, by the time I downloaded the app I had already become accustomed to other info sites, which had become my "go to" sources.

App was well designed and an easy source of information, but I guess that prior to having it my partner and I had already found useful sources/websites/communities from which we get our breastfeeding information.

Eight comments made suggestions relating to increasing the personalisation of the app. Four of these referred to being able to edit the username chosen at sign-up and to upload their own photo as opposed to being restricted to the avatars provided.

load up own photo, didn't like Avatar and name choice (use real name).

Other comments focused on linking the conversation forum to social media (n=2) and to better time the information being added to the conversation so it was closer to the actual stage their babies were at.

conversation topics when they come up, they're a bit behind the time, the ohh and ahh one, baby has been doing that for a while. If you could put when your baby was born then the topics of conversation would be better matched.

I think linking the app to social media would be good, this would make the experience much more personal.

7.2.2.1 Information library

The number of library articles viewed by participants ranged from 0 – 79 with an average of 11.46 per participant (std. dev. 13.7). Article views were recorded through the app analytics framework every time a user opened an article. This could reflect a participant reading a total number of unique articles and / or returning to an article multiple times. Table 7.3 shows the individual library articles and the number of times the article was viewed by participants. It was also possible to investigate whether the inclusion of a link to the article from within the conversation was associated with the number of article views and Table 7.3 also includes a column indicating this association. The 10 most read articles are highlighted in the table. All but one of these most read articles were linked to a conversation topic.

Table 7.3. Library article views

Content	Number of article opens	Linked from conversation
So, you're having a baby!		
1.1 Now what???	284	
1.2 Preparing for fatherhood	185	
1.3 What kind of dad will you be?	196	Y
1.4 How to be a dad	151	
1.5 Assemble the squad	230	Y
1.6 Time off work	318	Y
1.7 Supporting new dads	109	Y
1.8 Healthy pregnancy	166	Y
1.9 Smoking and alcohol in pregnancy	92	
Breast is best – why?		
2.1 Why is breastmilk good for babies?	116	
2.2 Why is breastmilk good for mums?	80	
2.3 What about formula?	118	
2.4 Breastmilk is more than just food	67	
2.5 Every breastfeed is a success	94	
2.6 Cost benefits	89	
Planning for Breastfeeding		
3.1 Do men need to worry about breastfeeding?	90	
3.2 Consider a breastfeeding plan	174	Y
3.3 Look into breastfeeding antenatal classes	130	Y
3.4 Practically speaking...	91	
Getting it off to the breast start		
4.1 What can I do to help it get off to a good start?	248	Y
4.2 Where is the milk!?!	94	
4.3 Hindmilk / foremilk	94	
4.4 How big is my babies stomach?	79	
4.5 Help, my baby is losing weight!	64	
4.6 How often should the baby feed?	108	
4.7 Is he getting enough?	93	
4.8 What about dummies and bottles?	85	

Content	Number of article opens	Linked from conversation
What to expect		
5.1 Relationship changes	81	
5.2 Why is my baby crying?	104	
5.3 Ahem, what about sex?	113	
5.4 Feeling low?	121	Y
5.5 Will I ever sleep again?	162	Y
5.6 What is with that poo?	134	Y
5.7 What's baby doing now?	77	
5.8 Say what now!?!	87	
What can I do to help?		
6.1 My partner is in pain – Why? What can I do?	87	
6.2 Tips for helpful dads	313	Y
Troubleshooting		
7.1 Breastfeeding problems	98	Y
7.2 Attachment	76	
7.3 Insufficient supply	51	
7.4 Nipple care	49	
7.5 Breast and nipple thrush	24	
7.6 Mastitis	30	
7.7 Engorgement	47	
7.8 Biting	36	
Bonding		
8.1 Dads skin-to-skin	380	Y
8.2 How can I bond without feeding?	215	Y
Breastfeeding in public		
9.1 What's the deal, can you breastfeed in public?	186	Y
9.2 Can't she just do it at home?	49	
9.3 Tips and strategies	58	
Do I really matter?		
10.1 Think you can't help with breastfeeding?	91	
10.2 Feeling a bit on the outer?	128	Y
Support just for dads		
11.1 DadsWA –Ngala	54	
11.2 Mensline	37	

Content	Number of article opens	Linked from conversation
11.3 How Is Dad Going (HIDG)?	64	
11.4 Man	65	
11.5 The fathering project	63	
Support for families		
12.1 Australian Breastfeeding Association	20	
12.2 Child Health Nurse	16	
12.3 Breastfeeding centre of WA	16	
12.4 Pregnancy, Birth and Baby Helpline	19	
12.5 Lactation consultants	18	
12.6 The Bump WA	21	
12.7 The Raising Children Network	23	
12.8 Health direct	11	
12.9 Ngala	19	
12.10 Beyond Blue	9	
12.11 PANDA	16	
12.12 Lifeline	9	
Additional information		
13.1 Alcohol and breastfeeding	70	
13.2 Going back to work	98	Y
13.3 Expressing and storing	81	
13.4 Mix feeding	61	
13.5 When breastfeeding doesn't work out	44	
13.6 Don't rush to mush	68	
13.7 How to start with solids	35	
13.8 Smoking and breastfeeding	28	
13.9 Medication and breastfeeding	38	
14.1 Strange but true Breastfeeding facts	426	Y

Many of the library articles contained links to external sources including websites and YouTube videos. Participants followed unique links to external sites (not including multiple visits to the same link over time) between 0-43 times. The average number of unique links followed per person was 3.0 (std. dev. 5.3). Table 7.4 shows the 10 most highly visited external links and the number of visitors. Links to external sites were either embedded in the conversation topics on the forum page, or linked to from an article within the library. In seeking to understand the impact the conversation had on the links that were followed, the table differentiates between external links that were directly accessed from the conversation forum, and those accessed from a library page which was linked to the conversation forum. All the top 10 most followed links were associated with topics in the conversation forum.

Table 7.4. Top 10 external links followed by users

Website link	Number of users visiting	Direct link from conversation	On a library page, which was linked to conversation
50 Things every guy should know about pregnancy and parenthood (Pregnancy blog)	210	Y	
Baby tummy time workout (YouTube)	142	Y	
Baby recognising father's voice (YouTube)	90	Y	
Dads guide to pregnancy (Raising Children Network)	54		Y
Skin to skin can be a dad thing (Fatherhood blog – Australian Breastfeeding Association)	46		Y
Poos and wees (Raising Children Network)	31		Y
Breastfeeding: how dads can help (Raising Children Network)	30		Y

Website link	Number of users visiting	Direct link from conversation	On a library page, which was linked to conversation
Men: planning your family support network (Raising Children Network)	29		Y
My breastfeeding plan (Australian Breastfeeding Association)	29		Y
Father-inclusive practice guide (Australian Government)	27		Y

Users were asked a series of questions seeking their perspectives on the library. Table 7.5 shows responses to all questions. Overall the responses were positive and demonstrated the value to participants. Two thirds of respondents reported (by choosing agree or strongly agree) that they found information easy to find (67%), and that the external links were appropriate and useful (66%). Almost three quarters (72%) of participants said that they learnt new information from the library and the information was trusted by 79% of respondents. However, only 24% of participants reported coming to the app when they needed to find information and just over half of participants (57%) agreed that the library contained enough information.

Table 7.5. User perspectives on Milk Man library

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The information was easy to find. (n=297)	22 (7%)	179 (60%)	79 (27%)	12 (4%)	5 (2%)
There was enough information. (n=297)	16 (5%)	155 (52%)	97 (33%)	26 (9%)	3 (1%)
I learnt new information. (n=296)	25 (8%)	189 (64%)	65 (22%)	16 (5%)	1 (1%)
I trusted the information. (n=296)	38 (13%)	195 (66%)	60 (20%)	3 (1%)	1 (1%)

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The links were appropriate and useful. (n=296)	30 (10%)	164 (56%)	93 (31%)	6 (2%)	3 (1%)
I went to the app when I needed to find information. (n=296)	9 (3%)	61 (21%)	93 (31%)	108 (36%)	25 (8%)

7.2.2.2 Conversation

The app conversation forum was facilitated by a series of topics in the form of posts and polls designed to be time-relevant, and to engage fathers in breastfeeding and early parenting information. From approximately 30 weeks of pregnancy to six weeks after the birth of their baby, a total of 32 topics were added to the conversation. The adding of this new content coincided with a push notification being sent out. The topics were scheduled to be released to fathers twice a week, on a Monday and Thursday, between 11am and 2pm. There were 19 posts and 13 polls in this time-period.

The total number of comments posted in the conversation forum by participants was 1,126. The number of comments made by each participant ranged from 0 – 57. The average was 2.21 (std. dev. 5.246). The way that fathers used the conversation to support and communicate with each other is described in detail in Chapter 8.

When analysing the app analytics data for the poll votes it became apparent there was a bug in the Android version of the app which was not identified until the study was concluded and analysis began. The bug allowed participants to vote more than once on a poll after relaunching the app. This cancelled the appearance of a completed poll, allowing the user to vote as if for the first time while accumulating points for each vote. It appears that a small number of participants had identified this bug and exploited the error by voting multiple times. To address this, when calculating the average number of poll votes per participant, poll votes made were capped to a maximum of 13 to exclude multiple votes. Using the capped figures, there were a total of 2701 poll votes over the time-period, which is an average of 5.3 per person (std. dev. 4.9).

When considering the actual number of times participants voted on a poll (including all poll votes), the range was from 1-101. Eleven participants voted over 20 times. Many of these participants were high point scorers, which suggests they may have identified this as a way of 'gaming' the system to increase their point score. While not all of these high poll voters completed the questionnaire, the following comments from the questionnaires of three of the participants reinforce that the number of points scored was important to the individual user, and the points associated with poll voting may have contributed to the increased voting.

*I feel the need to win at everything. For this reason I have dominated the app.
#1.*

Participant 1042, voted 101 times.

I think it's pretty good. Have you seen my points? I'm totally kicking ass.

Participant 3721, voted 75 times.

[I like] Points.

Participant 4342, voted 23 times.

A Spearman's rank-order correlation was conducted to assess both the relationship between the number of times a participant viewed a poll and voted on a poll, and the number of times a participant viewed a topic and commented on a topic. There was a strong correlation with both these tests, however the correlation between the number of polls people viewed and voted on was stronger ($r_s=0.930$. $p<0.0005$) than the correlation between topics viewed and comments made ($r_s=0.635$. $p<0.0005$). This demonstrates that participants were more likely to follow through with an action when viewing a poll (voting in the poll) than they were when viewing a topic (commenting on the topic).

Fathers were also asked their perspectives on how they found the conversation section of the app. The responses to each of the questions are displayed below in Table 7.6. There were strong responses of *neither agree or disagree* across all questions. Just under two thirds of fathers (63%) said that it was good to hear from other dads (choosing agree or strongly agree), yet only 30% agreed they found the conversation engaging. A total of 37% of participants reported returning to the conversation after viewing the topic to see if there were any new comments in the thread.

Table 7.6. User perspectives on the conversation

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
I find the conversation engaging. (n=297)	4 (1%)	85 (29%)	125 (42%)	68 (23%)	15 (5%)
It was good hearing from other dads. (n=295)	25 (8%)	161 (55%)	84 (28%)	21 (7%)	4 (1%)
I sometimes returned to the conversation to see if there were any new comments. (n=296)	12 (4%)	98 (33%)	88 (30%)	83 (28%)	15 (5%)
I trusted the information in the conversation. (n=297)	7 (2%)	82 (28%)	170 (57%)	33 (11%)	5 (2%)
I have acted on advice that I have read in the conversation. (n=297)	4 (1%)	53 (18%)	149 (50%)	68 (23%)	23 (8%)

Overall, 54% of fathers said that the information in the app had led to conversations with their partner and 53% said that the conversation forum itself had prompted discussion. There were differences in the reporting of this for those who had stopped using the app prior to six weeks postpartum, and those who stated they were still using the app at this time. Figure 7.3 shows the percentage of respondents in both groups who reported that the app prompted discussions with their partner. Of the participants who had stopped using Milk Man prior to six weeks postpartum, 38% (n=54) said the conversation forum itself had prompted a discussion with their partner and 34% (n=48) said the information contained in the app had prompted a discussion. The participants who were still using the app at the time of completing the six week questionnaire reported higher instances of the app prompting discussions. Approximately two thirds of participants (65%, n=102) said they had discussed something from the conversation with their partner and 72% (n=112) said information from the app had prompted a discussion.

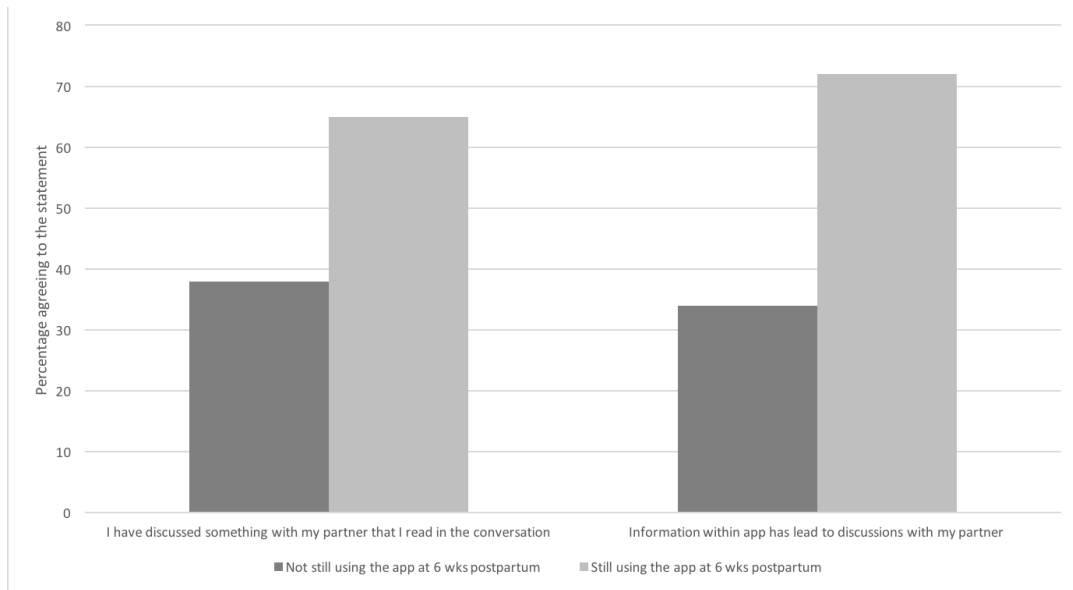


Figure 7.3. App prompted discussions with partner

7.2.2.3 Push notifications

As noted in Section 7.2.1, the most common factor fathers identified as motivating them to use the app was receiving the push notifications. This was reinforced by app analytics data on the usage of the app showing consistent spikes in activity (recorded as app opens) on the days new content was added to the conversation and the push notifications were being sent out. This suggests that the push notifications were a trigger to use the app. The usage over a one month period is displayed in Figure 7.4, demonstrating the spikes in activity on the days push notifications were sent out. This usage was typical of what was observed throughout the study.

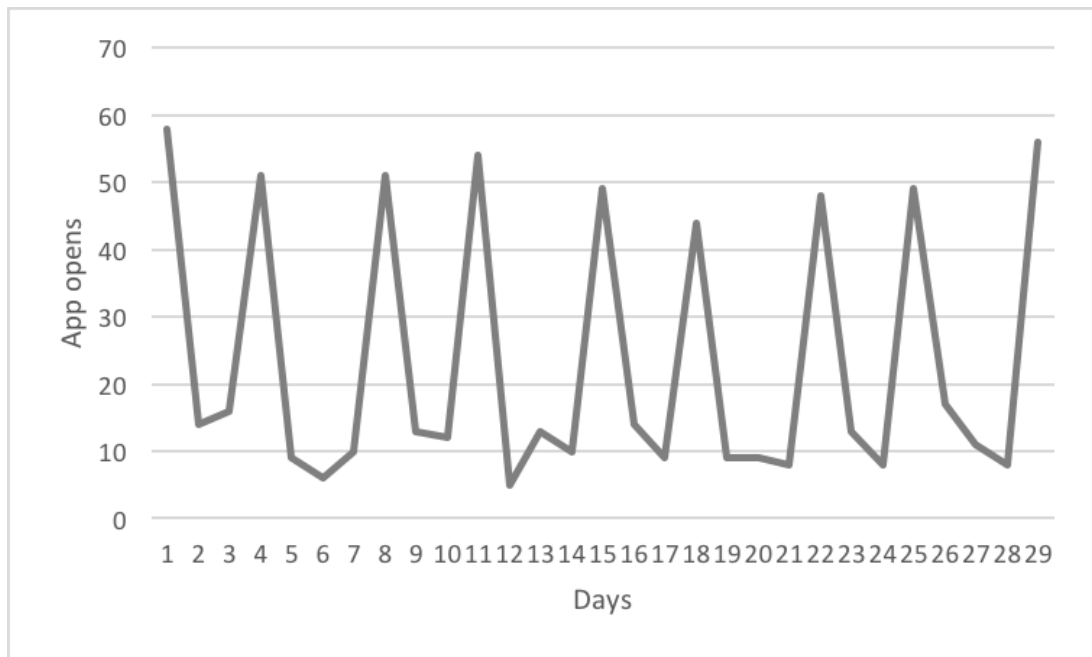


Figure 7.4. App usage over a one month period

There were some comments in the general feedback section of the six week questionnaire from fathers specifically addressing the notifications. None of the comments were negative. When asked about suggestions to improve the app, four fathers wrote comments about the push notifications, all of them referring to increasing the frequency.

I'd say the push notifications could be more frequent. Sometimes I go for days without opening the app. Wouldn't mind if one a day I was reminded of new posts or comments.

More posts on a regular basis.

In addition, when asked what they liked about the app, three fathers specifically cited the push notifications. There were no comments from fathers expressing dissatisfaction with the push notifications.

[I liked] The notifications on phone of new topics.

[I liked the] Different topic reminders.

7.2.2.4 Gamification

Users received points for the actions they completed in the app. The points schedule was detailed in Section 6.3.5. Participants earned points for their level of participation with the different components of the app that had been designed to engage them with the information. The number of points achieved by participants ranged from 0-153 with an average of 22.24 per user (std. dev. 25.6) A box plot (Figure 7.5) shows the interquartile ranges and identifies several high point achieving outliers, including two extreme outliers.

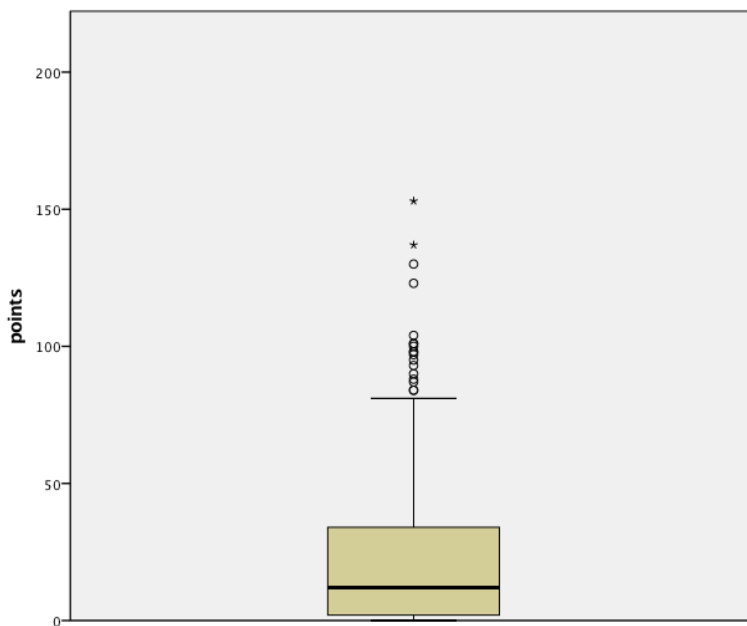


Figure 7.5. Points box plot

Badges were another feature of the gamification strategy and were earned by participants for completing certain actions. The full badge schedule was detailed in Section 6.3.5. Figure 7.6 shows the badges achieved by participants in the aggregate. The most commonly achieved badges were: voting on five polls (n=231); reading 10 articles (n=195); posting their first comment (n=187); opening the app five weeks in a row (n=184) and voting on 10 polls (n=155).

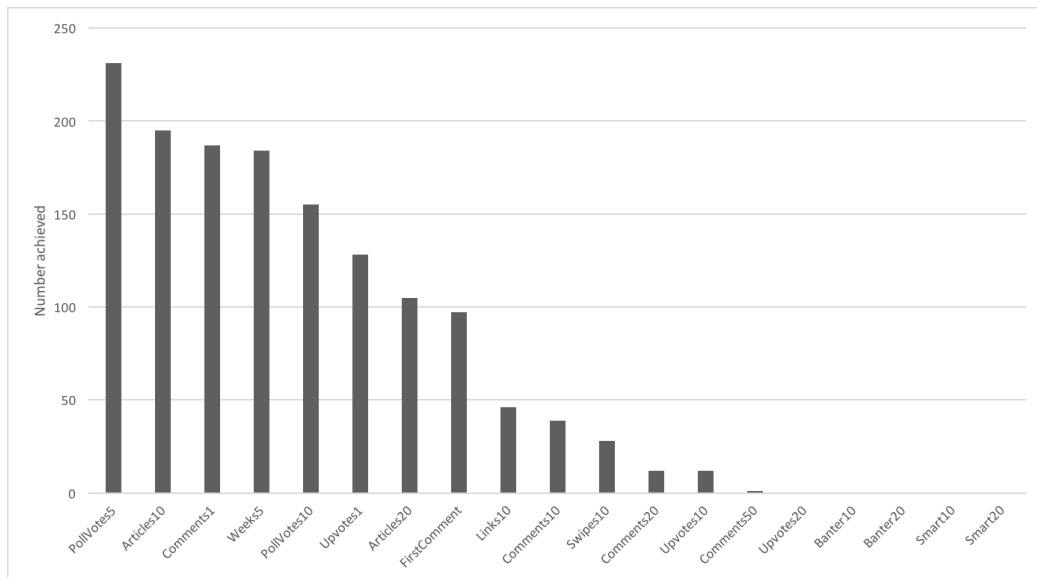


Figure 7.6. Badges achieved

A Spearman’s rank-order correlation was carried out to assess the relationship between the number of badges a participant achieved, and the number of times the user tapped on a badge to view the description. There was a strong positive correlation between the number of times a participant tapped on a badge and the number of badges they achieved ($r_s=0.670$. $p<0.0005$).

User opinions on the gamification differed depending on whether participants were still using Milk Man at the time of completing the six week questionnaire. A Mann-Whitney U test was run to determine if there were differences in answers given to the gamification questions between users who were still using the app at six weeks postpartum, and those who were not. Distributions of the scores for both groups were similar, assessed by visual inspection. The p-value for all questions was <0.05 , indicating that there was a significant difference in answers between groups. Table 7.7 shows the percentages of answers both for participants still using the app at six week postpartum, and for those who were not, as well as the p-value.

For those who were still using the app at six weeks postpartum, approximately one third of respondents said that the specific gamification elements were encouraging their use. This included earning points (41%), earning badges (35%) and their position on the leaderboard (28%). Those who had stopped using the app before completing the six week questionnaire were significantly less likely to agree that any of the gamification functions encouraged their use.

Table 7.7. User perspectives on gamification

	Still using Milk Man at 6 wks. post birth			Not still using Milk man at 6 wks. post birth			P value
	Agree	Neither agree or disagree	Disagree	Agree	Neither agree or disagree	Disagree	
Earning points encourages me to keep using the app. (n=295)	64 (41%)	42 (27%)	50 (32%)	20 (14%)	48 (35%)	71 (51%)	<0.001
Earning badges encourages me to keep using the app. (n=295)	54 (35%)	49 (31%)	53 (34%)	18 (13%)	53 (38%)	68 (49%)	<0.001
My position on the leaderboard encourages me to keep using the app. (n=293)	44 (28%)	50 (32%)	60 (40%)	15 (11%)	56 (40%)	68 (49%)	0.001

7.2.3 Technology

Data for the technology indicator were derived from the app analytics framework. The app was available for devices using the iOS and Android operating systems. Almost two thirds of fathers (65.4%) who signed up for the app did so using the Apple operating system the remainder used an android operating system (34.6%).

App analytics were used to map when fathers were using the app over time. Figure 7.7 shows the aggregated total number of unique days the app was opened each week, ranging from 10 weeks before birth, up to six weeks after the birth of their baby. The graph shows the highest usage of the app by fathers was in the first week after the birth of their baby.

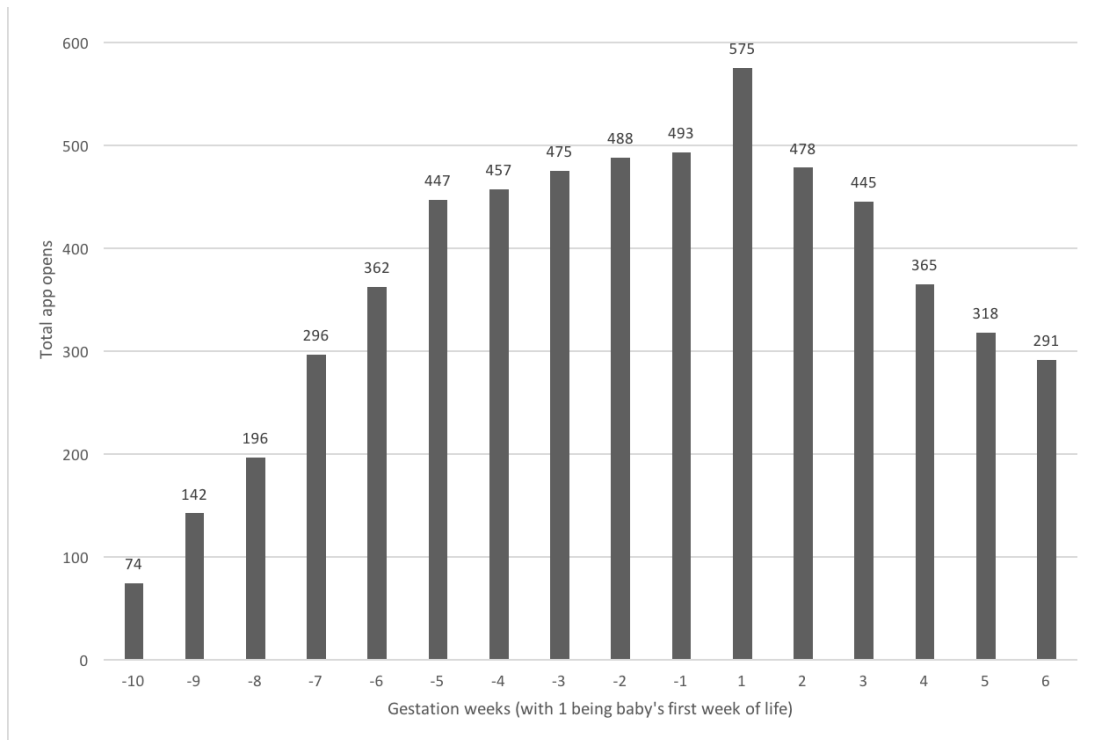


Figure 7.7. Unique days app was opened over time

7.2.4 Computer mediated technology

Computer mediated technology refers to the interaction between the users and the app interface, and whether this supported interaction between users. This includes examining usability, how easily participants could locate information and users' perspectives on the app in general. Data were derived from the quantitative and open text (qualitative) questions in the six week questionnaires. Two thirds of participants (67%) agreed or strongly agreed that the information was easy to find within the app. Participants were asked several questions about the usability of the app and their overall impressions of Milk Man. Figure 7.8 shows the percentage of users who either strongly agreed or agreed with each of the statements. A total of 83% of participants said that they found the app easy to use and 78% agreed that the visual design was appealing.

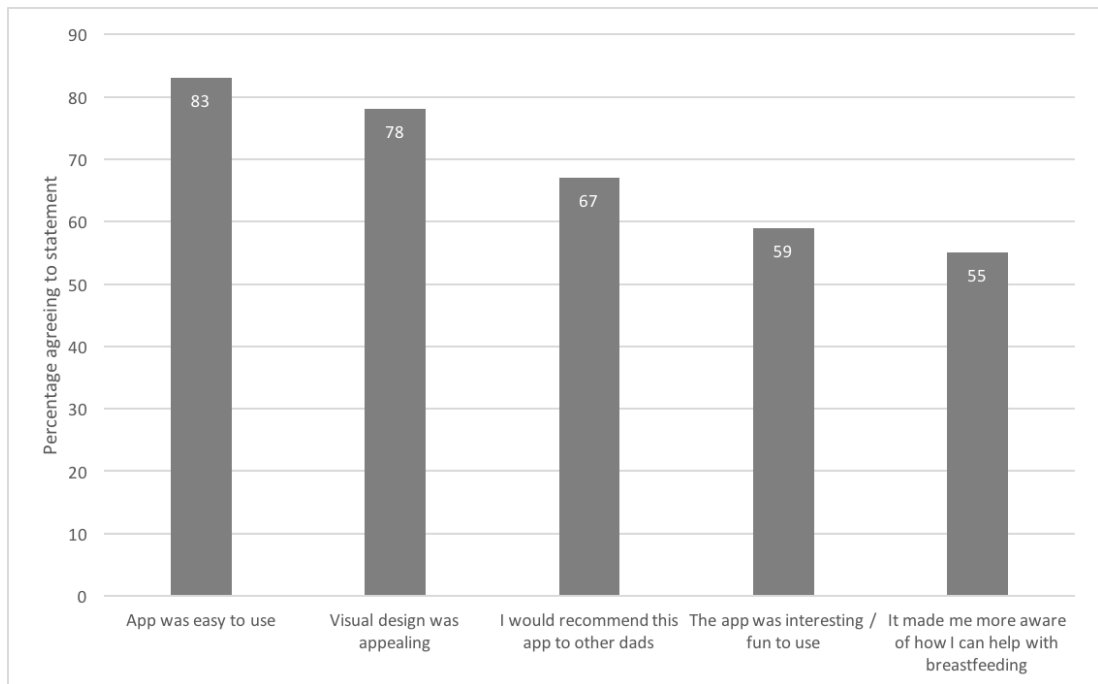


Figure 7.8. Users' perspectives on Milk Man

These findings were reinforced by qualitative feedback from the questionnaire. When asked what they liked about the app, comments about both the design and the ease of use were common. Of the 139 open text responses received, 23 specifically referenced the app design in a positive manner, and 31 said that they liked how easy the app was to use. Comments about the design of the app covered specific features such as the graphics, the visual design, the general layout and how well it worked.

Well designed and very engaging.

*I have no interest in the points thing but I thought it was good stuff, well done.
I thought the app was really well put together.*

graphical presentation, avatars.

Intuitive.

Many of the comments about how easy the app was to use focussed simply on that sentiment, or also included reference to the navigation or portability.

Simple interface, and very easy to use.

It's easy to use!

Easy to use, navigation was simple.

Easy to use right on your smart phone to check regularly.

In contrast, there were just four comments from participants saying that they found the app difficult to use.

Perhaps I wasn't using the app correctly but I couldn't make sense of how to navigate it and unless I can figure something out fairly promptly I discard it.

I don't think it was ever clearly explained to me what value the app would provide to me (before I installed it). As a result, I was a bit confused when logging in for the first time about what I should be doing and what functionality it contained. I think this confusion inhibited me from really giving the app a proper go.

7.2.5 Health system integration

Health system integration represents the larger system in which the intervention is being implemented. This was measured at the process level by examining how the app was facilitating utilisation of other services. Data were derived from the app analytics framework. Participants used the app to access the websites of other health organisations a total of 912 times. This included government and non-government health organisations. The analytics framework only recorded the link followed directly from the app, so it was not possible to ascertain how many times the user then accessed different pages within the organisation's website, or if they saved it to return later. Table 7.8 shows the total visits to each organisation by users from the app. By far the two most common websites visited were the Raising Children Network and the Australian Breastfeeding Association.

Table 7.8. Web visits to external organisations

Organisation Website	Number of visits
Raising Children Network	329
Australian Breastfeeding Association	264
Ngala (WA based parenting service)	54
Beyond Blue	41
The Fathering Project (WA)	36
Pregnancy and Baby	33
WA Health (Government)	31
The Bump WA (Pregnancy and childbirth NGO)	29
NHMRC	21
WHO	15
PANDA	12
Man (Health Promotion charity)	12
Pregnant Pause	9
Mind the bump	7
Quit Now (Government)	7
Lactation Consultant directory	6
Lifeline	3
Mensline	3
TOTAL	912

The call-from-app feature was not well utilised with very few participants calling organisations directly from the contacts page of the app. There were only six outbound calls made to organisations from within the app during the intervention period. Two were to the Australian Breastfeeding Association, two to Ngala (a WA based parenting NGO), and two to King Edward Memorial Hospital (WA's tertiary women's hospital).

7.3 Impact evaluation

Impact evaluation assesses the outcomes of the intervention. For the Milk Man app study, although the breastfeeding outcomes were the primary outcome measures, the evaluation plan described impact evaluation indicators across each of the five areas. This section addresses objective four: *to determine the effect of the Milk Man app on breastfeeding behaviour and whether level of app engagement was associated with breastfeeding outcomes*, and reports on the impact evaluation indicators as outlined in Chapter 4.

7.3.1 People

7.3.1.1 Breastfeeding outcomes

The primary outcome for this thesis was exclusive breastfeeding duration which was assessed in the six week questionnaires. This was considered with two different analyses. Firstly, an intention-to-treat (ITT) analysis was carried out based on the assignment to a Milk Man group, and compared to the control group. Secondly, a per-protocol analysis was conducted considering only those couples who had downloaded the Milk Man app, compared to the control group.

Intention-to-treat analysis

Preliminary analysis of the data revealed that there was no difference between any intervention group in cessation of breastfeeding to six weeks postpartum (Log rank test $p=0.562$, Breslow test $p=0.569$, Tarone- ware test $p=0.563$). Therefore, in the ITT analysis the intervention group included all participants who were randomised into a group that had access to the Milk Man app, regardless of whether the father downloaded the app or not, compared to the control group. The M1 group was not included. A chi-square test for association was conducted between all couples in the M2 and HI groups and the control group. All expected cell frequencies were greater than five. There was no statistically significant difference in exclusive breastfeeding at six weeks between the control group and those allocated to an app group ($p=0.917$). Table 7.9 shows the percentages and numbers of participants in each group.

Table 7.9. Intention-to-treat analysis

Group	Exclusive breastfeeding at six weeks	
	No	Yes
Control group	63 (27.3%)	168 (72.7%)
HI and M2 group (Milk Man Access)	117 (26.9%)	318 (73.1%)
TOTAL	180 (27%)	486 (73%)

Per-protocol analysis

Approximately 86% of participants who were randomised into an app group downloaded the app and a per-protocol analysis was carried out to determine the impact having downloaded the Milk Man app had on exclusive breastfeeding. As the ITT had demonstrated no difference in breastfeeding in app groups this analysis included all fathers in the M2 and HI group who had downloaded Milk Man, compared with the control group. Fathers needed to have matched data about exclusive breastfeeding duration available from their partner's questionnaire to be included in this analysis (n=286). A Kaplan Meier survival analysis was conducted to compare the impact the Milk Man app had on the cessation of exclusive breastfeeding. The final event (survival calculated as time-to-event) was when an infant ceased to be exclusively breastfed. This compared the risk of exclusive breastfeeding cessation of those who had downloaded the app (n=286), with those in the control group (n=229). The survival function plot is shown in Figure 7.9.

All three survival tests had a p-value of about 0.05 (log rank test p=0.052; Breslow p=0.046; Tarone-Ware p=0.049). These support the visual inspection of the survival function plot showing participants who installed Milk Man were less likely to have ceased exclusive breastfeeding at any time point from birth to six weeks postpartum. Mean survival time for those who did not have the Milk Man app (control group) was 4.70 weeks (95% CI. 4.39-5.00) and 5.06 weeks for those who did (95% CI. 4.83 – 5.30).

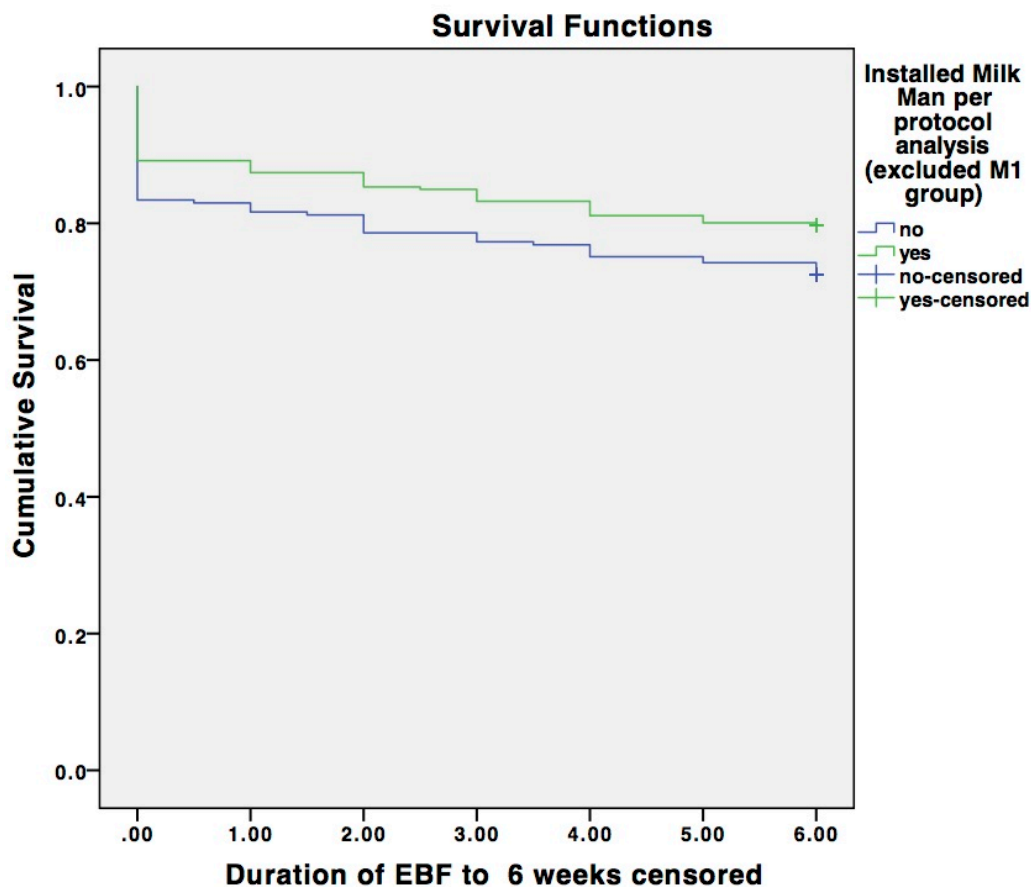


Figure 7.9. Kaplan Meier curve showing exclusive breastfeeding survival

7.3.1.2 Engagement Index

The engagement index calculation was described in Section 3.3.6. As the EI calculation included both app analytics data and data from the questionnaires, fathers needed to have both downloaded the Milk Man app and opened it at least once, and have completed the six week questionnaire to be eligible to be included in the calculation of this measure. In total, 400 participants met the criteria. The mean EI score was 29.7 (range 1-80, 80 being the highest score), median 27.6 and the standard deviation 19.8. The overall EI scores were left skewed as shown in Figure 7.10. There was no difference in the EI scores between the M2 and the HI group ($p=0.564$).

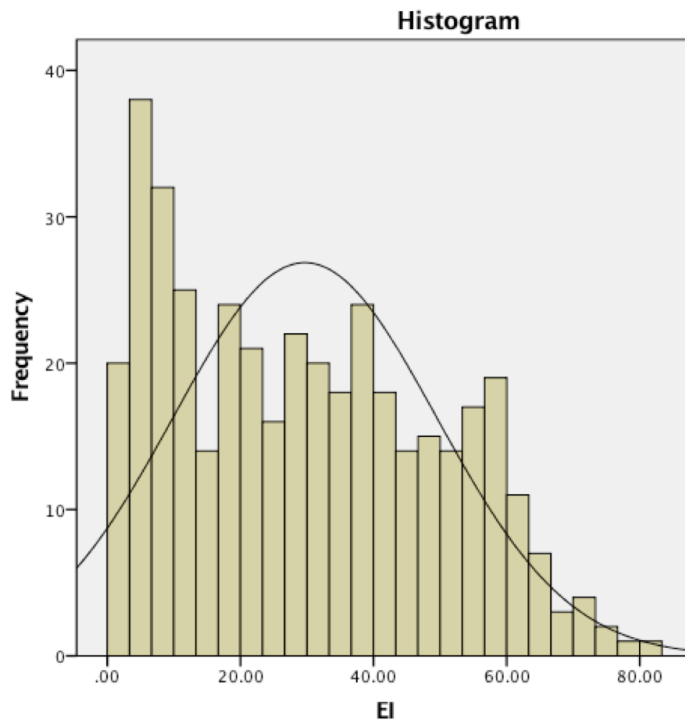


Figure 7.10. Engagement index frequency scores and distribution curve

Participants were divided into three equally sized groups to define an engagement level. The lower tertile was described as poorly engaged, the middle tertile as moderately engaged and the upper tertile as highly engaged. The range of scores in each tertile as well as the average and number of participants is given below.

- Poorly engaged (n=133. avg. 7.94. range 1.57 – 17.16)
- Moderately engaged (n=134. avg. 27.94. range 17.22-39.01)
- Highly engaged (n=133. avg. 53.17. range 39.01 – 80.09).

Participant characteristics were assessed with their engagement level to investigate any demographic differences between groups. A Pearson chi-square test was conducted to investigate the association of level of app engagement and the demographic characteristics of participants. The descriptive statistics and the p-value are displayed in Table 7.10. No association was found between engagement level and any of the participant characteristics.

Table 7.10. Participant characteristics by engagement level

Participant characteristics		Poorly N=133	Moderately N=134	Highly N=133	P- value
		Count	Count	Count	
Father's age (three groups)	<30 yr	16 (13.9%)	19 (16%)	27 (21.6%)	0.464
	30-34 yr	56 (48.7%)	50 (42%)	53 (42.4%)	
	35+ yr	43 (37.4%)	50 (42%)	45 (36%)	
Father's highest level of education (two groups)	High school / Trade	37 (32.5%)	41 (35%)	40 (32%)	0.866
	Some university	77 (67.5%)	76 (65%)	85 (68%)	
Father's Country of birth 5 groups	Aust/NZ	80 (70.2%)	73 (62.4%)	91 (72.8%)	0.606
	UK/Eire	15 (13.2%)	18 (15.4%)	12 (9.6%)	
	Africa/ Middle East	5 (4.4%)	7 (6%)	10 (8%)	
	Asia	5 (4.4%)	6 (5.1%)	5 (4%)	
	Other	9 (7.9%)	13 (11.1%)	7 (5.6%)	
Father's occupation (two groups)	Managers and professionals	78 (68.4%)	78 (66.7%)	90 (72.6%)	0.592
	Other occupations	36 (31.6%)	39 (33.3%)	34 (27.4%)	
IRSD deciles (two groups)	most disadvantaged deciles (1-3)	27 (23.5%)	25 (21%)	38 (30.4%)	0.213
	least disadvantaged (4-5)	88 (76.5%)	94 (79%)	87 (69.6%)	

Subindices

The EI was calculated as an average of the scores of five subindices. The calculation and justification for these subindices is described in Section 3.3.6. Results from each individual subindex are described below.

Reading subindex (Rei):

The Rei was benchmarked to the highest number of articles read by a participant (117) and the range of scores was from 0-100. The average Rei was 13.97 (std. dev. 17.84), and the median was 5.98, which equated to seven articles read.

Loyalty subindex (Li):

The Li was calculated by benchmarking the number of unique days the app was opened, regardless of how many times an app was opened on any particular day, to the highest number of app opens by a participant (62 days). The Li scores ranged from 1.61 – 100 and the average was 20.50 (std. dev. 18.23). The median score was 14.52, which represented the app being opened on nine unique days.

Interaction subindex (Ii):

The Ii was based on the gamification framework and calculated by benchmarking users to the highest number of points scored by a participant (153). The range of scores were 0-100 and the average was 15.42 (std. dev. 16.99). The median score of 8.82 represented a point score of 14.

Recency subindex (Ri):

The median Ri score was 33.33, which translates to a last app open when their baby was four weeks old (Ri calculated from 10 weeks antenatal to six weeks postpartum). The mean was 49.55 (std. dev. 37.84) and range of scores were from 6.25-100.

Feedback subindex (Fi):

The Fi was based on answers to the six general users' perspectives questions asked about Milk Man. A user scored 1 for each question which was answered as agree or strongly agree, and the number scored was divided by 6. The scores ranged from 0-100, the average was 48.96 (std. dev. 41.41) and median score was 50. The percentages of participants choosing strongly agree or agree to each of the individual question is listed below.

- The app was easy to use (83.4%)
- The visual design was appealing (78%)
- I would recommend the app to other dads (67.2%)
- The app was interesting / fun to use (60.1%)
- The app made me more aware of how I can help with breastfeeding (54.6%)
- The app has led to discussions with my partner. (54.1%)

Breastfeeding

A Pearson chi-square test was conducted to explore the association between level of app engagement and exclusive breastfeeding. All expected cell frequencies were over 5.

There was no statistically significant difference observed with exclusive breastfeeding and any engagement level, $p=0.754$ (see Table 7.11), or with the three engagement levels and the control group, $p=0.828$ (see Table 7.12).

Table 7.11. Exclusive breastfeeding and engagement group

EBF at 6 wk	Poor EI	Moderate EI	High EI	Total
No	24 (24.5%)	30 (27.5%)	27 (23.3%)	81 (25.1%)
Yes	74 (75.5%)	79 (72.5%)	89 (76.7%)	242 (74.9%)

EI - engagement Index

Table 7.12. Exclusive breastfeeding, engagement and control group

EBF at 6 wk	Control Grp	Poor EI	Moderate EI	High EI	Total
No	63 (27.3%)	24 (24.5%)	30 (27.5%)	27 (23.3)	144 (26%)
Yes	168 (72.7%)	74 (75.5%)	79 (72.5%)	89 (76.7%)	410 (74%)

EI - engagement Index

7.3.2 Content

7.3.2.1 Information Library

Fathers provided a range of feedback on the library section of the app. Data were derived from the open text (qualitative) questions in the six week questionnaires. Of the 139 responses recorded when fathers were asked what they liked about the app, 58 focused on the information provided, making this the highest rating single theme. Many of the responses stated that the information in the library was easy to find, relevant and informative

The information was useful and especially links to other websites and organisation.

It's helpful to have information at your finger tips.

Informative, fun and covers different areas of breastfeeding.

Other fathers reported that the app was useful in raising new topics they may not have otherwise considered, and that the app was good for 'killing time'.

It's great for killing time - when you are waiting for doctors etc ... which new Dad have to do heaps of.

Different topics provided that fathers may not have thought to discuss or read up on.

Comments about the library were also common in the suggestions for improvements offered by fathers. Many fathers (20 responses out of a recorded 96) wanted more in-depth information being included in the app. This included information being broader than breastfeeding, including more videos and just more content in general.

Maybe more content in the LIBRARY that doesn't necessarily focus as much on breastfeeding but on other newborn baby facts/issues/problems/events.

It's actually very good like it is. More contents would be good though.

With further development the app could be a very helpful tool to both mums and dads, however more comprehensive information in the library is needed.

Some fathers said the information was aimed at too basic a level for them and they wanted more depth including links to research,

Depth of information could be improved. Good for entry level information only which I was familiar with due to other reading. I read all library content once then didn't go back. Additional links to varying studies in the field would be super interesting for the more scientific fathers out there!

Two participants reported needing more information in order to determine the credibility of the information - including the following comment requesting more information about the researchers.

I had little confidence that the information presented was from reliable sources. Articles written specifically for the program as well as background information on authors would help me to relate to information.

This contrasted with feedback from others saying one of the things they liked was the reliability of the information.

useful source of reliable information from what I believe to be a reliable source- i.e. Research group who care!

Quick access to trusted information.

7.3.2.2 Conversation

The way that fathers used the conversation forum to communicate and facilitate support is described in Chapter 8. Mothers were asked about their experience with their partner sharing information from the app with them. Two different questions were posed to mothers:

1. Has your partner shown you anything from the app?
2. Have you had any discussions with your partner about anything from the app?

Just over a quarter of mothers (28%, n=116) said their partner had shown them something from within the app and 101 open text answers were given about what they were shown. The most common thing mothers reported being shown by their partner in the app was the discussion forum (n=47). This was followed by the information library in general (n=19), different aspects of the app in general (n=16) and information specific to breastfeeding (n=12).

A total of 416 mothers provided an answer to the question, 'Have you had any discussions with your partner about anything in the app?' Just over a third (37%, n=155) said they had. Open text answers were recorded to the question asking what they had discussed (n=123).

The main things mothers said they had discussed with their partners were related to the conversation forum (n=45) and to breastfeeding (n=37). This included general comments about the different content in the conversation, about how fathers were experiencing the forum and about how the forum was impacting on them.

Comments about how fathers were experiencing the app included reporting on dads finding it valuable, as well as identifying some of the drawbacks. Three examples of mothers reporting the benefit their partners were receiving from the app were:

He found it helpful to hear what other guys are struggling with.

How to latch. Where he is on the leaderboard. What people have said to his comments. He also told me about some of the other men's experiences with their partners and we learnt from their advice etc.

Conversations he has taken part in with other dads and information he has gained as a result of taking part in those conversations.

Mothers reported discussions with their partners that were broad and covered topics such as mastitis, alcohol and breastfeeding, breastfeeding techniques and support. The following responses give examples of specific discussions the app helped facilitate between parents about planning for breastfeeding.

How long we will try and breastfeed for. Advantages of breastfeeding.

What he can do to help when I am feeding.

The importance of breastfeeding for baby health.

Some mothers reported that the conversation forum had less activity than their partner wanted and that had impacted their experience.

He felt he was the only one contributing to some discussion and that he was a little gutted no one commented on his contributions.

He thought there would be more interaction between the dads. Was a little disappointed that there wasn't more of a chat feature on it. Was told when he signed up for it that it would be a great way to potentially meet other dads.

7.3.2.3 Gamification

There were large differences in users' perspectives of the gamification. Some fathers reported enjoying the gamification elements and said that aspects of it actively encouraged their continued use of the app, some even reported that it was their main motivator. Others however, did not like it and some participants reported that it discouraged their use of the app. The following comments were posted in response to the open text questions asking what participants liked about the app, and what could improve it. Some participants reported enjoying the competition:

Have you seen my points? I'm totally kicking ass.

[I liked] the competition aspect.

Others made specific suggestions for improving the system:

Make it a little easier to earn points and badges, at least initially, to motivate use.

review the points system as having points for people liking your comments etc creates scenarios of people making comments for the sake of it to get points.

Changeout the leaderboard style for one where people earn status credentials, where people's credentials are listed next to their name on posts. Eg such as how's it is done with reviewers in Amazon. Personally I do not want to be listed on a leaderboard on this kind of app; it didn't encourage me to use the app.

A few participants reported the gamification was detrimental to their participation in the app:

Remove the competition element - we're all dad's supporting each other, not trying to beat each other.

I don't think there is any need for a points system or leader board....

*I don't much like the ability to upvote people for "banter". It makes me think of d**kheads.*

Some participants who had used the app the most, provided feedback comments that were among the most negative. There could be several explanations for higher users responding in this way. It may be they expected more from the app than others from the outset, or that they were more invested in it having participated to a higher degree, or simply that having used it more, they could see the limitations more than others. A case study of two participants who were high users and offered negative comments is outlined below including their app usage indicators and their comments. Both participant's partners were still exclusively breastfeeding at six weeks postpartum.

Case Study 1

Participant 3011 scored 123 points (user average 22.2), wrote 20 comments (user average 2.2), read 21 articles (user average of 11.46) and had an EI score of 62.8 (user average 29.7). The participant agreed with the statement *I would recommend the app to other fathers* and provided the following comment in the open-text answers:

The conversation area is pathetic. Check out other forum apps for smart phone and either copy or use them. They've been doing it a long time and there is no point reinventing the wheel... Badly!

Case study 2

Participant 2016 scored 98 points (user average 22.2), wrote 21 comments (user average 2.2), read 37 articles (user average of 11.46) and had an EI score of 64.6 (user average 29.7). The participant disagreed with the statement *I would recommend the app to other fathers* and provided the following comment in the open-text answers:

I think the discussion boards are garbage. There are very few suggestions or comments that actually help. there is little use for the App. It is a conduit to information, but that's about it. I am a competitive person and therefore have been highly engaged in the App, but I don't necessarily think that's a good thing. Often its commenting for the sake of commenting. My suggestion is get rid of the App and work more closely with groups such as the Fathering Project to assist fathers.

7.3.3 Technology

Two years is a relatively long period to trial a mobile app for and there are challenges with trialling technological interventions over prolonged time frames (Mohr et al., 2015; O'Neil A. et al., 2017). As such, careful attention was paid to the ability of the app to sustain itself through OS updates and other technological events. During the implementation of the study there were four OS updates (two iOS and two Android) and the app required updating a total of four times. There were two major technological events that impacted on the app during the intervention. The first was the retiring of the Parse service (described in Section 6.2.4) which was hosting the backend of the app and the need to migrate the backend to another hosting service mid-trial, and the second was the identification of a bug which prevented the conversation showing for some users. Table 7.13 lists all of the technological events that happened over the trial period and the impact it had on the app intervention and participants.

Table 7.13. Technological events during intervention

Date	Platform	Event
1/8/15	iOS and Android	Milk Man trial commenced. Milk Man made available for public release on GooglePlay and iOS app stores in Australia.
16/9/15	iOS	iOS9 released. App tested with no apparent issues.
5/10/16	Android	Android 6.0 (Marshmallow) released. App tested with no apparent issues.
27/1/16	iOS	Released an update due to small bug identified in iOS9.2 which was resulting in conversation images not loading properly on some devices.
28/1/16	Parse	Parse announces it was retiring the hosting service in January 2017.
5/5/16	iOS	App store experiencing issues with search for approximately six hours. One email was received from a participant about not being able to access the app. Emailed to ask him to search again once App Store was fully operational again and he downloaded and logged in successfully.
9/5/16	Parse	Parse server down for most of Monday afternoon 9 th of May. Lower app usage was observed in the subsequent hours.
12/5/16	iOS	Released an update to fix a bug affecting some websites loading properly in iOS 9.

Date	Platform	Event
25/6/16	iOS and Android	Released an update to both apps updating library content including the updated Australian guidelines on starting solids.
18/7/16	Parse	App database migrated over from Parse system to Sashido and both apps updated to support this change.
22/7/16	Android	Delay in processing Android push notifications identified on the 20 th July 2016. Issue was fixed 21 st July 2016.
9/8/16.	Sashido (Android)	First report of August bug Server down for about 1.5 hours. Received email from a participant who said they had no conversation loading. Emailed user to log in and out again. Checked app on several test devices. No issues observed.
12/8/16	Android iOS	Second report of August bug Second email from a participant about no conversation loading. Emailed advising to log in and out again or delete and reinstall. This fixed problem. Checked again on test devices. Similar issue noted on one iOS device, logging out and back in fixed problem.
16/8/16	Android	Third report of August bug Third email from a participant about no conversation loading up. Bug identified and verified that logging out and starting a new session resolved the issue. Emailed advising to log in and out again or delete and reinstall. This fixed problem. Checked app on several test devices. No further issues observed.
17/8/16	Sashido iOS, Android	Conclusion of August bug Email sent to all current users who signed up prior to database change over (18 th July 2016). Noticed significant increase in comments and poll votes. Possibly because of the email reminding people about the app. No further issues reported or observed.
22/8/16	Android	Android OS7 (Nougat) released. App tested with no apparent issues.
25/8/16	Android	Email received from a participant saying they could not log in to the app as there were overlapping icons on an unusually small phone screen. Issue was identified and tested and then update with fix issued 26 th August 2016, participant emailed and successfully installed app on 27 th August 2016.
13/9/16	iOS	iOS 10 released. App tested with no apparent issues.
16/12/16	iOS	App was made available in UK app store for a short period for participant who only had UK account.
Mar 2017	iOS Android	Conclusion of the Milk Man trial recruitment. App removed from app stores.

The open-text questions in the six week questionnaire contained 11 responses from participants pertaining to technological difficulties. These included: in relation to the August 2016 bug (n=5); web links not working (n=3); difficulties resetting password (n=2) and general not working (n=1). Two of the five participants who reported the August 2016 bug as an issue had heard from, or contacted the research team in relation to it. One reported following the instructions emailed out to participants and regaining access, and the other reported that this presented a barrier to his continued access.

Application had a bug where ALL content suddenly and inexplicable disappeared. I received an email saying the only way to bring the content back was to log out and log back in again with username and password. Being busy and not having my username and password on hand, this issue was a big enough obstacle for me to not use the app again for then on after.

The research team reacted quickly in both identifying, troubleshooting and remedying the August 2016 bug. After the first report, identifying a pattern, testing and workshopping a solution, and notifying all participants about the bug fix took place within eight days. Performance of the app and the interaction was monitored closely both during the period of identifying the bug and in the following weeks to determine if the problem was recurring. It was evident that the problem manifested only in a sub-set of participants' devices. There were no further identified issues pertaining to the bug after the email sent to participants on the 17th August 2016.

7.3.4 Computer mediated interaction

At an impact assessment level, evaluation indicators for computer mediated interaction include investigating how the app functions have supported community interaction and the nature of the collaboration facilitated. Data were derived from the open text (qualitative) questions in the six week questionnaires. In the six week questionnaires, fathers provided answers to questions asking what they liked about the app (n=139), and what suggestions they had for improvement (n=96). Responses to both questions were manually coded in NVivo into themes for analysis. In looking at the collaboration of the community, relevant themes were derived from both questions. Many fathers (n=38) reported specific suggestions for improving the conversation which would better support interaction and collaboration. The most common suggestion was for fathers to be able to start their own conversation topics, as this was not available during the trial and fathers could only comment on researcher generated content.

Also, changing the format of the CONVERSATION aspect to maybe allow users to create their own conversation and polls on particular topics that they might be seeking guidance or support on.

A chat section where we can start conversations or ask questions and answer each others questions. At the moment we can only talk about what Milk Man posts.

Due to the way fathers were grouped depending on when their babies were due, some of the actual conversation groups were quite small (groups ranged from 16-47) and the lack of people in the groups impacted on the level of conversation. Several fathers also noted that having an active researcher participating in the conversation could be of benefit.

It's pretty quiet in there, hardly any interaction to comments. Need to get someone in there to reply to comments, get things going a bit in there.

The community is either not big enough or I am limited to only being exposed to what my own group posts. I find most of the time the conversation sections are empty. I post something and rarely does anyone else respond. I am 11th in the leaderboard and feel I have barely contributed. The people above me I have basically never seen post so maybe they used it a while ago and have since stopped?

Other suggestions for increasing collaboration included: having a more active moderator, incorporating threaded replies and dated comments and increasing the number of polls. Four fathers suggested incorporating a real-life aspect would be beneficial as well.

I think the app would work better if you had met the other dads a few times.

A real-world meetup would be nice as well - over a couple of beers.

The conversation was also one of the most highly cited things that fathers liked about the app. Some fathers reported the conversation had helped them feel less alone and had created a sense of community. Others reported enjoying the polls, talking to others and the humour.

Hearing from other dads; the community feel.

Help full tips from other blokes who are in the same position.

It's a reminder that I'm not alone!

Others noted that it led to discussion of things which may have not previously been considered.

generating discussion for something not normally considered.

[I liked] Different topics provided that fathers may not have thought to discuss or read up on.

7.3.5 Health system integration

7.3.5.1 Appropriateness of method

In targeting a breastfeeding intervention towards fathers, it was important to investigate mothers' perspectives on the appropriateness of the method. In seeking to understand how mothers felt about their partners' use of the Milk Man app, a sentiment analysis was carried out on the answers provided by mothers to the open text question in the six week questionnaire asking what their overall thoughts were about the Milk Man app. Just over half of the mothers (59%) were aware of their partner looking at or using the app. Most mothers (92%) had not used the app themselves.

In total, 162 responses were recorded by mothers in the six week questionnaire to the question "Overall, what do you think of the Milk Man app?" Of these, 33 responses were coded as N/A and included responses such as: n/a; I haven't used it; no comment; and I'm not sure. These responses were excluded from the rest of the analysis. The remaining 129 responses generated a total of 23 child nodes with 354 references. Each response was coded to a top-level sentiment node, and relevant categories organised as child nodes. Most responses were coded overall to a single top level node, and then were coded to one or more child nodes. The number of references under each sentiment, as well each category, is shown in Table 7.14.

Table 7.14. Categories derived from responses

Sentiment node (n)	Child nodes (categories)	Number of references
Positive		94
	Helpful / informative	48
	Good for dads	43
	Makes dads feel more involved	22
	Good support for dads	21
	Mums feel more supported	13
	General	10
	Entertaining / gamification	7
	Access requests	2
Negative		25
	Not useful	7
	Hard to use	6
	Not enough activity in conversation	4
	Too basic	3
	Prefer real-life	3
	Overwhelmed	2
	Gamification	1
	General	1
Neutral		21
	General	10
	Couldn't access app	5
	Not enough time	5
	Lack of internet access	1

Most of the comments from mothers about the app were coded as a positive sentiment (n=94). The top two categories referred to mothers stating that the app was good for their partners and that they had found it to be helpful or informative. There were no negative comments from mothers about the intent of the app or the appropriateness of targeting fathers. The comments received that were coded as negative tended to report on specific functions or usability of the app. Table 7.15 shows examples of comments coded to each sentiment, and the codes assigned to each comment.

Table 7.15. Examples of sentiments and categories

Sentiment	Examples	Codes assigned
Positive	<i>I think it is an excellent tool to support Men/fathers in participating in the breastfeeding experience and feeling part of providing for baby. It provides them information in an easy way which makes it more likely to be digested and called upon. A fantastic initiative - great work! Having the format be an app is excellent for engagement for modern men.</i>	Helpful / informative. Good for dads. Make dads feel more involved.
	<i>I do not know how often he uses it, but there have been the occasional times that I'm worried about something and he encourages me with something he's read on the app.</i>	Helpful / informative. Good for dads. Mums feel more supported.
	<i>It was surprisingly helpful. That first night was such a struggle and our baby and I just didn't understand how to latch. My husband opened the app with the info on how to do this and together he helped us figure it out. Whilst I know he would have been there to help me either way I don't think he would have felt like he could truly help and be involved like he was or have known where to go for this information.</i>	Helpful / informative. Support. Mums feel more supported.
Negative	<i>The knowledge base is not large, so doesn't allow for a lot of information to search for. My husband prefers to be able to search for information, preferably academic articles.</i>	Not useful.
	<i>I (assumed?) it was just for the dads so haven't look at it myself. I know my husband has said he hasn't found it useful, he is not really an app/forum/game kind of person mind you, he would much rather meet and chat to other dads over a beer or something like that.</i>	Not useful. Prefer real life.
	<i>My husband feels it is too complicated so we have not used it as a resource as much as I feel we could have</i>	Hard to use.
Neutral	<i>my husband hasn't used it as he couldn't find the code to log into it with!</i>	Couldn't access app.
	<i>Don't know. Partner says it was somewhat helpful. Recalling advice from hospital Midwife & CHN was more helpful.</i>	General
	<i>We haven't used the app but we found the dad only session about breastfeeding at the birth centre very useful.</i>	General

* All comments are reported as they were written by participants.

There were some comments that offered interesting insight. The following response demonstrates that a couple found value in the app despite initially not being very enthusiastic about it.

My partner was cynical about it but actually found it useful and did enjoy using it and reading things on it.

Another mother reported that while she initially thought the app was not a very good idea, she thought that the research had impacted on the support her husband could give her and that she had benefitted from this support. This couple was in the M2 group and did not have access to the antenatal session.

The app is a dumb idea - it's duplicitous to information and services already available on the internet. BUT: The mere fact that Dad's were a focus of this program I think helped my husband to realise Breastfeeding is no walk in the park, and he probably did a LOT more chores around the house and supporting me because of being prepped. All that is required is a session with Dads at parent education.

While some mothers had no knowledge of either the app, or their partners' use of it, others reported using it themselves or knew a lot about how their partner was using it. This was reflected in the comments specifically offering suggestions that mirrored feedback from fathers including about the need for more users in the forum.

Useful, but needs more people on the forums to really be helpful in feeling less isolated.

Mothers also posted comments that reinforced the complexity of the gamification strategy and the app raising new things for their partner to consider.

Great resource for men, my husband loved the competition.

I like the idea of an app with information targeted at fathers but I don't think it's necessary to make it a 'game' with points. I think it stopped my husband from utilising it as much as he could have.

My partner has used it and it's made him think about things he may otherwise not have thought about.

Importantly, some of the responses offered specific detail about how the app had helped their partner to support them as a mother, and with breastfeeding.

It is an app that has allowed my husband be both informed and confident to support me with breastfeeding. He was so helpful in the hospital in establishing breastfeeding and attachment - reminding me of techniques which I believe allowed me to relax more and be successful in establishing exclusive breastfeeding without baby.

Awesome. As my partner gets to feel involved with the baby and he also gets loads of information so he can support me the best way he can. Friends have already asked if it's available to the public for their partners to use.

I like how it has given my husband more confidence in supporting me as a mother.

I think it helped my husband with getting used to a newborn & that he had similar issues to other fathers. I liked that he could have a laugh about some of the things to do with fatherhood.

Mothers showed differing involvement and knowledge of Milk Man in their responses to the question of what they thought of the app. The answers given were mainly very positive and demonstrated that targeting breastfeeding education and support to fathers is an approach that is acceptable to, and deemed appropriate by, mothers.

Dissemination and reach

Another method to measure the appropriateness of an approach in terms of the wider health system and public is to monitor the reaction from the community. This includes both the health professional and public health research community, as well as the general public. A breastfeeding app for fathers is a novel and innovative idea and there was significant interest in the Milk Man research project. During the implementation of the trial, there were 28 presentations given on the Milk Man app (up to September 2017). This included 12 professional presentations or seminars; nine conference presentations and seven capacity building seminars. The full list of presentations is included in Appendix F.

Recruitment from the general population was not possible in the PIFI study and, as such, the research team carried out no promotion of the app to the general community throughout the trial. However, several requests were received by people seeking access to the Milk Man app. These included 23 emails directly from parents, four emails from midwifery students or lecturers and one request from a UK based infant feeding health worker enquiring about integration into their practice.

On 11th August 2017 an article about Milk Man was shared on the Keep It Clever Universities Australia website (Taylor, 2017). As shown in Figure 7.11 the post was 'liked' 497 times, shared 59 times and generated 127 comments. The clear majority of comments were positive and included community members expressing a desire to download the app.

Mac, this is the app I was talking about. Can you see if it's available in iTunes?

*Brendan *****you're already all over being the best daddy but might be interesting for you.*

Definitely downloading this app.

As well as health professionals expressing support of the app.

Wonderful! Support and information makes such a big difference. I will definitely be making all the men in my dads only childbirth education program to download and use this.



Figure 7.11. Keep it Clever Facebook post

These results, although not comprehensive enough to draw conclusions from, indicate a willingness in the wider community to embrace digital breastfeeding interventions being targeted to both parents, and to fathers.

7.4 Summary

This chapter has reported the process and impact evaluation results for the Milk Man app study. While it appears that use of the app had only had a marginal impact on the breastfeeding evaluation measure, at all times up to six weeks postpartum participants who had downloaded the Milk Man app were less likely to have ceased exclusive breastfeeding. Additionally, the app performed well on all other measures. Detailed findings about user perspectives on the engagement strategies, and about what impacts a participant's engagement with an app, are key factors in understanding implementation outcomes. Understanding usage patterns and the impact of engagement level on outcomes is important and this chapter has presented broad findings from a combination of qualitative and quantitative data. The findings from this chapter are discussed in Chapter 9

Chapter 8 A qualitative analysis of the Milk Man app forum

8.1 Introduction

Chapter 8 describes the way fathers in the Milk Man intervention used the conversation forum embedded in the app to communicate with each other. This chapter has been written for publication as a journal article, and at the time of thesis completion was under review but has since been published. Unlike the results in the previous chapter that report to six weeks postpartum, this chapter includes analysis of activity in the conversation forum from recruitment up to 26 weeks after the birth of their baby.


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Author contributions:


- **Becky White** was responsible for the study implementation, data collection, thematic analysis and coding as well as the draft and final manuscript.

Signature: 

- **Dr Roslyn Giglia** provided advice and critically reviewed the manuscript.

Signature: 

- **Professor Jane Scott** oversaw the study implementation and data collection and provided advice and critically reviewed the manuscript.

Signature: 

- **Associate Professor Sharyn Burns** provided advice and oversaw the qualitative analysis, confirmed NVivo coding and critically reviewed the manuscript.

Signature: 

8.2 Abstract

Title

How do new and expecting fathers engage with an app-based online forum? A qualitative analysis.

Background

Breastfeeding is important for infants, and fathers are influential in supporting their partner in their decision to breastfeed, and how long they breastfeed for. Fathers can feel excluded from traditional antenatal education and support opportunities but highly value social support from peers. Online health forums can be a useful source of social support, yet little is known about how fathers would use a conversation forum embedded in a breastfeeding-focussed app. Milk Man is a mobile app that aimed to increase paternal support for breastfeeding using a range of strategies, including a conversation forum.

Objective

To examine how fathers used a breastfeeding-focussed conversation forum contained within a mobile app throughout the perinatal period.

Method

A qualitative analysis of comments posted by users in the online forum contained within the Milk Man app was conducted. The app contained a library of information for fathers, as well as a conversation forum. Thematic analysis was used to organise and understand the data. The NVivo 11 software package was used to code comments into common nodes, which were then organised into key themes.

Results

In all, 208 contributors (35% of those who had access to the app) posted at least once within the forum. In total 1,497 comments were included for analysis. These comments were coded to 3,799 individual nodes, and then summarised to 54 tree nodes from which four themes emerged to describe how fathers used the app. Themes included: seek and offer support; social connection; informational support provision and sharing experiences. Posting in the forum was concentrated in the antenatal period and up to approximately six weeks postpartum.

Conclusions

This data shows that fathers are prepared to use a breastfeeding-focused online forum in a variety of ways to facilitate social support. Fathers can be difficult to reach in the perinatal period yet engaging them and increasing social support is important. This research demonstrates the acceptability of an innovative way of engaging new and expecting fathers.

8.3 Background

Breastfeeding is of key importance to public health and the World Health Organization recommends that babies are exclusively breastfed to six months, and for breastfeeding, supplemented with appropriate complementary foods, to continue for two years and beyond (World Health Organization, 2011a). There are numerous, well-evidenced health benefits for infants and mothers including a reduction in risk of a number of infections, sudden infant death syndrome and obesity in later life for infants (Ip et al., 2007; Victora et al., 2016), and protection against ovarian and breast cancer and improved bone remineralisation in mothers (Labbok, 2001; Victora et al., 2016).

Despite the recommendations, and the benefits of breastfeeding, only about 15% of Australian infants are exclusively breastfed to five months of age (Australian Institute of Health and Welfare, 2011). There are many factors that impact breastfeeding (Scott & Binns, 1998; Scott, Binns, Oddy, et al., 2006) including the support of fathers. Targeting breastfeeding interventions towards fathers can positively impact breastfeeding duration (Maycock et al., 2013). While research shows most fathers are supportive of their partners breastfeeding (Kong & Lee, 2004; Scott, Binns, Oddy, et al., 2006), there are a number of factors that impact the support they can offer (Brown & Davies, 2014; Tohotoa et al., 2011; Tohotoa et al., 2009). These include:

- Social support – fathers not receiving enough social support with pregnancy and early parenting
- Knowledge – gaps in knowledge about breastfeeding, pregnancy and early parenting
- Empowerment – a lack of understanding and recognition of the paternal role in breastfeeding
- Barriers – specific barriers such as public breastfeeding and bonding postponement

8.3.1 Social support via online health forums

Increased levels of social support can have benefits for participants in terms of their mental and physical health (K. B. Wright & Bell, 2003). The facilitation of social support via Online Health Communities (OHC) is an area of increasing research interest (X. Wang, Zhao, & Street, 2017). Seeking social support can be a key reason that people participate in OHC, and there are benefits for those who receive social support online (Kim et al., 2012). One of the benefits of OHC is that participants can use them in different ways, and that access to the information is available whenever the user wants. Some participants will use an OHC to actively connect with others, while others will prefer to simply observe and receive the information (Choi et al., 2017).

Participation in OHC can offer both benefits and drawbacks to users. The availability of access whenever the user requires, as well as the ability for online forums to facilitate bringing people together who may share an interest or health issue but are geographically distant, can be a significant benefit (M. White & Dorman, 2001). Social networks can also offer a level of anonymity which may make it easier for people to seek support, especially in circumstances where they may not feel comfortable talking to people they know (Kauer et al., 2014). People seeking to lose weight for example, could join a support group of people from around the country, or even worldwide, that share their specific goal. Same sex attracted young adults in rural communities could find peers online. Parents struggling with their children's behaviour could find others in the same situation.

While there are positive aspects of connecting people, technology also comes with risks. The anonymity which can enable sharing, can also provide opportunity and impunity for people to attack and bully others (Kowalski et al., 2014). In terms of health information seeking, some studies report it can also lead to misinformation being sourced and shared (Sudau et al., 2014). However, other studies have found community moderated OHC can maintain a high quality of health information (Cole et al., 2016).

In their analysis of a large, popular breast cancer OHC, Wang et al. found participants used the forum in a number of different ways (X. Wang et al., 2017). Informational support, including seeking and providing information was the most popular way support was facilitated. Companionship, which is the discussion of other issues rather than the actual health issue, was the key factor in retaining engagement in the online community over time (X. Wang et al., 2017).

8.3.2 Reaching new fathers via online forums

Some of the benefits offered by online forums are particularly pertinent when developing social support opportunities for fathers. Social support has been shown to have a buffering effect on parental stress (Koeske & Koeske, 1990). In preparing for the birth of their child, fathers can feel isolated and feel that antenatal education is not inclusive of them (Tohotoa et al., 2009). In the perinatal period, fathers highly value social support, and support from peers is particularly sought after (Brown & Davies, 2014).

Participants in the Fathers Infant Feeding Initiative study, a fathers-focused randomised control trial that aimed to increase paternal support for breastfeeding, identified barriers to their access to support services (Tohotoa et al., 2011; Tohotoa et al., 2009). These included accessibility and flexibility (particularly the need to balance work commitments) and the use of information technology was one recommendation to overcome these barriers. As fathers have reported feeling disempowered about their role in breastfeeding (Halle et al., 2008; Mitchell-Box & Braun, 2012), the relative anonymity associated with online forums may further facilitate fathers actively participating in conversations about breastfeeding.

8.3.3 Milk Man app

The Milk Man app was designed to engage fathers in information and conversation about breastfeeding, with an aim to increase the support they offered to their breastfeeding partners. The development and trialling of the Milk Man app has been previously described (Maycock et al., 2015; B. K. White, Martin, et al., 2016). A key component was the 'conversation', a facilitated forum whereby participants were posed questions via a series of topics and provided opportunities to comment. When fathers first signed up to use the app in the antenatal period, they were grouped depending on when their baby was due. This enabled time-relevant questions to be posed and for the opportunity to talk to other fathers at a similar stage of pregnancy or early parenthood. New content was added to the app from when fathers signed up until their babies were approximately 26 weeks of age. The topics were designed to be either timely in relation to infant milestones in the perinatal stage or to focus on community building – that is providing light content designed to encourage men to communicate with others. The purpose of these topics was to deliver small items of relevant information to participants in an engaging manner and to encourage them to share information and support their peers by participating in the conversation. New content was added to the app twice a week, coinciding with a push notification being sent out to alert users.

8.4 Study aim

The aim of this qualitative study is to describe the way new and expecting fathers used the breastfeeding-focussed conversation forum provided in the Milk Man app.

8.5 Methods

8.5.1 Sample

This study was part of a randomised control trial, the Parent Infant Feeding (PIFI) Initiative, which has been previously described (Maycock et al., 2015). The PIFI aimed to investigate the impact on breastfeeding duration of two different interventions, a male facilitated antenatal class and the Milk Man app, both in isolation and combination.

Participants were recruited to the study through antenatal classes at maternity hospitals in Perth, Western Australia. In total, 681 couples were randomly assigned to an intervention arm which gave them access to Milk Man, of these 586 went on to download the app.

8.5.2 Procedures

After the study was explained, participants were issued a consent form, and upon consenting, were informed of the group they had been randomised into. As fathers signed up to the app on a rolling basis, conversation groups were started when there was a minimum of five participants with babies due in that month. Participants who commented at least once in the forum were included in this study. Data collected for this study includes the period from antenatal sign up to 26 weeks postpartum.

The Milk Man forum was moderated by the research team and a set of management protocols was developed to govern the administration of the app. The team took a hands-off approach to moderation, intervening only when the protocols required it. In the event intervention was deemed necessary, a member of the research team who was a father of two young children assumed the role of *MacDaddy* to provide a peer response. The peer-dad responder was identifiable through his avatar (the Milk Man app logo) and username (MacDaddy), to ensure it was clear to participants that he was connected with the study, as opposed to another father participating in the trial.

8.5.3 Data analysis

All comments posted by participants were included in this data analysis. The data were then imported into NVivo 11 and analysed using a thematic analysis, which involved coding the data into themes to enable organisation and understanding of data (Braun & Clarke, 2006). Line-by-line analysis was used to examine words and phrases to explore the frequency, intensity and extensiveness of discussion. Nodes were initially generated and then collapsed to form key themes. Data were coded manually and then checked by a second researcher trained in qualitative analysis to ensure conformability (Bryman, 2004). A comment could be allocated to multiple individual nodes depending on the content. For example, the following comment was coded to four individual nodes (Concern: Not being good father, Reflective parenting, Sharing intimate information and Getting ready to be a dad).

One thing I fear about fatherhood is not being the best parent and role model. I've got pretty big shoes to fill as my parents were pretty amazing in their approach!

8.6 Results

There were 586 participants who signed up to the Milk Man app, of those 208 (35.5%), hereafter known as contributors, posted at least once in the forum. Demographic information was available for 187 of these 'contributors' (baseline questionnaire not completed by 21 individuals). Most contributors were aged over 30 years (84.5%), had some university education (60.4%) and approximately two thirds were born in Australia (66.8%). Table 1 describes the contributor characteristics.

Table 8.1. Contributor characteristics (n=187)

Characteristic	N (%)
Age	
<30	29 (15.5)
30-34	88 (47.1)
35+	70 (37.4)
Education	
High school / Trade	72 (38.5)
Some University education	113 (60.4)
Country of birth	
Aust / NZ	125 (66.8)
UK / Eire	22 (11.8)
Africa / Middle East	12 (6.4)
Asia	10 (5.3)
Other	16 (8.6)

A total of 1,493 comments were posted in the forum from the 208 contributors, in addition, there were four comments posted by MacDaddy in response to fathers sharing misinformation. The comments posted by the research team mainly provided correct information, and links for Milk Man users. These 1,497 comments were assigned to a total 54 tree nodes, generating a total of 3,799 individual nodes (comments could be assigned to multiple nodes). These 54 tree nodes were then collapsed to form four key themes.

The number of comments posted per contributor ranged from one to 71. The average number of comments posted per contributor was 7.2 (mode 1; median 36). The number of comments per discussion topic ranged from one to 86 (average 24, mode 4, median 26). Participation was concentrated in the antenatal period and up to six weeks post birth, with approximately 80% of commenting activity happening within this time. Four main themes emerged from the data, and these and the subthemes describing the way fathers used the forum are presented in Table 8.2.

Table 8.2. Themes and subthemes

Theme	Subtheme	Example quote*
Seek and offer support	Support seeking	<i>My wife's friend who has had a baby said to be flexible with a plan as breastfeeding often does not go to plan has anyone else heard people say this?</i>
	Support giving	[Responding to another user talking about the benefits of attending antenatal classes] <i>Yeh agreed! I gained allot more than anticipated tbh [to be honest]. Definitely recommend to up and coming future fathers :)</i>
	Supporting mums	<i>I've found just sitting with her while she's breastfeeding is helping her. Doing small things like moving baby's hand out of the way rubbing her back getting her water or a snack etc.</i>
	Other support	<i>I've learnt tonnes in all the antenatal classes looking forward to putting my knowledge to good use</i>
Social connection	Joining in	[In reply to 'What's your best bloke outing?'] <i>Getting to footie</i>
	Conversational	<i>I play soccer. so I'll be keeping that up. great fitness and stress relief and catch up with friends after the match.</i>
	Using humour	[when discussing skin-to-skin with baby] <i>My wife suggested I trim the rug [chest hair] down!! I've spent a lifetime on this</i>

Theme	Subtheme	Example quote*
Informational support		<i>Up until now my main contribution to reducing the housework load was a simple lowering of standards (only half kidding). We recently sat down and spelled out / wrote down some specifics to go on my plate like kitchen benches cleared and wiped every night so not waking up to a depressing site.</i>
Sharing experiences	Breastfeeding	<i>Just be supporting and encouraging will go a long way! I know If I give up my wife will give up on breastfeeding!</i>
	Fatherhood	<i>I'm looking forward to be a loving supportive encouraging Dad with an aim to assist in moulding a wonderful self-sufficient human being in the long run. AND I want to be a great friend to my child</i>
	Sharing intimate information	<i>My son arrived last week and I can safely [say] words cannot describe how amazing it was and how proud I am of mum and Bub it really is an intense experience</i>
	Bonding	<i>Had some skin-to-skin contact directly after my wife about 30 minutes after our son was born. An amazing feeling that I'll cherish forever.</i>

* Quotes are reported verbatim as posted by the contributors.

8.6.1 Seek and offer support

Fathers used the forum in several different ways relating to social support. This included using it to seek support, to offer support, to discuss how they were supporting their partners, as well as discussing other forms of support including from professionals and other apps.

Support seeking and giving

Across a range of parenthood related topics, fathers both sought and offered support within the forum. The giving of support, including offering tips and suggestions was more common than fathers specifically seeking support. Support was offered directly in response to a request from another user, in response to a question posed within the app, or sometimes was unsolicited. The following comment is one example of a father offering unsolicited support to other fathers when discussing paternity leave.

[I am] Lucky with FIFO¹ I will get 5 out of 6 weeks off so hopefully that works well before going back to the normal roster thinking the even time roster should work pretty well but you never know. Feel sorry for the boys who work the longer rosters away or fellas that can't have too much time off. Planning the flight home is the biggest gamble!!

Support seeking was characterised by direct questions posed to the group, or users posting about a difficult experience.

it is day 3 since our bundle of joy arrived. my wife is struggling to get the milk flowing and the baby is not sucking hard enough. We were told that it takes up to 72 hours before milk flows which I didn't know until the baby arrived. my worry is with bottle feed[ing] the baby seems to just easily get his feed. Will he choose to not work as hard when we try the breast and when should we say OK baby is hungry let's feed him bottle? I don't want my wife to feel as a failure if our desire to breastfeed fails. Any other fathers with similar dilemma?

There were instances of fathers seeking more support and connection from the app than they were able to receive. This includes fathers expressing a desire for real-life meet-ups to be organised, posting questions or comments and not getting a response in return, or expressing disappointment in the lack of conversation.

I tell you who makes woman depressed it's the health nurses. She needs to put on weight or she has to be put on formula! She's only a few grams lighter she was born 2 weeks early and she eats like her Daddy and [I] can never [gain] weight, they go by a stupid table. She's nice and healthy. They tell you to eat healthy and then tell you [she's] eating too many greens. These health nurses are useless! We doing pretty well. Shame we don't have any family to help out here. No one wants to make friends on here? That's the whole point of the App?

Supporting mums and other support

Contributors used the app to talk about how they were supporting their partners. This included discussions about breastfeeding, work, practical support, and mental health. One father in discussing the way he was getting ready to support his partner with breastfeeding posted:

¹ An abbreviated term for 'Fly In, Fly Out' which describes the shift work patterns of mining and oil/gas platform workers who work away from home.

Got a rocking chair with leg rest set up next to the window looking out over the streetscape facing a TV and a tower speaker connected to an old iPad with her favorite music. I think we're ready!?

Fathers also posted examples of specific topics in the app prompting real-life conversations with their partners about how they could better support them.

This is a good idea. I might talk to my wife about a breastfeeding plan. I would be keen to know how she wants my help.

I asked my wife what our plan was after reading this. Apparently if we get separated she would have already expressed milk and it won't be an issue. Plan ahead and hope for the best is our plan I suppose!

8.6.2 Social connection

Topics posted to the app by the research team varied in their intent. The content areas, while with a focus on breastfeeding, were broad and included other parent related issues such as sleep, relationship changes, starting solids and bonding amongst others. Throughout the schedule of topics was an ongoing focus on community building. Ensuring there were topics that provided opportunity for light conversation and connection was deemed important in keeping fathers engaged and interested in the forum content.

A major emergent theme was that fathers used the forum as a way of connecting with other fathers and seeking companionship by participation. This was evident in the posts which didn't relate to a particular health or parenting issue and simply reflected fathers 'joining in', or creating conversation, often by using humour. Many fathers used humour when posting conversationally. This included recounting experiences, anticipating experiences and merely joining in. In responding to a post asking what tips fathers may have for new dads, one contributor wrote:

*Learn how to make her Vegemite on toast just right. It sounds like an easy job but f**k me I never knew you could get it wrong! Tip for rookies 'ensure the butter is melted in before the vegemite is applied 👍👍 near death experience that one.*

Another father shared this post when answering a topic asking if he was talking to his baby antenatally.

We would often fall asleep listening to an audio book. Our bub might think Stephen Fry is her father...

Posts coded as 'joining in' included any time fathers came to the app to participate, rather than to specifically seek or share information. These were often shorter answers, yet these posts still reflect a commitment to participation and companionship. The following is an example of answers given to the "Who is the best celebrity father?" question.

The Pitt has got it wrapped up in the current landscape!

Has to be Phil Dunphy [Modern Family]. Everyone thinks I've modelled myself on him. Dad jokes just come natural for me though I'm still flattered.

Homer Simpson

Hugh Hefner

Surely George Foreman. Has 10 children (5 boys all named George and 5 girls). He found new and innovative ways to feed them and in the process created an empire of cooking appliances.

8.6.3 Informational support

Informational support has been defined as the provision of advice, suggestions or information that will be useful to someone else (Glanz et al., 2008). The provision of this type of support through the app also created opportunities for observational learning, and was one of the four key ways fathers used the forum. Sometimes these posts were in response to specific questions, and sometimes were fathers simply sharing what had worked for them. They all displayed opportunities for other fathers to learn from, and for normalisation of specific behaviours or attitudes. One example is from a topic asking whether fathers were planning on having skin-to-skin contact with their babies in hospital. The topic linked to an article in the library section of the app containing information about one father's experience. The following posts provide an example of informational support:

I read an article on this app where the dad was the first skin to skin contact his baby received. Something to do with a complicated birth and having a caesarean. He went in prepared with a top he could un-button easily in fact.

In the event of a tricky birth and if my Mrs wasn't in a position to make that first contact for sure I'd love to be the first person my son meets!!!

Definitely keen to do skin to skin - or rather skin to chest rug - being more appropriate in my case.

I did skin to skin it was cool and helped relieve some stress of the birth when mum was taken to theatre

This topic generated considerable discussion. The following examples are from fathers responding to the conversation, and considering something they may not have thought of otherwise.

Hadn't thought about dad/baby skin to skin. It makes sense that it could benefit the bonding experience.

Wow what a great read! Something for fathers right from baby's first hours alive

As research has demonstrated that some fathers report feeling uncomfortable about their partner breastfeeding in public, the app included content about this issue. The comments posted on this topic provide an example of how the forum provided opportunities for the normalisation of public breastfeeding.

We have had no issues. Makes me think it really isn't an issue.

My wife uses a shawl for a little discretion. She actually had a lady tell her that she shouldn't have to cover up!

Pretty good, no issues or disagreeing public response

8.6.4 Sharing experiences

Sharing experiences, both anticipatory and as reflections, emerged as a key way that fathers used the app forum. These experiences were broad, including a wide range of content areas, for example, breastfeeding, fatherhood, sleep, relationship changes, bonding and mental health.

We have just made it past week 2 but it has had some challenges especially the first week. Just need to persevere as it did get easier we got a lot of advice from the mid wives and you just need to figure out what is right for you and your new bub will pick it up. Just be supportive as the wife can get emotional during this.

Some of the information and experiences shared was of an intimate nature. The following post is from one father who is discussing how they announced their pregnancy.

We lost [our first] one. The emotional struggles after that meant telling people the second time wasn't the same. All good now though. 34 weeks and the little one is fit as a malee bull!

Other posts were confessional and honest:

I must admit I like being at work a lot more than being left [with] the baby by myself for an extended period. Talk about stressful!

8.7 Discussion

The qualitative data reported in this paper demonstrate that fathers are prepared to use a breastfeeding-focussed app-based forum. Contributors in this study used the forum in a variety of ways. To seek and offer support, to share experiences, to build connection and to offer informational support. Some fathers used the app to share very personal information, including about miscarriage, resuming intimacy with their partner and how fatherhood was making them feel. Others used it in a less intimate way, using it simply to join in, or to participate. This is an important finding, as even by contributors providing short comments, the commitment to seek companionship and to connect is evident by the completed action of writing and posting a comment.

An earlier study of an OHC found that discussion of topics other than the health issue were a key factor in retaining engagement (X. Wang et al., 2017). The sub-theme of users seeking connection by joining in suggest this may be a factor in this study as well. This is an interesting finding as although off-topic discussions may be viewed as irrelevant, including and encouraging this type of conversation and posting in an OHC may be a key component of sustained engagement. The relative anonymity of the online forum may have made fathers feel more comfortable participating in the conversation.

The Milk Man forum was a researcher-facilitated forum, in that fathers were encouraged to respond to questions posed by the research team. Naturally, this has guided the content covered by the posts. Approximately a third of users with access to the Milk Man app commented in the forum. This is a higher percentage than has been observed in other studies and is further validation of this approach with new and expecting fathers. For instance, in exploring interaction with OHC, some researchers have described a 90-9-1 principle (Nielsen, 2006; van Mierlo, 2014). This principle observes that 90% of users are lurkers, who observe, but never post, 9% contribute a small amount of content, and 1% of users contribute most of the activity in the forum (Nielsen, 2006). To investigate if this rule applied to DHBC interventions, a study was carried out with four OHC (based on alcohol, depression, panic and smoking cessation)(van Mierlo, 2014). Across the four OHC there were 578,349 posts and 63,990 users. The authors found that overall, less than 25% of users posted at least once in a forum. Usage patterns were consistent with the 90-9-1 rule with an average of 73.6% (59% - 75%) of the content being generated by the top 1% of users, an average of 24.7% (17.3% - 24.7%) by the next 9% and the remaining 90% contributing an average of just 1.7% (1.1% - 7.8%) (van Mierlo, 2014). Similar to these findings, a breastfeeding app for mothers with a socially connected function found that 14% of their app users' commented at least once (Balaam et al., 2015). Other participants used the Milk Man app in different ways and further evaluation is in progress of the benefit these non-contributors, or lurkers, received from the forum.

Most activity in the forum occurred between when fathers first signed up to the app (antenatally), and six weeks post the birth of their child. Content continued to be added to the conversation up to 26 weeks' post birth. It is unclear if the drop off in posting activity was due to reduced activity in the forum, or if that is the natural time that fathers would use the app for. There were examples of fathers wanting more support and connection from the app than they received. Due to the relatively small size of the conversation groups (avg. 32 participants, range 16-47), participants may have been dissuaded to continue posting in the forum as momentum declined over time. More meaningful interaction between fathers, including more genuine conversation, may be achieved with a bigger cohort. It is important to note that participants in different groups will have had different experiences with participation in the forum as some groups were significantly more active than others, and users could only view the content in their own group. Further evaluation of the app, and the wider project, including breastfeeding and other outcomes is currently underway and will provide further insight into app engagement.

The research team took a very hands-off approach to the forum, intervening only when the management protocols required it. As there were examples of fathers wanting more support from the app than they received, and that activity dropped off after six weeks postpartum, it would be valuable to examine the impact of an increased level of researcher interaction in the forum. This could include through the implementation of a peer-based coaching program embedded within the app. Peer-mentors could help get discussions going, could lead conversations with fathers and provide individualised support and future research can investigate the impact this has on the way fathers use the app and their engagement with it. Other studies have found that participants can highly value professional moderation and feel that it can help create vibrant communities, provide information and help with solutions (Huh et al., 2016).

As has previously discussed, connecting people via technology can provide both opportunity and challenges (Kowalski et al., 2014). In the Milk Man app forum, there were no instances of people bullying or attacking each other, however there were four instances of misinformation sharing. The protocols that were in place meant that the research team could react quickly, via MacDaddy to offer evidence-base information and links to participants.

The way this study has found fathers used the forum will be useful in informing the development of strategies designed to engage participants in digital social support interventions. Researchers can create content designed to enhance opportunities for fathers to communicate in the way this study has described. Additionally, including light, conversational driven content may increase forum activity and the number of app users contributing in the conversation forum. Further research with a larger sample size and alterations to the forum to increase connectivity will be of value in further determining the impact online forums can have on engaging fathers with breastfeeding information and support.

8.8 Strengths and Limitations

This study had some clear limitations. The forum discussion was researcher led and limited to topics posted by the research team. Fathers were not able to post their own content for other fathers to comment on. Allowing this function may change the way fathers use the forum. Due to the way participants were grouped, the number of fathers in a conversation group were relatively small. Participants from across the study will have had different experiences of the forum as usage differed between groups and users could only see content in their own group. The strength of this study is that this is the first paper we are aware of to report on the way fathers use a conversation forum about breastfeeding. While there were limitations, the interaction reported in this study points to this being an area that requires further exploration as a way of supporting fathers

8.9 Conclusion

Research has shown that fathers value peer support in the perinatal period and this research adds to that evidence, including, importantly, that fathers are prepared to access that support online through a mobile app. Fathers have an important role to play in supporting their partners with breastfeeding, however they are rarely a key target group for antenatal education and support services and are often a hard group to reach. To better support fathers in this important time in their life, as well as increase their support for their partners, it is vital innovative ways to reach parents are explored. This paper demonstrates that an app-based online forum delivering parenting and breastfeeding information is an acceptable method and one in which fathers were prepared to use to share information and display supportive behaviours.

There remains more that can be done in terms of research with this hard to reach group, including conducting research on a population level with a larger sample, including more interactive features and investigating the impact peer coaching has on utilisation of the app. This paper adds to the evidence on how to reach fathers in the perinatal period, and discusses the different ways fathers use an app-based forum. This research will be of interest to anyone seeking to reach fathers in this critical period.

Chapter 9 Discussion, recommendations and conclusion

9.1 Introduction

This thesis has described an ambitious study. There are relatively few health promotion apps developed to be trialled in adequately powered RCTs and the strengths of this study were the large sample size, the inclusion of breastfeeding outcomes and the strong focus on reporting on implementation outcomes and evaluating the engagement strategies.

This study sought to understand the use of mobile technology in health promotion initiatives through a comprehensive literature review and to develop a mobile app using a best practice approach. This involved being grounded in behaviour change theory, developed within a multidisciplinary team and informed by end users throughout. Comprehensive evaluation sought to explore the implementation of the intervention, and the subsequent outcomes. An engagement measure was adapted and described for this research to investigate the impact that different levels of engagement had on breastfeeding outcomes. In this chapter, the objectives for the study are listed with key findings from each phase. This is followed by a detailed discussion of each finding. The four objectives for this study were:

1. To review the evidence of the use of mobile technology in health promotion initiatives in general, and with the target group.
2. To develop an engaging breastfeeding app for fathers, informed by the literature and market audit and with input from stakeholders and members of the target group, that would provide them with the information and support they need to effectively support their breastfeeding partners.
3. To conduct comprehensive process evaluation investigating which of the engagement strategies were effective in motivating and engaging users.
4. To determine the effect of the Milk Man app on breastfeeding behaviour and whether level of app engagement was associated with breastfeeding outcomes.

9.2 Objective 1: Evidence review

Objective

To review the evidence of the use of mobile technology in health promotion initiatives in general, and with the target group.

Key points

- Challenges and opportunities exist with mHealth research and more evidence is needed.
- There are few breastfeeding interventions targeted at fathers, and at the time of development, no father-focussed mobile apps about breastfeeding.
- Fathers are generally supportive of their partner breastfeeding but there are factors that impact on that support.

9.2.1 Challenges and opportunities exist with mHealth research

There is a large and growing body of evidence investigating the impact of mHealth interventions across a range of health areas, yet there remains a lack of consensus on their effectiveness. There is considerably more published research about mHealth initiatives for health issues such as physical activity, nutrition and mental health than there is about breastfeeding. Mobile technology is a medium people want to use to receive health information and interventions, and is one that they are already comfortable using.

Utilising mobile technology for health interventions has great potential in terms of reach and the potential to impact on health on a large scale. However, there is still much more researchers need to understand (Michie et al., 2017). More evidence is needed on how health professionals can best utilise digital technology for health interventions and this thesis adds to that evidence. It is clear however, that a challenge exists in the large number of published articles that state more research is needed from large sample size RCTs (Baskerville et al., 2015; Free et al., 2013), alongside an understanding that these large trials require longer time periods to run, which can often be contrary to software development principles (Mohr et al., 2015; O'Neil A. et al., 2017). Recognising the challenge, this study sought to address this by incorporating rigorous process evaluation indicators into an adequately powered RCT. This included an ongoing assessment of the performance of the technology and the impact any technological changes were having on the users' participation and experience with the intervention.

Mobile technology offers a range of different ways to engage with people and the ability to use them to deliver EMIs and intervene with personalised programs as people go about their daily lives is a promising component of digital interventions. Strategies such as goal setting, gamification, push notifications, personalisation and social connectivity are all ways mobile interventions can be tailored to interventions, and to individuals. There is an ongoing conversation regarding the impact engagement has on app-based interventions, and on the best approach to measure engagement. Engagement is complex and often subjective. Exploring the impact of different levels of engagement on app use and outcomes is important and more research is needed on how best to measure this. Investigating and defining *effective* engagement on an individual level and understanding what levels of engagement are needed for intervention outcome is another area where further research is needed. Mobile technology offers opportunities for an intervention to be tailored to an individual, delivering slightly different content or notification schedules based on the users specific needs. More research is needed on how to tailor interventions to the individual to optimise *effective* engagement.

9.2.2 Factors that impact on fathers' support for breastfeeding

The support of fathers is important for new mothers and most fathers want to be supportive of breastfeeding. A review of the literature identified four broad areas that can impact on fathers' ability to provide support. The four areas described in Section 2.3.1 were:

- **Social support:** Fathers can experience a lack of social support in the perinatal period, particularly opportunities for peer support, with interventions often targeted solely to the mother.
- **Gaps in knowledge:** Fathers want more information about the benefits of breastfeeding, and practical suggestions to help their partner and with managing expectations.
- **Empowerment:** There is a lack of understanding of the importance of paternal support in breastfeeding and fathers may not understand their role.
- **Specific barriers:** Some barriers exist in terms of bonding postponement, public breastfeeding and feeling left out.

Information within these four areas of focus was used to direct the focus groups with fathers as well as to inform the intervention structure and the app content and engagement strategy. Researchers developing breastfeeding interventions for fathers should consider each of these areas in designing programs.

9.2.3 Few father-focussed breastfeeding interventions

While there is much evidence about the importance of fathers in supporting their partner with breastfeeding, there are few digital breastfeeding interventions targeting fathers. At the time of this study there were no father-focussed mobile apps about breastfeeding reported in the literature. During the implementation of this research, information about the pilot testing of two father-focussed digital interventions was published. The SMS4Dads intervention aimed to support the mental health of fathers who are either expecting a baby or have a baby under the age of three months and the small pilot study (n=40) reported good acceptability (Fletcher et al., 2016). A Canadian website was designed to target breastfeeding information both to mothers and fathers, and the pilot study (n=149) reported promising results in terms of acceptability and breastfeeding self-efficacy (Abbass-Dick et al., 2017). Yet at the time of completion, Milk Man remained the only father-focussed mobile app about breastfeeding. As such, there was little in the literature to specifically guide the development of such an app for fathers, including how to structure an engaging mobile app and how fathers would use an app-based forum to offer and seek support. Additionally, there had been no research published describing how appropriate mothers would find a breastfeeding app for fathers. The results of this study will provide significant guidance to others seeking to use mobile technology to reach fathers in the perinatal period.

9.3 Objective 2: Milk Man app development

Objective

To develop an engaging breastfeeding app for fathers, informed by the literature and marketing audit and with input from stakeholders and members of the target group, that would provide them with the information and support they need to effectively support their breastfeeding partners.

Key points

- Stakeholder and target group consultation provided key insights to inform app development.
- Development of Milk Man followed a best practice approach.
- There is complexity in developing apps for RCTs.
- Social Cognitive Theory was a useful and broad theory for developing an mHealth intervention for fathers about breastfeeding.
- The evaluation plan developed for Milk Man was broad, comprehensive and useful.

9.3.1 Stakeholder and target group consultation

Formative discussion with fathers was informed by SCT (Bandura, 1986) and focussed on further understanding mobile usage and uptake within the target group, as well as focussing on breastfeeding attitudes and support pathways, and investigating the best way to target a mobile resource. The thematic analysis of the focus groups carried out with fathers revealed four main themes:

- Mobiles are used throughout the day for a variety of reasons
- App engagement should be carefully considered
- App should be targeted and funny
- Fathers need support and information about breastfeeding and parenting

These themes, which emerged from the thematic analysis, were described in Section 5.2.4. The feedback from fathers was integral in guiding the development of the app, including the app design and the engagement strategies. Peer support was highly valued by participants and fathers were clear on wanting more information, and having it delivered in a concise and easy to use format.

The consultative sessions with health professionals aimed to ensure the content was relevant and appropriate, and to ensure any emerging or current issues were included. Health professionals were enthusiastic about the intent of the project and provided a range of feedback and specific ideas that were incorporated into the app.

Including father and stakeholder input and feedback at this early stage of app ideation undoubtedly resulted in a better targeted app and was a key factor in optimising engagement with the intervention.

In addition to this consultation, the app development was overseen by a multidisciplinary team at Curtin University who provided input and insight at each stage throughout the intervention development. These professionals included breastfeeding researchers, health promotion professionals, dietitians, an epidemiologist, a health economist and a midwife, as well as an app designer and developer. The approach of involving end-users in the formative stages of design and development of an app, as well as establishing a multidisciplinary team have been described as '*crucial*' by other researchers (Castensøe-Seidenfaden et al., 2017). Due to the multi-faceted nature of app development, incorporating a broad range of experiences and expertise from early on is a very important consideration.

9.3.2 Building Milk Man

There are factors that are integral in developing mobile health interventions using a best practice approach. These included: working with multidisciplinary teams, involving app developers from early in the planning process, creating apps based on behaviour change theory, tailoring information to participants and involving end users throughout the development process (Dialogue Consulting, 2015). The development of the Milk Man app followed a best practice approach including all the aforementioned factors.

The consultation that preceded the development, as well as the marketing audit, helped guide the design and engagement strategies. In addition to this phase, end users also provided input through a phase of user testing with the app prior to the trial starting. The user testing phase was described in Section 6.4.2 and involved users completing a think-aloud walkthrough (Someren, Barnard, & Sandberg, 1994) and the Mobile App Rating Scale (MARS) (Stoyanov et al., 2016). It allowed for validation of the app as well as identifying six key functionality and usability issues that could be addressed prior to the trial starting. The use of both of these methods individually has been reported many times in the literature (see Chapter 6). The combination approach of the think-aloud walkthrough and the MARS used in this study was both convenient and easily understood by users while also providing rich feedback informative for the app development process. This easy to implement testing method can be used in other app intervention studies.

There are many different considerations when designing and developing an app for a health promotion intervention. The process of development described in this thesis (see Figure 6.1) is a practical and easy to understand process that follows a best practice approach and will be a useful framework for others to follow.

9.3.3 Complexity in app development models

The Milk Man app was developed for use in an RCT and followed a linear development process whereby the app was developed, tested and then released for the trial with no further iterations during the implementation. Having a phase of user testing and input before the final phase of iteration prior to the start of the trial was useful and informative. Due to time constraints with the RCT, the app was designed, built, tested, iterated and finalised over six months. This limited the time available for pilot testing. There is an ongoing challenge in digital health interventions, with the need to develop apps that are robust and have been developed in a methodical, thorough manner and the need to keep the process moving quickly to mitigate the risk of technological change. In this case, there were several limitations in the app that became apparent to the research team relatively quickly. These were mainly in the conversation and included the ability to mention other users in text in a way that triggers a notification (@mentioning users) and for users to be informed of new comments being posted on a thread they had already commented on.

However, app development in the real world is cyclical and app developers are always looking to the next round of iteration, rather than considering an app to be 'finished' (J. A. White, 2015). In that sense, each round of release offers new opportunity for input and to plan for the next round. With Milk Man, the RCT can inform the further development and public release of the app. Regardless of the structuring of pilot studies and trials, technology does change, bugs will be continually identified and opportunities for improvement will continue to arise. Rather than striving to have an app that is 'finished' prior to an intervention, researchers would benefit from adopting a more agile approach and considering each phase of implementation as an opportunity to continue to gather data that will improve the app. To facilitate this though, new and innovative ways of funding these public health initiatives need to be developed. The current funding model which often consists of a one-off grant given at the start of the project with deliverables and the promise of a 'finished' app built into the deliverables on a grant application, is not consistent with best practice app development principles. As mHealth continues to integrate into public health, better pathways to research translation, demonstrated sustainability models and more adaptive research designs and suitable funding models are needed.

9.3.4 Social cognitive theory is a useful and broad theory

SCT (Bandura, 1986) was a useful and practical theory to guide the development of the app. Due to the triadic framework, the theory is a good fit both for breastfeeding interventions targeting fathers, as well as mobile health promotion interventions. The theory guided the consultation with fathers in the consultative phase, forming a basis for the conversation in line with behaviour change principles. In developing the engagement strategies with the app, the key factors impacting on fathers' support for breastfeeding were mapped to specific SCT constructs which then informed the engagement techniques. Few app-based interventions have comprehensively described how behaviour change theory was incorporated into the intervention development. The theory provided a framework for consistent consideration of key factors throughout the development. Being the first breastfeeding app for fathers, there was a lack of clear guidance in the literature about how to best structure the app. The theory provided guidance to the researcher about key factors affecting breastfeeding support and the subsequent alignment with app engagement strategies. These findings are consistent with other research that has reported SCT as a suitable theory to use to develop breastfeeding interventions targeting fathers. This thesis adds to this by finding it suitable for a mobile health behaviour change intervention.

9.3.5 Evaluation planning

The evaluation plan developed for the Milk Man app was a useful, practical and thorough plan for evaluating an app within an RCT. Planning evaluation over the five different areas of people, content, technology, computer-mediated technology and health system integration and considering each phase of evaluation is a good way of ensuring that all the components integral to implementation validity are considered. The impact of digital health promotion interventions can be affected by many different factors. The plan that was used for Milk Man described each area over the course of the trial and was in line with other, more recently published guidance on how best to evaluate mobile health promotion initiatives (Agarwal et al., 2016). What is missing from this model is the cyclical process of development. For a traditionally structured RCT such as the one described in this study, the cyclical iteration process was not as important to include. For other initiatives, taking a more agile approach, including shorter, repeated phases of evaluation and iteration may better suit, yet there remains the need to include behaviour change or health outcomes as a measure at some time point.

Growing the evidence in this space is important and researchers can do this by understanding all the factors that impact an intervention. Paying careful attention to technological changes over the intervention time-period, including the impact of OS updates is a key factor that is not always included in process evaluation. This study benefitted from monitoring and logging events, and other studies should consider incorporating this in their evaluation as a matter of course. Technological events impacting on studies should be routinely reported. The comprehensive approach described in this thesis can be a model for others seeking to measure the efficacy of a mobile health promotion initiative in an RCT, or other studies. Researchers and practitioners, can consider all, or part of the plan and report accordingly. In order to promote standardisation and transparency in reporting, Table 1.3 details this study's compliance with the mERA checklist developed by the WHO mHealth technical evidence review group (Agarwal et al., 2016).

9.4 Objective 3: Process evaluation of app engagement strategies.

Objectives

To conduct comprehensive process evaluation investigating which of the app engagement strategies were effective in motivating and engaging users.

Key findings

- The Milk Man app intervention is an acceptable approach and the weeks immediately around the time of their baby's birth may be a key time to reach fathers with information.
- The conversation forum emerged as the hub of app activity, and there are ways it could be strengthened.
- Push notifications were an effective way of encouraging engagement with a mobile app.
- The library was well received and trusted, but fathers wanted more comprehensive information.
- Gamification can be a powerful motivator with this target group, however care needs to be taken to better understand how its inclusion may impact those who do not enjoy it, and the app should be fully functional without active participation in the gamification.
- The app showed encouraging results with facilitating conversations between parents.
- Working in partnership with the app developer throughout the trial was beneficial.

9.4.1 Acceptable approach

This research has demonstrated that a perinatal focussed app for fathers is an acceptable approach that many will engage with. Fathers reported liking the general concept of the app and the fact that there was something available for dads. Participants used the app in a range of different ways to get information, share information and facilitate support. The researcher identified a potential risk of mothers feeling their partners' use of the app could undermine them by implying fathers should adopt an instructional role.

Therefore, app content was very carefully created to avoid this, and a key focus was on encouraging fathers to ask their partners what they thought about different issues and how they could best support them. Evaluation shows that mothers were positive about the idea of the app for their partners and reported that their partners benefited from the app, and that they personally benefited from their partner's engagement with the app.

Of all the feedback received, there was only one comment from a father identifying a potential harm in relation to increased stress deriving from information overload leading to heightened parenting expectations (see Section 7.2.2). This has been observed in research with mothers where a recent study found that use of parenting books for infants was associated with increased stress and lower self-efficacy (Harries & Brown, 2017). While this comment was only received from one participant it raises an important consideration. To the best of the authors knowledge, there has been no research completed looking at the experiences of fathers with consuming parenting information and associated wellbeing and this is an important area for future research.

The data show fathers used the app most in the week their baby was born, and this usage declined thereafter. Therefore, the weeks immediately around the birth of their child may be a key time when fathers are receptive to new information. While fathers' involvement in breastfeeding may have traditionally been viewed as limited, this study demonstrates broad acceptability in targeting a breastfeeding app intervention towards the father. This includes the intervention being received in a positive way by mothers and fathers, as well as the health professional community and the public.

One advantage with this study is that app usage was not prescribed; fathers were simply asked to use the app as they would in real-life, rather than being asked to spend a specific number of hours using it each week. This resulted in a wide variance in usage patterns, which is likely to reflect what would be seen in a real-life situation. Mobile apps do not appeal to everyone, and not everyone will use an app for health information or support. However, a lot of people will (Carroll et al., 2017) and the difference in engagement levels demonstrate wide variation in how people will use an app. Most of the cohort was highly educated and lived in the least disadvantaged IRSD areas of Perth. As all participants were from metropolitan Perth, further research needs to understand the acceptability and impact of this method with parents living outside of the Perth area, Aboriginal and Torres Strait Islander parents, culturally and linguistically diverse parents and other disadvantaged groups.

Mobile apps need to be part of comprehensive interventions, rather than being the only intervention component. This is particularly true of breastfeeding interventions. Breastfeeding is inherently complex as the factors influencing it are a mix of biomedical, socio-demographic and support factors. Targeting breastfeeding interventions towards fathers, while seeking to influence maternal behaviour, is even more complex. Despite the advances in breastfeeding education and support services, and recognition of the importance of including fathers, there is still more that needs to be done in terms of building support systems and referral pathways for families in the community.

9.4.2 Conversation was central

The conversation forum emerged as the hub of app activity. When asked what motivated them to use the app, *'liking seeing what other dads have written'* was the second highest motivator. All the most read library articles and external links followed from the app originated from the conversation. The conversation was the most common feature mothers reported being shown in the app, and it was also the highest discussion prompter with their partners. Fathers were more likely to vote on the polls (avg. 5.3 poll votes per user) than they were to comment on the conversation topics (avg. 2.2 comments per user). While the results showed an association between both polls viewing and answering, and topic viewing and commenting, the association was higher with the polls. These results show that when a user viewed a poll, they were more likely to follow through with completing the action of voting, than they were to write and post a comment. Voting on the polls required less commitment and effort on the part of the participants, and resulted in an immediate reward of seeing how other people had voted. There were a few comments asking for more of these polls in the conversation, and perhaps combining with the ability to comment on the polls may increase participation.

Fathers used the conversation in several different ways including to seek and offer support, establish connection, offer informational support and share experiences. The key findings of this were discussed in Section 8.7. Creating content designed to encourage use of the app in-line with the ways this study identified fathers used the forum, may increase activity in the conversation and associated reported value. Fathers were grouped depending on their baby's expected due date. As a result, all fathers with a baby due in March were in the same group, regardless of whether the due date was the 1st or the 31st, and also, regardless of their actual delivery date. As such, the groups could potentially include fathers whose babies were up to two months in age difference. While the personalised messages were designed to be broad to counteract this, there will have been fathers receiving information that could have been better timed to their baby's needs. By refining the personalisation processes on a larger population sample, the information could be better targeted and be more relevant to fathers.

While the conversation was clearly important, some of the overall perspectives its value of it were relatively low. While 63% of participants said it was good hearing from other dads, only 30% found the conversation engaging and only 30% trusted the information in the forum. There are opportunities to further explore how this forum could best work on a population level and participants had some good suggestions to improve it, most notably the ability for fathers to start their own conversation topics. Other suggestions included threaded replies and conversation notifications. Over a third of participants (37%) said that they sometimes returned to the conversation to see if there were any new comments. Incorporating a function whereby users are notified if a new comment is added to a conversation they are already involved in, or if anyone has replied directly to their comment, may increase interaction. Notification systems such as these are common features in popular social media platforms such as Facebook (2017) and Twitter (2017). Other studies have examined the use of prompts in engaging users with digital interventions and reported borderline positive results (Alkhaldi et al., 2016). More research is needed to better understand the impact of different types of notifications and prompts in promoting engagement with an mHealth intervention.

There were several different aspects of the conversation where fathers wanted more. The first suggestion was simply for more participants, and more conversation. Due to the way fathers were grouped, the number of participants in each conversation group was relatively small, and groups who had a few early members who were active in the conversation had a more active forum throughout the study period.

Several fathers also suggested that having an active researcher participating in the conversation could be of benefit. While Milk Man used a peer mediator, the moderation was intentionally kept to a minimum. Having an active peer-facilitator embedded in the app may help to start conversations, to answer respondents and increase opportunities for conversations and support. Having a professional moderator can also help ensure advice is in-line with the current evidence-base. eCoaching has been demonstrated as a promising approach to healthy lifestyle interventions (Lentferink et al., 2017), yet to the author's this has not been tested in a father-focussed perinatal intervention. Trialling different methods of peer-facilitator interaction in the app by embedding a coaching program is a clear direction for future research which would address many of the suggestions made by fathers. Trained volunteers could be peer facilitators offering support, conversation and information. This research has demonstrated that fathers are prepared to share intimate information through a mobile app-based forum and gain benefit from the interaction with peers. Trialling the app on a population level will enable researchers to take an agile approach to testing different methods of sustainability, reach and engagement.

9.4.3 Push notifications

Push notifications were the number one factor motivating fathers' use of the app, and it is clear from the analytics data that there were regular check-ins on the days push notifications were sent out. No fathers reported negative comments about the push notifications and several asked for a higher frequency and for greater personalisation opportunities. Pushing reminders to individuals to check into an app removes some of the onus from participants to remember to access the service. This research demonstrates that incorporating regular push notifications that are carefully timed and linked to new content can be an effective way of encouraging engagement with a mobile app.

9.4.4 Library information

The use of the information in the library section was closely associated with the conversation. Library articles and external websites that were linked from the conversation, were more likely to receive a higher number of visits. The app was useful as a gateway to other organisations. The top two external websites visited were national peak bodies, the Raising Children Network (2017) and the Australian Breastfeeding Association (2017). These were followed by the WA-based parenting service Ngala (2009), Beyond Blue (2016) and the WA-based The Fathering Project (2017).

Fathers trusted the information in the library section (79%), yet only 25% reported coming to the app to find information. The library contained information on topics broader than breastfeeding including sleep, crying, fatherhood and mental health among others. Despite this, there was also a strong push for more information, including for more diverse and greater quantity of content in the library. Although the app content was broader than breastfeeding, several fathers noted that they did not need to use the app because their partner did not have breastfeeding problems. Repositioning the dissemination approach to be broader than breastfeeding and including a wider range of content may enhance the relevance of the app for a greater proportion of fathers.

9.4.5 Gamification complexity

The gamification strategy received mixed results in this study. While some fathers embraced gamification with it being their main motivator for using the app, other did not like it and said it impacted negatively on their app use. There was evidence of some fathers 'gaming the system' by exploiting the ability to vote multiple times to increase their point score. There were differences in how individuals perceived the gamification with participants who were still using the app at six weeks postpartum being significantly more likely to report the gamification functions were encouraging that use, than those who stopped prior to six weeks. The results showed a strong positive correlation between users tapping on a badge to view the badge descriptor, and the number of badges they went on to achieve. This suggests an active intention to achieve badges, rather than achievement by default. There are some interesting case studies with users who were highly engaged in the app and the gamification, offering strong negative feedback on this feature. Adding a separate qualitative component to the outcome assessment and completing some in-depth interviews with targeted sub-section of users would have helped to understand some of the complexity in the gamification strategy.

Interestingly, the gamification was not intrinsically linked to the app functions or content. Unlike in some gamified apps, achievements were not required to "unlock" certain content (for example, special user avatars). It was entirely possible and reasonable to use the app and ignore the gamification function if desired. Despite this, a small number of fathers reported the gamification discouraged their use. The feedback included some suggestions for better integration with the gamification, including better explanation of the points system to users so the way users are awarded points is more transparent.

This study has shown that gamification can be a powerful motivator with this target group, however care needs to be taken to better understand how its inclusion may impact those who did not enjoy it, and the app should be fully functional without participation in the gamification.

9.4.6 Encouraging communication between parents

A key aim of the app was to increase self-efficacy through encouraging communication between parents both before and after the birth of their child, to better enable them to plan and anticipate problems and work together for solutions. This, along with increasing understanding and knowledge about breastfeeding, were important in enhancing parents ability to work together. Throughout the app, the content regularly suggested fathers 'check-in' with their partners about different issues. The findings showed promising results in terms of fathers discussing or showing their partner something from the app.

Pregnancy and childbirth is a time of many firsts for new parents and the app was useful in facilitating conversation about aspects participants may have not previously considered. This is an important finding as parents that work together to prepare for challenges and changes in the perinatal period fare better in terms of mental health outcomes than those who do not (Colquhoun G & Elkins N, 2015). There were very promising results with some mothers reporting the app was helping them to feel more supported and to also help their partner.

I like how it has given my husband more confidence in supporting me as a mother

It is an app that has allowed my husband be both informed and confident to support me with breastfeeding. He was so helpful in the hospital in establishing breastfeeding and attachment - reminding me of techniques which I believe allowed me to relax more and be successful in establishing exclusive breastfeeding with our baby

Overall over half of fathers (54%) said the information in the app had led to a discussion with their partner. This was more apparent for those participants who used the app for longer than six weeks, with 72% of those still using the app saying the information had led to a discussion, compared with 34% who were not still using the app. Aiming to keep individuals engaged with the app for longer may increase the number of discussions. Fathers had a number of suggestions to improve the conversation which can be incorporated into future research to investigate the impact on duration of use.

9.4.7 Working in partnership with the app developer

Many researchers have recommended bringing app developers on-board early in the planning process and to involve them in the project planning and implementation (Becker et al., 2014; Dialogue Consulting, 2015; Lister et al., 2014). This study benefitted significantly from implementing this recommendation. Trialling an app over a 24-month period is a long time, and there were several technological events identified over this time-period including bugs identified and operating system updates. The bugs that were identified were addressed quickly and smoothly with minimal disruption to participants and the project implementation. For example, one participant contacted the researcher with an issue about icon overlay on his unusually sized phone. The app developer was able to debug the problem, issue an update through the app store and enable the participant to sign up to the app within 48 hours. Responding quickly is important as the window in which participants will remain interested and engaged is small, and this project benefitted from the responsiveness. The two major technological issues that occurred during the study, the August 2016 bug, and the retiring of the app hosting service, were both addressed efficiently and quickly in a way that resulted in minimal impact on participants.

In addition, the app developer contributed heavily to the app's design and usability, both of which were key factors with many participants. Most users said the app's design was appealing (78%), the app was easy to use (83%) and information in the app was easy to find (67%). In addition, many open text responses from fathers commented on the design and the usability. Overall, the Milk Man app was well designed, worked well, was easy to use and technologically robust. With the Milk Man intervention, the app developer was engaged at the design and ideation phase of the study, and remained a team member throughout.

A number of digital research projects have reported development issues that have significantly impacted on their study. In a recent blog post Dr Curtis recounts her difficulty with technology and working with app developers that significantly impacted on her PhD research (Curtis, 2017). The Growing Healthy study experienced technological difficulties with push notifications that required changes to the intervention implementation (Taki et al., 2017). Another nutrition-based app intervention found the login procedure and the app development as a web app reliant on internet connectivity, resulted in a slow operating speed that was a barrier to their participants' engagement (Hebden, Cook, van der Ploeg, & Allman-Farinelli, 2012). Furthermore, it is likely the incidence of technology impacting poorly on research is under-reported, either because the researchers were not aware of the problem, were ill-equipped to assess the scope or impact of the problems, or simply because studies that do not return positive results are less likely to appear in the peer reviewed literature (Assem, Adie, Tang, & Harris, 2017). Reporting adverse outcomes on intervention implementation due to technological difficulties has significant value to other researchers. Incorporating monitoring and reporting of technological performance as standard is in line with the mERA guidelines and will help to grow the evidence in this area.

By engaging app developers as part of the research team and having them share responsibility for monitoring implementation outcomes throughout the trial it is more likely that technological challenges will be identified earlier, and can be addressed promptly.

9.5 Objective 4: Breastfeeding outcomes

Objective

To determine the effect of the Milk Man app on breastfeeding behaviour and whether level of app engagement was associated with breastfeeding outcomes.

Key findings

- The whole PIFI study cohort exhibited high rates of exclusive breastfeeding.
- Those couples who downloaded Milk Man were less likely to cease exclusive breastfeeding at any time point up to six weeks post birth.
- Engagement levels had no impact on exclusive breastfeeding.

9.5.1 Exclusive breastfeeding

Exclusive breastfeeding was the primary outcome measure for this study. While the app was shown to have only a marginal effect on duration of exclusive breastfeeding, these results are likely to have been attenuated by sample selection bias. The 2010 Australian Infant feeding survey found that 55.8% of Australian infants were exclusively breastfed to less than two months (Australian Institute of Health and Welfare, 2011). With 73% of the overall PIFI cohort still reporting exclusive breastfeeding at six weeks, it is evident that participants in this study exhibit differences to the general population in terms of breastfeeding. The original sample size calculation for the RCT was based on the assumption that the control group would reflect the breastfeeding practices of the general population. However, as breastfeeding rates in all groups were substantially higher than the national average, it would be difficult to achieve the targeted 10% difference between groups on which the sample size calculation was based.

There is always likely to be a selection bias in breastfeeding intervention studies, in that those who are not planning to breastfeed, or not particularly invested in breastfeeding, are less likely to volunteer for a breastfeeding study. While there were no reported demographic differences between groups, most of the PIFI cohort was university educated (61.8%), aged over 30 years of age (81.5%) and in the least disadvantaged IRSD bracket (50.1%).

Using the ITT protocol there was no difference observed in breastfeeding outcomes between app groups and the control group. However, a per-protocol analysis with couples who had downloaded the app showed promise in terms of impacting on the risk of exclusive breastfeeding cessation. At all time points, participants in the app groups were less likely to have ceased exclusive breastfeeding. While encouraging, these data should be interpreted with caution as fathers who downloaded the Milk Man app, may have already been more engaged with breastfeeding and further research is required. Breastfeeding data in the broader RCT are being collected to 26 weeks (outside the scope of this thesis) and it is possible more variance in breastfeeding rates will be seen at this time.

Even small increases in the duration of exclusive breastfeeding can lead to increased health benefits (Dieterich, Felice, O'Sullivan, & Rasmussen, 2013). The potential wide reach of a mobile app and ability to personalise and deliver support as needed means that this intervention shows potential in terms of being able to reach fathers, impact on breastfeeding on a wide-scale, and lead to better health outcomes.

9.5.2 Measuring engagement

There have been efforts in the recent literature to develop a standardised method of measuring engagement, and work from the Growing Healthy study (Taki et al., 2017) describes a comprehensive engagement index that has contributed to increased understanding in this area. Yet any standardised measure is unlikely to be universally applicable due to the complex nature of different interventions in terms of app complexity, user requirements and intervention implementation differences. Rather, consensus around a standard set of engagement principles, able to be adapted for specific interventions would be valuable. The engagement measure developed for Milk Man was informed by current research in this area and adapted to work within the study cohort by benchmarking relevant subindices to the highest score for each subindex achieved by a user. This approach may be useful for others seeking primarily to define and describe engagement within their own study groups, rather than comparing engagement across different studies.

The difficulty with interpreting engagement levels, is that they do not necessarily reflect *effective* engagement. With a breastfeeding education and support initiative, as with other initiatives, this is likely to differ between individual and groups. Some fathers may visit the app once, read three articles about the benefits of breastfeeding and this may be enough to increase their support for their breastfeeding partner. Others may need more sustained and prolonged usage to have the same effect. Further research is needed to better understand the impact wider cultural and socio-contextual factors have on user engagement (Yardley et al., 2016).

Increased engagement could also reflect a poorly designed app that was difficult to use. For example, if the content is displayed in a manner that is difficult to navigate and understand, a user may open many articles looking for the information they need, hence giving an artificially high number of article opens. Conversely, an app that is highly responsive and intuitive may take the user to the exact information he needs in one click. In this scenario, using an analytics-only approach, the former user may appear to be more engaged, but that engagement is not rich and unlikely to lead to sustained usage. These considerations are why an engagement index must use a range of metrics to define engagement levels.

In addition, other studies have reported an association between higher engagement with the app and poorer health behaviours (Businelle et al., 2016). As previously discussed a smoking cessation app found those who used the *quit tips* feature of their app the most, where the heaviest smokers and were less likely to abstain from smoking.

This was an interesting consideration in measuring engagement with Milk Man. It was reasonable to assume that couples who had the most difficulty with breastfeeding may use the app the most. If breastfeeding was going well, fathers may not have felt the need to engage with the information and support in the app. Conversely, if a mother was struggling with breastfeeding, increased app activity from the father may have resulted. Fathers may have been more engaged in looking for information to support their partners, and the articles and conversations about breastfeeding problems may have held more relevance. Hence, in this scenario, the couples who were having the most difficulty may have poorer breastfeeding outcomes, and those with longer breastfeeding duration may have had much lower levels of engagement with the app.

However, this study showed that while those who had downloaded the Milk Man app were less likely to cease exclusive breastfeeding at any time point prior to six weeks, the level of app engagement did not impact on this. Regardless of the actual level of app engagement, couples who downloaded the app were less likely to cease exclusive breastfeeding at all time points. This reinforces the discussion above about individual users having individual levels of *effective* engagement. *Effective* engagement, rather than engagement level may be a more useful predictor of outcomes. These findings suggest benefit from the app has been seen with all participants who engaged with the intervention, including those who used the app even minimally. This finding would benefit from further exploration in subsequent studies. More research on how to measure and report on *effective* engagement is needed.

9.6 Strengths and limitations

This thesis describes a significant study that has made an original contribution to knowledge about mobile health promotion initiatives. The findings of this study will be of significant interest to anyone planning breastfeeding interventions for fathers, and for those developing mHealth interventions. To the authors knowledge, the PIFI is the largest male partner focussed breastfeeding intervention study ever conducted, and Milk Man is the first breastfeeding app for fathers. Comprehensive evaluation is vital in continuing to progress the field of mHealth research and the evaluation plan described here is comprehensive and adaptive and will be of significant benefit for anyone implementing a health promotion mHealth intervention.

This study adds to the evidence about the impact targeting interventions towards fathers can have on breastfeeding duration. This research has been the first to demonstrate that fathers will use a mobile app to seek and share information about breastfeeding and early parenthood, and that use of the app may impact positively on exclusive breastfeeding outcomes. It has also been the first to show that fathers will use an app-based forum in different ways to seek and offer social support, including that fathers are comfortable using this medium to share intimate information.

A strength of this study was the mixed methods approach which included a combination of qualitative and quantitative data from different sources. The combination of self-reported data from the questionnaires, analytics data from the app and qualitative data from the conversation forum enabled rich understanding of how fathers used the app, and how they perceived it.

The study design is robust and comprehensive and components of the design, including the development process, evaluation plan and engagement measure are significant strengths that can be adapted by other researchers to guide their own work. While this thesis did not report on cost-effectiveness of the intervention, a cost-consequences analysis from the perspective of the health service is planned for the whole PIFI study conducted by an experienced health economist. This will provide further evidence of the efficacy of the approach described in this thesis.

This study had several limitations. Most of the cohort was highly educated, lived in the least disadvantaged IRSD area, were aged over 30 years and demonstrated higher rates of exclusive breastfeeding at six weeks postpartum than the population average. This limits the ability to generalise the findings to the general population. By targeting recruitment through antenatal classes, most of the participants recruited were first time parents, and those who were already engaged in the birthing process. It is likely there was a selection bias as well with individuals volunteering to participate in the study who were already planning to breastfeed. Comparison of the breastfeeding outcomes of the PIFI cohort with the most recently available national breastfeeding statistics (Australian Institute of Health and Welfare, 2011) reveals a self-selection bias. All PIFI groups exhibited higher rates of exclusive and any breastfeeding at all time points compared with the national indicators.

With only 439 of the 586 participants who downloaded the app completing the six week questionnaire, there is little indication of why the 147 individuals may have disengaged with the study and / or the app. To be included in the app analysis contained within this thesis, fathers needed to have provided a date of birth for their baby to enable the calculations. As such, this excluded 77 participants (from the 586 who downloaded the app) from this analysis. They may have continued using the app, but not completed any further questionnaires with the study, which has resulted in not understanding their motives and drivers. Having brief incidental assessments delivered through the app directly could have been one way of mitigating this loss.

The lack of a pilot study and the complexity with incorporating one has been discussed previously. Technology changes quickly and to minimise these risks Milk Man was used in the PIFI study without a pilot study. A larger pilot study of the app, before starting the PIFI study, would have been of value in providing further insight into the way in which men would use the app in a real setting and there were components within the conversation which could have been improved using information which a pilot study is likely to have produced. However, the comprehensive evaluation plan has captured these, and the results from this study will inform the next phase of implementation.

Incorporating qualitative in-depth interviews with a selection of high and low end users, as well as those who did not download the app, would have been beneficial in further understanding the app use. Despite the large sample size, due to the way fathers were grouped, the number of participants in each conversation group was relatively small and this impacted on the range and depth of conversation, as well as fathers' experiences in using the app. Trialling the app on a larger population scale will be useful in further exploring the potential of this intervention on a larger scale.

9.7 Recommendations

The findings of this thesis have resulted in a number of recommendations which include insights for further research with the Milk Man app, and broader recommendations for public health researchers or others seeking to develop mobile apps for health behaviour change.

9.7.1 Recommendations for further research with Milk Man app

- This thesis demonstrates that the Milk Man app was an acceptable and engaging intervention for fathers that mothers and fathers saw benefit from, and that impacted positively on breastfeeding outcomes. It is recommended that Milk Man be developed further to allow for public release and for research to continue on a larger scale. This can include testing different methods of dissemination, of moderation, and of facilitating the conversation including with peer facilitators.

- Further work should be conducted to understand the acceptability and impact of the app with individuals living outside of the metropolitan area, including Aboriginal and Torres Strait Islander, culturally and linguistically diverse parents and with other disadvantaged groups.

9.7.2 Recommendations for broader mHealth interventions

- To standardise and ensure best practise in app development, public health researchers should consider adopting the development method described in this thesis, and adapting the evaluation plan. Researchers should plan ways to closely monitor the robustness of the technology over time to ensure any impact on the intervention is identified and addressed quickly.
- Incorporating regular push notifications that are carefully timed and linked to new content can be an effective way of encouraging engagement with a mobile app.
- The weeks immediately around the birth of their child are likely to be a key time when fathers are receptive to new information and more information and support should be targeting fathers at this important time.
- Gamification can be a powerful motivator with this target group, however care needs to be taken to understand how its inclusion may impact on those who do not enjoy it, and apps should be fully functional without participating in the gamification.
- Researchers should take care to understand that while mobile apps offer great potential in terms of reach and behaviour change, they are not for everyone and should be incorporated as part of comprehensive programs, rather than being the only strategy.
- Public health researchers seeking to develop mobile apps should work with app developers throughout the study, and base apps on behaviour change theory.
- Researchers should seek and incorporate the ideas and feedback of end-users and stakeholders in the development and design phase of app development, as well as throughout implementation.
- More research is needed on understanding *effective* engagement, including how to measure this and identify individual engagement needs.
- Personalisation and tailoring of interventions to the individual is important in establishing and maintaining engagement. More research is needed to better understand how to structure this to best encourage and maintain engagement.

9.8 Conclusion

This thesis has described a research project that has sought to develop and trial an evidence-based mobile app about breastfeeding for fathers, based on behaviour change theory. Trialled in the largest male-partner focussed breastfeeding intervention study, this thesis has made an original contribution to knowledge of mobile health promotion initiatives. It is the first study to show that a breastfeeding mobile app intervention targeting fathers is an acceptable approach and one that can impact positively on breastfeeding outcomes. It has also contributed to knowledge of what specific strategies are effective in engaging fathers and how to best target an mHealth intervention.

While much of the evaluation has focussed on describing the interaction of the participants with the mobile app, it is important to focus on the breastfeeding implications. The health benefits of breastfeeding are well evidenced for both mothers and infants. There are many complex factors that impact breastfeeding and there is a continued need to address those such as creating supportive environments for breastfeeding, both in a clinical setting, and the broader community, and increasing the availability of support services and education for families. However, the findings of this study have promising implications for breastfeeding outcomes. A mobile app has potentially very wide reach at a low cost. In this study, at six weeks postpartum the difference in exclusive breastfeeding outcomes were marginal, but the potential to extrapolate this small increase to a population level may result in significant health gains. Finding innovative ways to support parents that have wide reach and fit with the ways they want to receive information and are available when they need to access it, clearly fits with the way information exchange is moving. This thesis has demonstrated the acceptability of a mobile app for receiving health information and added an original contribution with the focus on a father-focussed breastfeeding intervention.

Broader than the Milk Man intervention, this study has implications for researchers and practitioners developing mHealth interventions. This study utilised an innovative and practical study design, including an evaluation plan that included indicators that are broad and comprehensive. The implementation of this plan can be adapted for other mHealth interventions to guide and standardise evaluation.

This thesis, and the broader study it is a part of, began with the simple observation, confirmed by the literature, that women's partners are an important part of the breastfeeding journey but can sometimes feel otherwise. Milk Man contained a wide range of information, and had many goals, but none were more important than this: to tell men that, in this shared journey, they mattered, and that their support was important for breastfeeding. While the technical and procedural details of this study are important, perhaps the most important finding was that this message and the method whereby it was delivered, appeared to resonate with both new mothers and new fathers and impact positively. This affirmation should be central to future efforts to assist parents in starting, and continuing, to breastfeed.

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Appendix A Fathers six week questionnaire

The following questions are from the six week questionnaire that were asked of fathers in the Milk Man app groups and are relevant to analysis in this thesis.

As part of this study you have been given access to the Milk Man app. The following questions refer to the app.

1. Have you installed the Milk Man app?
 - a. Yes (go to 2)
 - b. No. If no why not? Please let us know why not, (tick all that apply)
 - i. I don't use apps
 - ii. I can't be bothered looking at it
 - iii. I'm too busy
 - iv. I don't trust info from apps
 - v. I don't like the look of it
 - vi. Breastfeeding isn't men's business
 - vii. Embarrassing having it on my phone
 - viii. Just haven't gotten around to it
 - ix. Partner not breastfeeding
 - x. Other ____ (go to 1c)
 - c. Do you want us to contact you to help you install it?
 - i. Yes
 1. Yes, please provide contact number (go to end)
 - ii. No (go to end)
2. Have you used the app?
 - a. Yes (go to 2ai)
 - i. Are you still using it?
 1. Yes (go to 3)
 2. No (go to past tense. This involved the below questions changed to past tense)
 - b. No (go to 2bi)
 - i. If no, do you intend to?

1. Yes (go to end)
2. No (go to 2bi.2.a)
 - a. Please let us know why not, (tick all that apply)
 - i. I don't use apps
 - ii. I can't be bothered looking at it
 - iii. I'm too busy
 - iv. I don't trust information from apps
 - v. I don't like the look of it
 - vi. Breastfeeding is not men's business
 - vii. It's embarrassing having it on my phone
 - viii. My partner isn't breastfeeding
 - ix. Other ____ (go to end)

3. What motivates you to visit the app? Please tick all that apply

- a. The push notifications remind me to check in
- b. I need to find information
- c. I want to get points
- d. I like seeing what other dads have written
- e. I like the conversation topics
- f. I like that there's always new stuff to read
- g. I need to find a service or organisation
- h. I like the competition element

4. These questions relate to the LIBRARY section

Please indicate how strongly you agree or disagree with the following statements.

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The information in the library is easy to find					
There is enough information					
I am learning new information					
I trust the information contained in the library					
The links to further information are appropriate and useful					

I come to the app when I needed to find information					
-----------------------------------------------------	--	--	--	--	--

5. These questions relate to the CONVERSATION section

Please indicate how strongly you agree or disagree with the following statements.

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
I find the conversation engaging					
It is good hearing from other dads					
I sometimes return to the conversation to see if there are any new comments					
I trust the information in the conversation					
I sometimes check back to see if my comment had received any upvotes					
Getting upvotes encourages me to comment more					
I have acted on advice I have read in the conversation					
I have discussed something with my partner that I read in the conversation					

6. These questions relate to the GAME

Please indicate how strongly you agree or disagree with the following statements.

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Earning points encourages me to keep using the app					
Earning badges encourages me to keep using the app					
My position on the leaderboard encourages me to keep using the app					

7. These questions relate to MILK MAN in general

	Strongly Agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
The app is easy to use					
The visual design of the app is appealing					
I would recommend this app to other new or expectant dads					
I find the app interesting / fun to use					
The app has made me more aware of how I can help with breastfeeding					
Information within the app has lead to discussions with my partner.					

8. What did you like about the app? (open text)

9. What suggestions do you have to improve the app? (open text)

Appendix B Mothers six week questionnaire

The following questions are from the six week questionnaire that were asked of mothers in the Milk Man app groups and are relevant to analysis in this thesis.

SECTION A: Breastfeeding

1. How are you currently feeding your baby?
 - a. Breastfeeding exclusively
 - b. Breastfeeding fully (with occasional water and juice)
 - c. Formula-feeding only (go to 3)
 - d. Combination of breastfeeding and formula-feeding (go to 3)
 - e. Other (open text)

2. Has your baby ever received any formula since his/her birth?
 - a. No
 - b. Yes: occasional bottle of formula (go to 3)
 - c. Yes, in hospital (go to 3)

3. When did you first give your baby infant formula? _____

SECTION B: Milk Man questions

As part of this research project, your partner has access to the Milk Man app.

1. Have you been aware of your partner using or looking at the Milk man app?
 - a. Yes
 - b. No

2. Have you used the app yourself?
 - a. Yes, often
 - b. Yes, occasionally
 - c. Yes, a little
 - d. No, not at all

3. Has your partner showed you anything from the app?
 - a. Yes (go to 3.a.i)
 - i. What information has he shown you? (open text)
 - b. No (go to 4)
4. Have you had any discussions with your partner about anything from the app?
 - a. Yes (go to 4.a.i)
 - i. What have you discussed? (open text)
 - b. No (go to 5)
5. How helpful has the app been?
 - a. I haven't used it
 - b. No help at all
 - c. Slightly helpful
 - d. Fairly helpful
 - e. Very helpful
 - f. Not applicable
6. Overall what do you think about the Milk Man app? (open text)

Appendix C App development Publication

White, B. K., Martin, A., White, J. A., Burns, S. K., Maycock, B. R., Giglia, R. C., & Scott, J. A. (2016). Theory-Based Design and Development of a Socially Connected, Gamified Mobile App for Men About Breastfeeding (Milk Man). *JMIR Mhealth Uhealth*, 4(2), e81. doi:10.2196/mhealth.5652. [Impact Factor 4.636]


Author contributions:

BW, and JS conceived and planned the study. JS provided overview of all aspects of study implementation. BW and AM carried out the focus groups. BW carried out thematic analysis of the focus group data and facilitated the user testing. JW designed and developed the app and contributed to the app's engagement strategies. SB provided guidance of the use of the theory and confirmed thematic analysis coding. BW took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.


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Original Paper

Theory-Based Design and Development of a Socially Connected, Gamified Mobile App for Men About Breastfeeding (Milk Man)

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Abstract

Background: Despite evidence of the benefits of breastfeeding, <15% of Australian babies are exclusively breastfed to the recommended 6 months. The support of the father is one of the most important factors in breastfeeding success, and targeting breastfeeding interventions to the father has been a successful strategy in previous research. Mobile technology offers unique opportunities to engage and reach populations to enhance health literacy and healthy behavior.

Objective: The objective of our study was to use previous research, formative evaluation, and behavior change theory to develop the first evidence-based breastfeeding app targeted at men. We designed the app to provide men with social support and information aiming to increase the support men can offer their breastfeeding partners.

Methods: We used social cognitive theory to design and develop the Milk Man app through stages of formative research, testing, and iteration. We held focus groups with new and expectant fathers (n=18), as well as health professionals (n=16), and used qualitative data to inform the design and development of the app. We tested a prototype with fathers (n=4) via a think-aloud study and the completion of the Mobile Application Rating Scale (MARS).

Results: Fathers and health professionals provided input through the focus groups that informed the app development. The think-aloud walkthroughs identified 6 areas of functionality and usability to be addressed, including the addition of a tutorial, increased size of text and icons, and greater personalization. Testers rated the app highly, and the average MARS score for the app was 4.3 out of 5.

Conclusions: To our knowledge, Milk Man is the first breastfeeding app targeted specifically at men. The development of Milk Man followed a best practice approach, including the involvement of a multidisciplinary team and grounding in behavior change theory. It tested well with end users during development. Milk Man is currently being trialed as part of the Parent Infant Feeding Initiative (ACTRN12614000605695).

(*JMIR Mhealth Uhealth* 2016;4(2):e81) doi:[10.2196/mhealth.5652](https://doi.org/10.2196/mhealth.5652)

KEYWORDS

mHealth; smartphone; mobile phone; app; breastfeeding; fathers; gamification; social connectivity

Mobile Technology and Health Promotion

While specific recommendations from the FIFI study focused on the use of the Internet and DVDs, the technological landscape has changed markedly since the FIFI study was implemented in 2008. Smartphone usage is now virtually ubiquitous in Australia. In July 2014, Deloitte estimated that 81% of Australians aged 14 years and over owned a smartphone [30]. App usage is also prevalent, with the Australian Communications and Media Authority finding that 75% of Australian smartphone users had downloaded an app to their smartphone in a 6-month period [31]. Data from the United States in 2014 revealed that Android and iOS smartphone users were spending 65% more time using apps than they had 2 years previously, equating to 30 hours and 15 minutes each month per user [32]. Australians now spend more time accessing the Internet from smartphones than they do from desktop computers [33].

Mobile technology has been incorporated into health promotion programs targeting various health behaviors. Initiatives have targeted new parents [34], physical activity and nutrition [35-37], alcohol [38], suicide prevention [39], and mental health [40,41]. The use of smartphones offers specific benefits in terms of high user engagement [42], including the opportunity to deliver ecological momentary interventions [43]. These are interventions that occur as people participate in their daily lives and happen in real time [43]. As mobile users become increasingly savvy about app usage [44], their expectations grow, and it is important that apps developed for research purposes match the usability and sophistication that users expect from other “real-world” apps.

Developing mHealth interventions in multidisciplinary teams is a best practice approach recommended by many researchers [45-47]. It is important to design apps that are a good fit for user expectations and that make effective use of the devices on which they are deployed. Working with app development professionals early in the process can help to ensure that apps are well planned and executed [48]. This involvement can also identify trends in app development and user behavior, which may be incorporated into an app-based health intervention. In the case of Milk Man, we included push notifications, social connectivity, and gamification as engagement and motivational strategies.

Push Notifications

Push notifications are a means by which mobile apps can send information or alerts to users [49]. Compared with other notification methods, such as email, push notifications are immediate and quick to act upon; swiping the notification takes the users directly to the app, and even into the specific context referenced by the notification. Notifications remain in a list until they are acted upon or removed, meaning they can potentially act as triggers for later action. Use of push notifications means that the onus is not solely on a participant to remember to engage with the service; to some extent the service comes to them.

Social Connectivity

The use of technology for information gathering has changed markedly over the last 20 years. Increasingly, people want to interact with technology and use it to socially connect rather than simply passively receiving static information [50]. Many people are now socially connected throughout the day, over a number of platforms. Australians are enthusiastic users of social media, with approximately 68% of Internet users having at least one social media profile [51]. Breastfeeding research with fathers shows that peer support and peer connection is highly valued [14,16,21,23], and results from the FIFI study demonstrated that this approach can affect women's breastfeeding duration [12].

Socially connected mobile technology can encourage people to reach out to each other and build communities [52-55]. Encouraging results have been reported in studies of online social support communities in interventions across a broad spectrum of health areas, including weight management [52,56], physical activity [57], and social anxiety [58]. For example, a focus group study that investigated the feasibility of an app for overweight adults suggested that social support networks that create a virtual community could be the primary component in creating a successful healthy lifestyle app [52].

Gamification

Gamification is the practice of using game-like components to motivate and encourage people in non-game contexts, and it is becoming increasingly popular in health and fitness apps [59]. Gamification elements include badges, leaderboards, points, and challenges [60]. Evidence about the increasing use of gamified apps in health is emerging [47,61,62]. A review of physical activity and nutrition apps found that the use of gamification was widespread; however, behavior change theory was not widely incorporated and there was no industry standard for developers [62]. Several studies have noted the need for further investigation of the potential for gamified health apps to effect behavior change [47,61-63]. Australian mental health research with young men suggested that gamification may be of value in enhancing engagement and enjoyment with using technology [64].

Parent Infant Feeding Initiative

We developed the Milk Man app to be trialed as part of the Parent Infant Feeding Initiative (PIFI), which has been previously described [65] (ACTRN12614000605695). The PIFI study is a 4-armed RCT comprising 1 control group, 2 medium-intensity intervention groups, and 1 high-intensity intervention group. Participants are being recruited from antenatal classes at hospital sites in metropolitan Perth, Western Australia. The control group has access to the usual care provided by the hospital. One medium-intensity group receives a male-facilitated antenatal class, while the other has access to the Milk Man app. The high-intensity group has access to both the male facilitator-led antenatal class and the Milk Man app.

One of the largest intervention breastfeeding studies to target male partners, the PIFI study will be conducted between 2015 and 2017 and is expected to provide valuable insights into infant feeding outcomes. This paper focuses on the Milk Man app,



Introduction

Breastfeeding

Breastfeeding is universally recognized as the optimal way for babies to receive nutrition, and breastfeeding offers many well-documented health benefits for both mother and baby [1-4]. Despite concerted effort in policy, research, and community and hospital practice, breastfeeding rates in Australia at 6 months, and in particular rates of exclusive breastfeeding, remain low [5]. Breastfeeding initiation rates are generally good, with 96% of Australian women initiating breastfeeding. However, rates decline steadily thereafter, with only 15% of babies exclusively breastfed at 5 months [5].

Targeting Fathers

The influence of the father has been identified as one of the most significant factors influencing the breastfeeding behavior of the mother [6-10]. Scott et al reported that a woman's partner has an important influence on the mother's decision to initiate and to continue breastfeeding [11]. These findings were reinforced in 2015 with data from the Australian Infant Feeding Survey, which found that multiple factors have an impact on breastfeeding cessation, with the most influential factors being the partner's views, the use of pacifiers, and maternal obesity [6].

Relatively few father-focused breastfeeding interventions have robustly evaluated breastfeeding outcomes using a randomized

controlled trial (RCT) design. However, the Fathers Infant Feeding Initiative (FIFI), conducted by members of our team, trialed a male-facilitated antenatal class for expectant fathers and a follow up social support component consisting of age-relevant information being mailed out to participants [12]. The FIFI RCT reported a significant difference between intervention and control groups in the percentage of babies who received any breastmilk at 6 weeks of age (intervention: 81.6%, control: 75.2%) [12]. The researchers recommended extending the study to 6 months and separating the social support intervention from the male facilitator-led antenatal sessions to measure the relative effect. The study also reported that fathers expressed a preference for Internet, email, and video to be used as a basis for the delivery of information [13].

Mothers have reported that partner support makes a difference to their confidence, as well as helping them to achieve their breastfeeding goals [14,15], and fathers typically indicate they are supportive of breastfeeding and want to be involved [13,14,16,17]. Involving fathers and increasing their support for breastfeeding has been recommended repeatedly in the literature [10,11,16-19]. However, despite fathers generally being supportive of breastfeeding, the literature highlights several factors that can affect the level of support they are equipped to offer. These factors include social support, knowledge, empowerment, and other specific barriers (see [Textbox 1](#) [13,14,16,17,19-29]).

Textbox 1. Factors affecting the support fathers offer to their breastfeeding partners.

<p>Social support [13,14,16,20-23]</p> <ul style="list-style-type: none"> • Insufficient social support • Frequent exclusion from family support programs • Lack of opportunities to learn and share • Lack of peer support <p>Gaps in knowledge [13,14,16,17,19,22,24,25]</p> <ul style="list-style-type: none"> • Expectations about breastfeeding, bonding with baby, and about how life changes after baby arrives • Health and other benefits of breastfeeding • Practical suggestions to help family • Professional services available, for mothers and fathers <p>Empowerment [14,16,19,20,22,26]</p> <ul style="list-style-type: none"> • Lack of recognition of paternal role • Lack of understanding of importance of paternal support for breastfeeding • Need for more information and practical advice on how men can better support their family <p>Barriers [14,16,17,22,23,26-29]</p> <ul style="list-style-type: none"> • Concerns around having to postpone bonding with baby until breastfeeding has finished, or around other ways to bond with baby besides feeding • Public breastfeeding • Feeling left out of the relationship (with their partner and with the baby)

with particular emphasis on the formative research underpinning its design, development, and preliminary testing.

This research adds to the literature by describing the design and development of, to our knowledge, the first breastfeeding app targeted at men. The app uses carefully considered mobile strategies to engage men with an issue that is typically seen as the domain of women, and the results will add to the literature on mHealth and health promotion, particularly with respect to what works for targeting men with breastfeeding initiatives.

Methods

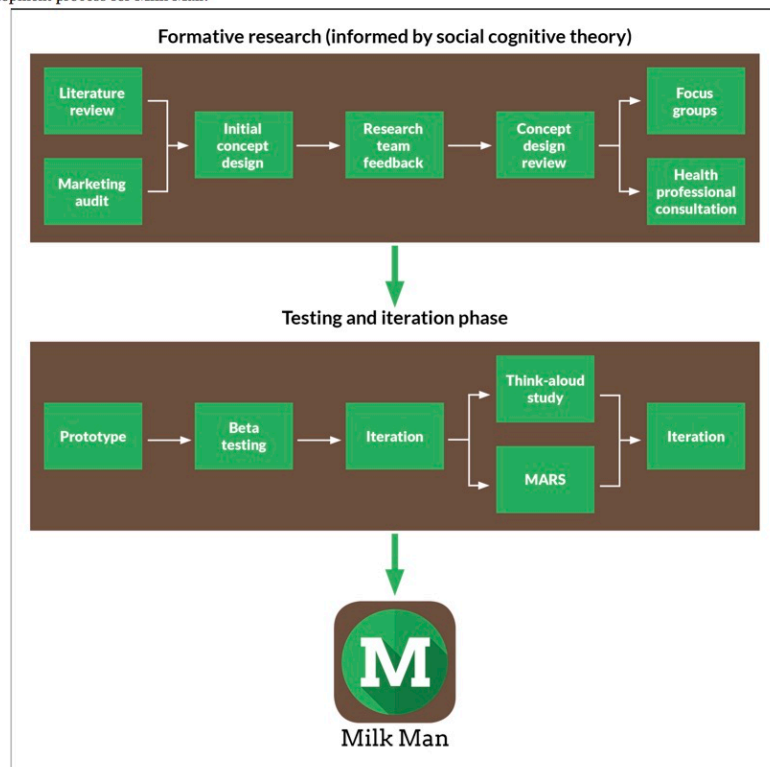
App Design

We developed the Milk Man app as a socially connected information and support resource for men. It is focused on breastfeeding and infant feeding, but includes broader information on topics including early parenting, being a supportive partner, and local service providers. It is based on evidence about the main factors affecting fathers' support of

their breastfeeding partners and is informed by social cognitive theory (SCT). As part of the formative research process, we completed a marketing audit of current advertising campaigns investigating how health messages, products, and services were being designed for the target group. This information helped guide the design of the app. Breastfeeding interventions are often targeted at the mother, resulting in fathers reportedly feeling excluded from family support programs [14,16,19]. Milk Man was explicitly designed for, and targeted toward, fathers, and this was a key consideration in encouraging men to access and use the information.

Milk Man was informed by focus groups with men in the target group, in addition to consultation with health professionals. We refined it through a testing phase comprising beta testing and user testing with men in the target group. User testing involved participants completing a think-aloud walkthrough, as well as completing the Mobile Application Rating Scale (MARS) [66] (see Testing and Iteration sections below). Figure 1 illustrates the Milk Man development process.

Figure 1. Development process for Milk Man.



Theoretical Framework

SCT is a social learning model that operates at the interpersonal level, assuming an interaction between the social environment, the psychosocial determinants of behavior, and the individual

[67,68]. In seeking to understand and predict human behavior, SCT can help to inform strategies for interventions to motivate and enable people to adopt healthier behaviors [69,70].

Reciprocal determinism is a key principle of SCT, describing the influence of both personal factors and the social environment

on a person's behavior. The factors that affect fathers' decisions about and capacity to support breastfeeding are broad and include a combination of environmental and personal influences. Two specific social environmental factors that have been identified in the literature for this target group are the sometimes complex issues related to public breastfeeding, and the role that health professionals can have [16]. SCT acknowledges the impact these influences can have rather than simply focusing on the individual. In recognition of this, SCT has been recommended in the literature as a useful framework for breastfeeding interventions that target fathers [22,71]. It was used as the basis for the FIFI study, particularly in designing the male-facilitated antenatal sessions, which considered the constructs of self-efficacy and observational learning. It also

helped researchers to understand the potential interrelation of different factors, including the overestimation of parental capacity and the underestimation of potential problems with breastfeeding.

We based the design of the Milk Man app and its engagement model on SCT constructs, to address the key issues affecting men's support for their breastfeeding partners. The specific constructs of observational learning and goal setting were key components. In seeking to address self-efficacy, the app encourages problem solving between couples. Table 1 describes the theoretical framework underpinning the app and how the key engagement techniques used address the key factors identified in the literature.

Table 1. Milk Man engagement techniques mapped to social cognitive theory (SCT).

Key factors	SCT constructs	Engagement technique in Milk Man app
Social support		
Men feel they do not receive enough social support with pregnancy and early parenting.	Observational learning Goal setting Self-efficacy	Connected social support function via the guided "conversation" feature. App was specifically designed for, and targeted towards men. Gamification functions to encourage inclusion, engagement, and positive feedback.
Knowledge		
Men have gaps in knowledge around breastfeeding, pregnancy, and early parenthood.	Outcome expectations Goal setting Self-efficacy	Provision of information via the library, including practical solutions and support service contact details. Regular, age-relevant topics sent out as push notifications.
Empowerment		
Men report lack of recognition of paternal role and understanding of their supportive role.	Self-efficacy Self-regulation Outcome expectations	Focus on empowering men to understand their role through the library and the conversation. Provision of practical advice Encouragement to discuss issues with partner.
Barriers		
Men report specific barriers, including bonding post-ponement, public breastfeeding, and feeling left out.	Self-regulation Self-efficacy Observational learning Outcome expectations Goal setting	Forum for men to share information and an opportunity for discussion about solutions to barriers. Provision of information and strategies on public breastfeeding. Provision of information on specific barriers and solutions with the aim of establishing realistic outcome expectations.

Engagement Strategies

We specifically designed the app to be attractive and engaging to the target group. The app is contemporary, delivers important information in a fun and lighthearted manner, and contains quirky imagery throughout. Milk Man contains engagement strategies that aim to keep men interested in using the app. The main engagement strategies are the use of push notifications, social connectivity via a guided conversation, an information library, and gamification.

Push Notifications

The Milk Man app has new content being added in the form of conversation topics twice a week. Push notifications are used to alert users to new discussion topics.

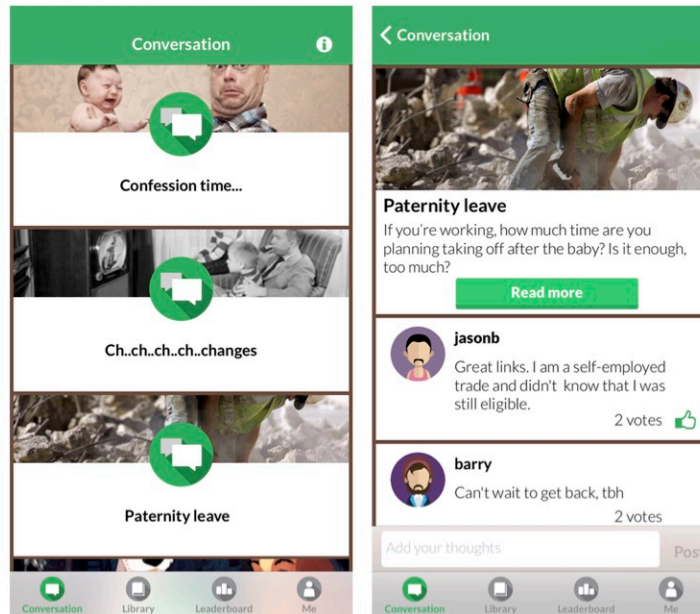
Social Connectivity Through Conversation

Milk Man aims to socially connect men by engaging them in a guided conversation. The conversation consists of a series of topics initiated by the app administration team twice a week. Participants receive a push notification alerting them to new topics and inviting them to participate in the conversation. On swiping the notification, they are taken directly to that conversation within the app. Topics are either posts or polls. A post, shown in Figure 2, consists of a question, usually with a link to a static information article in the library component of the app.

Users can add comments to the conversation, and "upvote" (that is, like or recommend) other users' comments. A poll is a multiple choice question, where users can choose an answer and view the aggregated responses of other users. Users are placed into conversation groups on the basis of the estimated

due date of their baby, enabling age-relevant information to be sent at appropriate times.

Figure 2. Milk Man conversation function.



Information Library

The app also contains a library of static, evidence-based information tailored specifically to fathers (see Figure 3). This includes information on preparing for fatherhood, breastfeeding and infant feeding, managing expectations, and how to seek support. The library uses the progressive disclosure technique [72], where information is sequenced so the initial information is concise, then progressively more detailed as the user requests further information. External links provide further information from service providers, including the Australian Breastfeeding Association [73] and the Raising Children Network [74]. We

restricted the length of the articles to approximately 150 words to ensure content is succinct and minimal scrolling is required to see the whole article.

Gamification

The app uses leaderboards, badges, and points to encourage engagement with both the social conversation and the static library of information. Users are awarded points for commenting on posts, contributing to the conversation, voting on polls, receiving upvotes from other users, and reading library articles. Users can see their score and rank on the leaderboard. Figure 4 shows these features.

Figure 3. Milk Man library.

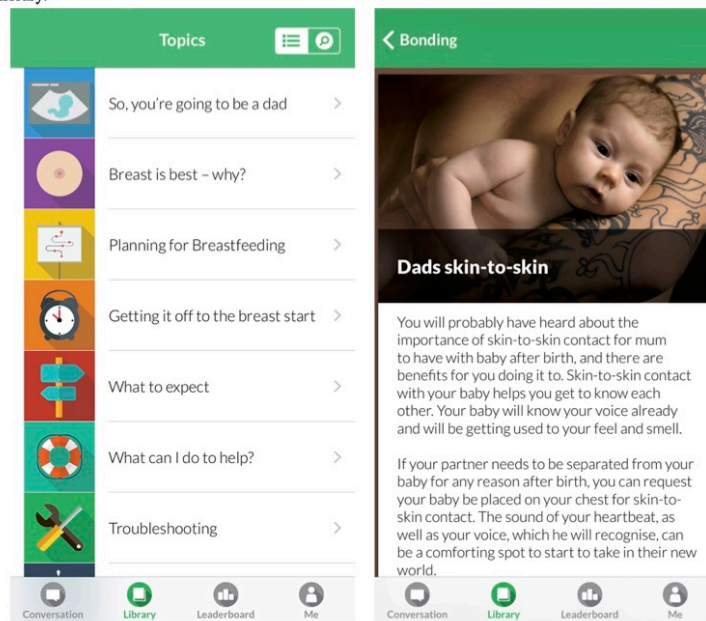


Figure 4. Gamification features used in Milk Man.



Formative Research to Inform Development of the App

Focus Groups With Target Group

Following internal review with the research team, we tested the initial app concept with members of the target group in a series of 3 focus groups. We recruited a purposive sample of men (n=18) through existing networks, including through the university staff and student body and a local playgroup. Participants were required either to be expecting a baby or to have a baby under the age of 6 months. The focus groups aimed to investigate the acceptability of the engagement strategies, provide guidance in the framing of the app, and ensure the proposed approach and content were appropriate. Participants were asked to complete a brief demographic survey before starting the session. The lead author recorded, transcribed, and reviewed the focus groups to maintain dependability [75].

Consulting Health Professionals

We held 2 separate consultative sessions with health professionals from 2 of the maternity hospital sites (1 public and 1 private) participating in the PIFI study. Before the session, we developed an outline of the library content to be included within the app, and this outline formed the basis for the discussion with stakeholders. We invited health professionals to comment on the proposed design, engagement strategies, and content of the app.

Testing and Iteration of the App Prototype Phase

App testing was divided into 2 phases: beta testing and user testing. The beta testing involved providing early versions of the app to experienced app testers, who examined it for errors, crashes, layout issues, software bugs, or other problems. Beta testing was not carried out by members of the target group, as we were not seeking design and functionality feedback at this stage. Rather, it was tested by 4 experienced software testers, as well as members of the research team. We incorporated feedback into successive iterations of the app.

The second phase of testing, user testing, involved obtaining feedback on the app's functionality, design, and usability. It was important that this phase of testing was carried out by members of the target group, as the objective was to gain an indication of the way in which the app was likely to be used and received by those for whom it was intended. Therefore, we invited participants to the testing phase if they were either expecting a baby or had a baby under the age of 6 months, and had previously expressed interest in the focus groups, but had not attended an earlier group. Once they had consented, we first asked participants to undertake a think-aloud walkthrough of the app, and then to complete the MARS [66,76]. We recruited 4 users to this testing phase. A previous study into think-aloud testing recommended that 4 to 5 test users is generally sufficient to identify up to 75% of usability issues, with the value of additional participants decreasing exponentially as the number increases [77].

Think-Aloud Walkthrough

Think-aloud walkthroughs are an industry standard approach in software development and a well-recognized way of testing

mobile health apps [35,78-81]. In this study, after observing a researcher-led example using a different health app, participants were asked to spend a minimum of 10 minutes using Milk Man and to verbalize their thought processes as they navigated through the app. As the researcher wanted to observe the natural flow of app usage and observe organic navigation, the initial instruction was simply for users to "use and open the app as you would exploring any app for the first time."

As the participants explored the app independently, the researcher monitored a checklist of 10 tasks and marked each off as it was completed. At the completion of the walkthrough, we specifically asked users to complete any tasks on the checklist that they had not completed unprompted. In keeping with best practice in conducting think-aloud studies, the researcher remained quiet throughout the study, speaking only to remind the participant to keep talking aloud and to issue tasks at the end. We recorded and transcribed the think-aloud sessions.

Mobile Application Rating Scale

Released in December 2014, the MARS is a comprehensive questionnaire used for rating mobile health apps with reference to 5 key criteria. The first 4 *objective* quality subscales give a measure of *aesthetics*, *engagement*, *functionality*, and *information*, while the fifth criterion is a *subjective* quality subscale and seeks users' views on whether they would recommend the app, asks how often they would use it, and asks for an overall rating [66,76]. The MARS is scored by calculating the average of the 4 objective subscales. The MARS comprises 2 different versions, one for professionals, and a simplified version for app users. The app user version comprises 20 questions over the 5 criteria, with a final section asking 6 questions designed to describe the potential for impact on a user's knowledge, attitudes, and intention to change [76]. After completing the think-aloud study, users were asked to independently complete the app user version of this scale.

Results

Focus Groups With Target Group

A total of 18 men attended the 3 focus groups. Participants were aged between 30 and 43 years. Most were married (n=14), just under half were expecting a baby (n=8), and just over half had a new baby aged under 6 months (n=10).

All men owned either an iPhone or Android smartphone, and all said that they kept their phone close at hand and referred to it throughout the day. All participants had some third-party apps on their smartphone. Most participants were positive about the idea of apps for new fathers. Most of the comments about the use of push notifications were positive, although some mentioned that they should be used judiciously and the content should be relevant.

I think the lesson really is notification fatigue. You know some people like them, some people don't. I suppose if you got far too many you just become disinterested and that can actually be more dangerous than not getting a notification. [Focus group 1]

There was a mixed response to the idea of a discussion forum for men to connect to each other. Some participants were very enthusiastic about the idea, while others stated they would not use it. Some of the reasons participants gave for ambivalence about a forum were not trusting the information, preferring to talk to people in real life, and that information on forums can be alarmist and cause unnecessary concern.

I don't know, I wouldn't talk to a stranger for starters on an app and then I mean you go, we go to barbecues and friends' house and their kids are ratbags or this and that and you can't tell your mate how to look after their kid, it's their kid. You don't know what they've been through the night before, you don't know what they've eaten the night before, so I wouldn't ask someone for advice on my child in that sense. [Focus group 3]

We stopped trusting anything that wasn't from a doctor 'cause we got 50 opinions and my wife ended up freaking out. [Focus group 1]

Some participants suggested that humor and a lighthearted tone would be appropriate, and that the app should be quick and easy to use.

For me lighthearted would be better. Even the best baby I think that first period is probably strap in and get through it kind of time. So if I have to read a textbook of really...dry text I'm probably not going to do it. But if it's something quick and easy that...tells me that what I'm seeing in front of me is correct [I'm more likely to use it]. [Focus group 1]

Push notifications can add that element to the humor. [Focus group 2]

Reinforcing findings from the literature, men were also clear on wanting practical tips for helping their partner, with information ideally delivered in short, summarized formats, including bullets points and checklists. Access to more detailed information could be provided via links.

I want bullet points and if I want to read into it more I'll look into it more if I've got the time. [Focus group 2]

Checklists, perhaps a list of [reasons why] my baby won't stop crying and then people could maybe leave suggestions. Doing an upvoting, downvoting vetted type system. Say "try this top answer, this worked really well" [or] "that didn't work, give me another thing on the list to try." [Focus group 1]

Participants' experiences with mobile apps were varied, as were responses to the proposed engagement strategies. Some participants had experience sourcing and using apps for parenting and pregnancy, while others identified specific barriers to their use, including issues with trusting information and preferring face-to-face interaction. In general, fathers supported targeting fathers with such an approach, and the focus groups provided good insights into how to structure the app's engagement strategies.

Consulting Health Professionals

To provide input about the content and engagement strategies proposed for the app, 16 health professionals attended 1 of 2 sessions. All participants were hospital-based midwives working with new and expectant parents. Some had additional, specialist roles: they were lactation consultants or parent educators, or they were in charge of discharge and follow-up of patients. Some specialized in working with aboriginal families, with young families, or with families requiring complex care relating to issues with alcohol and other drugs, or mental health problems.

The health professionals were generally enthusiastic about the app, and in particular about having men as the focus of the intervention.

Knowing the success of the woman's breastfeeding experience is single-handedly influenced more by the support that [partners] give at home, than any other factor...makes [partners] feel like, "hey, I can do something to help."

They want to help, but they don't know how they can help.

The health professionals offered views that reinforced those from the focus groups, about keeping the tone of the app lighthearted, and ensuring the information provided was short and to the point.

Lighthearted and informative, because otherwise you'll lose them, and they won't come back if they're finding it too heavy and judgmental.

Are you using dot form? Because I just find, they won't read a whole big [article]. You just need dot points [and] keywords.

Pictures and dot points will work well.

Health professionals also offered specific content recommendations, including websites and online videos they typically used with new parents. They further advised the need to include information about postnatal depression for fathers and to focus on the message that every breastfeeding is a success.

Testing and Iteration of App Prototype Phase

A total of 4 new or expectant fathers participated in the user testing phase. Of these 4 recruited participants, 3 had a baby aged under 6 months, while 1 was expecting a child. The age range was 34–44 years.

Think-Aloud Walkthrough

User testing via the think-aloud walkthrough identified 6 issues related to usability and functionality. Usability issues included text in the comments section being too small, a lack of clarity about how the points system worked, and the need for an important icon to be more prominent. In terms of functionality, 3 additional features were suggested: the ability for users to post their own questions, the inclusion of a tutorial or walkthrough to explain the different sections of the app, and the ability to later change the avatar they had selected on creating a user profile.

Most participants completed the 10 tasks on the walkthrough checklist while independently using the app, without needing to be prompted. In each case, they completed all of the remaining items when prompted.

Mobile Application Rating Scale

We averaged the MARS scores from each user list them in Table 2. All 4 participants said they would recommend the app, and they all gave the app a 4- or 5-star rating.

Table 2. Average (out of 5) Mobile Application Rating Scale (MARS) scores for each category applied to the Milk Man breastfeeding app.

MARS criterion	Average score
Aesthetics	4.3
Engagement	3.8
Functionality	4.6
Information	4.5
Total average score	4.3

Discussion

Developing and Refining Milk Man

Formative research was a critical component of the development process used for the Milk Man app. Guided by the existing literature, and theoretically underpinned by the SCT, the app content and functionality were refined and focused through feedback and input from clinical health professionals, members of the target group, and a multidisciplinary team of professionals. These professionals included breastfeeding researchers, health promotion professionals, nutritionists, and a midwife, as well as an app designer and developer. Qualitative data from the formative evaluative phase provided insight into the use of mobile technology by members of the target group and into what engagement strategies might be most effective. While this was not intended to be an exhaustive qualitative study to thematic saturation, there were many overlapping themes and participants provided rich insight to help guide the app development.

The testing phase identified 6 issues, 5 of which we addressed before starting the PIFI trial. The one identified issue that we did not act on was the suggestion that users could post their own conversation topics. We deemed this to be outside the scope of this research and a potential risk, in that topics could be poorly informed and contain inaccurate or misleading information. We added a brief tutorial (usually known as an onboarding exercise), to be displayed to users on first launching the app. This addressed several of the identified issues, including a description of the points system, an explanation of how the app worked, and an explanation of how users would be assigned to a group.

MARS scores were high, indicating good user acceptability, usability, and functionality. While still high, the engagement score was slightly lower. This appeared to relate to participants' stated need for further instructions, explanations, and the ability to change avatars to better customize their user account, all issues that we addressed in the next iteration of the app.

Next Steps for Milk Man

We have developed a comprehensive evaluation plan to measure the acceptability and effectiveness of the Milk Man app in the PIFI RCT. We will collect data through a mixed methods

approach, including a customized analytics framework built into the app and a self-report questionnaire, which users will complete when their baby is 6 weeks old, and again at 26 weeks.

Evaluating adaptive technological interventions such as this requires a comprehensive approach, and we based the evaluation framework for this research on the one proposed by O'Grady et al [82]. This framework includes indicators for app users, content analysis, technology, computer-mediated interaction (user interaction with the interface), and broader health system integration.

While the use of mobile technology in public health interventions has grown significantly, there are still too few high-quality, adequately powered RCTs evaluating the use of such apps [83,84]. This large RCT will add to the evidence about the efficacy of mobile technology in delivering health interventions. The robust evaluation design will have broader relevance to public health interventions looking to use mobile technology to reach target groups.

Limitations

This study sought to include the views of members of the target group in the app design and development through focus groups. Participants in the focus groups were aged between 30 and 43 years, meaning that younger fathers were not represented in this sample. This was due to the purposive sampling method used. However, this research builds on the aforementioned FIFI study, in which both younger and older fathers were consulted.

Although we recruited only 4 participants for the testing phase, this number has been previously shown to be effective in identifying most usability issues [77], and indeed participants' reported issues overlapped significantly. While the MARS has been found to provide a reliable indicator of app quality when used by trained raters, the reliability of the app user version is being evaluated [66]. As such and because of the small number of users rating the app, these results should be interpreted with caution.

Technology changes quickly. There is a balance to be struck between developing health intervention apps in a thorough, methodical fashion and moving quickly to minimize the risks associated with a changing technological environment. To minimize these risks, we proceeded to the RCT without a pilot study. A larger pilot study of the app, before starting the PIFI

study, would have been of value in providing further insight into the way in which men would use the app in a real setting. This may be particularly true of the more interactive components of the app, such as the conversation and the leaderboard; observing men engaging with these features may have further assisted refinement. However, we will be able to monitor this throughout and make those recommendations at the trial's conclusion.

Conclusion

Milk Man is a theoretically grounded app that provides information and support for the antenatal and postnatal periods and aims to socially connect fathers around a central theme of breastfeeding. We anticipate that providing a platform for men to discuss, share, and support each other through the breastfeeding journey will positively affect the support they offer their partners.

To our knowledge, Milk Man is the first breastfeeding app developed specifically for men. It uses innovative strategies to encourage user engagement. The development of Milk Man has involved stages of formative research, testing, and iteration. The process of design, development, and testing described here follows a best practice approach to app development, including being developed by a multidisciplinary team, being based on behavior change theory, and having a design process centered on the user.

The comprehensive evaluation plan includes indicators for the app's engagement strategies, as well as psychosocial and health outcomes up to 6 months after the birth of a child. This will provide valuable insights into what works for reaching the target group, and will ensure that the findings are transferable and that the data will be broadly relevant to future mobile health interventions. We expect results from the PIFI study in 2017.

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Conflicts of Interest

None declared.

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Abbreviations

FIFI: Fathers Infant Feeding Initiative
MARS: Mobile Application Rating Scale
PIFI: Parent Infant Feeding Initiative
RCT: randomized controlled trial
SCT: social cognitive theory

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Appendix D Formative evaluation documents

D.1 Focus group poster



New and expectant Fathers needed for research

Do you own a smartphone and have a new baby aged under six months or are expecting a baby?

Would you like to participate in a focus group helping out with important research for new dads and receive a \$25 voucher?

If so, we'd love to hear from you!

This study is aiming to develop a smartphone application about breastfeeding that is targeted at fathers. This application will be used as part of a wider research project looking at fathers and breastfeeding duration and exclusivity. The focus group will run for approximately 60 minutes and all participants will receive a \$25 voucher as a thank you for your time.

The focus group will be held at:
Curtin University Bentley Campus
School of Public Health - 400:303
Thursday 19th February, 12pm - 1pm

If you are interested in being involved but can't make this group, please let us know as we may have some alternative times.

For any further information on this research, or to register your interest please contact Becky White at becky.white@curtin.edu.au, or by mobile 0450 169 891.

This research has been reviewed and has received ethical clearance by the Curtin University Human Research Ethics Committee (Approval Number 82/2014). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

D.2 Focus group consent form and information sheet



Parent Infant Feeding Initiative

PARTICIPANT INFORMATION SHEET

Introduction

My name is Becky White and I am a PhD researcher at Curtin University. I am working to develop a smartphone application about breastfeeding that is targeted at fathers. This application will be used as part of a wider research project looking at the support of fathers on breastfeeding duration and exclusivity. I am asking people to participate in focus groups to help us ensure that the application is appropriate and targeted and something that fathers are likely to want to use. Your participation in this research will help us to build the best application we can.

What will I have to do?

Fathers who are expecting a baby, or who have a baby aged under six months of age, and own a smartphone are invited to take part. If you agree to participate, I will be asking questions about your use of smartphones, about breastfeeding information and about your opinions on engaging fathers via a smartphone application. The session will be recorded to ensure we don't miss anything. The focus group will run for no longer than 90 minutes.

Will my identity be protected?

All of the information you provide will remain confidential. Data will be stored on computers that are password protected. Your name will not be identified in any publication or any report. All responses will be de-identified.

Are there any risks in participating?

There are no anticipated adverse effects from your participation in this research. Your participation is voluntary and you have the right to withdraw at any time with no further questions asked. You also have the right to participate in the focus group, and to refuse to answer any of the questions asked that you chose to.

Are there any benefits to me?

You will be taking part in research that is designed to help other families. Once you have completed the focus group, you will be given a \$25 voucher as a thank you for your time.

Who can I contact for more information?

If you have any questions you can contact Becky White, PhD Candidate, Phone: 0450 169 891, or via email: becky.white@postgrad.curtin.edu.au, or her supervisor, Professor Jane Scott, Phone 9266 9050 or via email jane.scott@curtin.edu.au.

Should you wish to make a complaint about the manner in which the research is conducted, you can contact the Secretary, Human Research Ethics Committee, Curtin University by phone: 9266 2784 or hrec@curtin.edu.au or in writing C/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth WA 6845);

This research has been approved by the Curtin University Human Research Ethics Committee (approval Number: 82/2014).

Parent Infant Feeding Initiative

FOCUS GROUP CONSENT FORM

I _____ (print your full name) been given, and have read the information sheet provided. I have had the purpose and details of the study explained to me. I understand I can ask any questions at any time, and that I have the right to withdraw at any time without prejudice, or to decline to answer any particular questions.

I understand that data gathered from this research may be published, but that my name, and any other identifying features will be removed.

I agree to participate in the study as outlined to me.

Participant's Signature

Date

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number 82/2014). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Parent Infant Feeding Initiative

Demographic questionnaire

First name: _____

Suburb: _____

Age: _____

Marital status (please circle):

Never married

Married

Defacto

Divorced or seperated

Widowed

Age of children or expected due date:

Baby Due on: _____

Child 1 Date of Birth: _____

Child 2 Date of Birth: _____

Child 3 Date of Birth: _____

Child 4 Date of Birth: _____

Any Breastfeeding (please circle)?

Y/N

Y/N

Y/N

Y/N

D.3 Semi-structured Interview guide

Section one: Mobile app usage and behaviour

Aim: To establish smartphone ownership and usage patterns and to identify popular apps and engagement techniques.

- Do you own a smartphone or tablet?
 - What type?
 - Do you carry it with you all the time?
- Do you have apps on your phone?
- How many apps do you think you have on your phone?
- How many do you look at weekly?
- What are the top three apps you use most?
 - What is it about these apps that you find engaging?
 - <Prompt – are there game elements? Do you talk to your friends / to strangers through the app? Do they use notifications? >
- Have you ever sought parenting advice online or through an app?
 - If yes, which sites / apps?
- Have you downloaded any parenting apps?
 - If yes, which ones? Why do you like them?
 - If no, did you look for any?
- Do you have any health-related apps on your device?
 - If yes, which ones?
- Do you use any health apps that use game elements? These could be apps where you are competing with others (Provide list - Runkeeper, Myfitness pal, Zombie run etc).
- What aspects of these apps do you enjoy / motivates you?
 - <Prompt: do you like competing with friends? Do you feel the need to complete a task? Do you enjoy challenges?>
- How much do you trust information you source online or through apps?
 - What kinds of things are you likely to look for in deciding if the information is trustworthy (source, references etc)
 - Are you more likely to trust something from another parent, from a university, a government body?

- We are looking at the use of push notifications. Do you allow push notifications on apps? What turns you off push notifications? What time of day works best?
-

Section Two: Breastfeeding attitudes and support pathways.

Conversation – peer based social support

Aim: To inform the framing of the intervention and investigate the acceptability of the engagement strategies. To ensure content is appropriate and credible and that the approach is appropriate.

SCT constructs: Observational learning, outcome expectations, self-efficacy.

- One of the main features of the app is the function whereby dads can talk to other dads. Did you have / will you have any kind of education around your baby's birth which was peer-support, from other dads?
- Do you think you would find it useful to hear from other dads about how they've found birth and early parenthood?
- Do you think you would value the opportunity to share your experiences, and support other men?
- We are looking at facilitating this through app-based discussions sent out via push notifications, whereby men can talk to and encourage each other. How do you think this would work best? What would be the best approach to engage men? What kinds of things would you like to talk about?
- Do you use any other platforms to talk to other men about parenting?
- Think about the things that you might read or marketing that you find engaging – what style is more likely to appeal to you, that you will find engaging? <Prompt - Be it funny, lighthearted, very male driven, factual.>

Infant feeding attitudes

Aim: To ensure that the approach is appropriate and to help determine framing for the intervention.

SCT constructs: Intentions, goal setting, outcome expectations.

- For those of you who are yet to have your babies, have you discussed feeding with your partner?
 - If yes, what have you discussed?
 - If no, why not? (not your decision, haven't got there yet?)
- For those who have had babies, or who have older children did you discuss feeding with your partner prior to birth?
 - If yes, did you do anything to prepare for breastfeeding?
 - Was anything especially helpful?
- Do you think having access to information targeted at you about breastfeeding from before the birth would have made this easier for you?
 - To talk to your partner?
 - To prepare?
 - If yes, what kinds of things would you like to have known, or to have talked about?

Situational / environmental factors

Aim: To inform the framing of the intervention and to ensure content is appropriate and credible.

SCT constructs: Observational learning, outcome expectations, self-efficacy, self-regulation.

- We know some men can find the idea of their partner breastfeeding in public a bit challenging. If you feel this way, or if you did feel this way, is there anything that might help you feel more comfortable or that did make you feel more comfortable?
 - <Prompt: legislation, understanding baby needs, baby friendly cafes, talking to partners, talking to other men>

D.4 Health professional consent form and information sheet



Parent Infant Feeding Initiative

STAKEHOLDER GROUP CONSENT FORM

I _____ (print your full name) been given, and have read the information sheet provided. I have had the purpose and details of the study explained to me. I understand I can ask any questions at any time, and that I have the right to withdraw at any time without prejudice, or to decline to answer any particular questions.

I understand that data gathered from this research may be published, but that my name, and any other identifying features will be removed. My organisation may be listed a stakeholder in reports generated by the research, but all comments will be de-identified and not attributed to any particular organisation.

I agree to participate in the study as outlined to me.

Participant's Signature

Date

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number 82/2014). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Parent Infant Feeding Initiative

STAKEHOLDER INFORMATION SHEET

Introduction

My name is Becky White and I am a PhD researcher at Curtin University. I am working to develop a smartphone application about breastfeeding that is targeted at fathers. This application will be used as part of a wider research project looking at the support of fathers on breastfeeding duration and exclusivity. I am asking stakeholders to participate in a discussion group to help ensure that the application content is appropriate and targeted and to help guide the engagement with fathers. Your participation in this research will help us to build the best application we can.

What will I have to do?

Stakeholders working with fathers, or with new parents are invited to take part. If you agree to participate, I will be going through the outline of the content for the application and asking questions about current issues and services and about your opinions on engaging fathers via a smartphone application. The session will be recorded to ensure we don't miss anything. The group will run for no longer than 90 minutes.

Will my identity be protected?

All of the information you provide will remain confidential. Data will be stored on computers that are password protected. Your name will not be identified in any publication or any report. All responses will be de-identified. The name of your organisation may be listed as a stakeholder on any reports generated by the research but all comments will be de-identified and not linked to any particular organisation.

Are there any risks in participating?

There are no anticipated adverse effects from your participation in this research. Your participation is voluntary and you have the right to withdraw at any time with no further questions asked. You also have the right to participate in the focus group, and to refuse to answer any of the questions asked that you chose to.

Are there any benefits to me?

You will be taking part in research that is designed to help Western Australian families.

Who can I contact for more information?

If you have any questions you can contact Becky White, PhD Candidate, Phone: 0450 169 891, or via email: becky.white@postgrad.curtin.edu.au, or her supervisor, Professor Jane Scott, Phone 9266 9050 or via email jane.scott@curtin.edu.au.

Should you wish to make a complaint about the manner in which the research is conducted, you can contact the Secretary, Human Research Ethics Committee, Curtin University by phone: 9266 2784 or hrec@curtin.edu.au or in writing C/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth WA 6845;

This research has been approved by the Curtin University Human Research Ethics Committee (approval Number: 82/2014).

Appendix E App development documents

E.1 App design brief

PIFI breastfeeding app targeted at men: App design brief

Background

This application is to be developed as part of a university research project. The research involves a randomised control trial with four arms. One group will be receiving the usual hospital care, one group a special antenatal class, one group the smartphone app, and one group both the app and the antenatal session. The research aims to increase breastfeeding duration and exclusivity but it is targeted at the male partner. There is evidence that the support of men is an integral part of breastfeeding success and if men are supportive about breastfeeding, women are more likely to breastfeed for longer.

Application brief

This is a breastfeeding application, targeted at dads. It will look to socially connect men to each other via conversations facilitated by the researchers. We want men to use the app to talk to each other around the topics we initiate. Engagement for the conversation will be provided via push notifications and gamification functions embedded within the app. It will contain a library of information. The design needed includes:

- Overall 'look and feel' for the app
- Development of avatars and badges
- A unique icon

The design needs to be contemporary, fun and attractive to men. It needs to be fresh, and professional. It needs to be non-discriminatory, and contain no questionable material which may potentially offend.

The app is being developed for both the iOS and Android platforms. We will also need to strike a balance between consistency between the two versions, and intuitiveness for the users of those two platforms. It is important, from a scientific point of view, to reduce differences between the versions which could lead to confounding variables (things that may produce different results between the two groups, that we haven't controlled for). However, we understand that some basic design and interface paradigms differ between the two platforms, and that trying to make the two versions identical would create its own confounders – one of the groups would end up using an app that did not work the way they were used to apps working. In summary, we want to make the two versions as similar as possible, whilst honouring the interface design cues of the two platforms.

Prime objective

The prime objective is to design an app that is attractive and engaging, and one that men want to use. Design is key. While the application is for research purposes, we want a real-world feel and to test in as close to life situation as possible. Accordingly, design needs to be professional, polished and consistent.

Target group

The target group are men who are expecting a baby, and men with a baby under the age of six months. The age range will likely be in the 18-44 yr. group.

Image and tone

It is important that the app have a visual look that is in line with modern app design trends, whilst also being unique and distinctive. It should strike a balance between modern "flat" design (i.e. minimal texturing, ornamentation and lighting effects), and usability (i.e. not being so flat and minimalistic as to be difficult to use). All features should be very discoverable and intuitive to regular users of mobile apps.

We would like the app to be strongly branded, with a distinctive name, logo, icon, colour palette and typography. The colour palette should be modern, and the typefaces used should be suitable both for on-screen display and any print materials we might like to produce in a matching style.

We would like the app to be fun, a little quirky, and in the slightly ironic, tongue-in-cheek style that is currently popular in men's advertising. The Who's Your Daddy app (see below) is a great example of this.

Other products

The following products are similar type projects designed for the same or a similar target group that should be reviewed and considered when developing the design for this app.

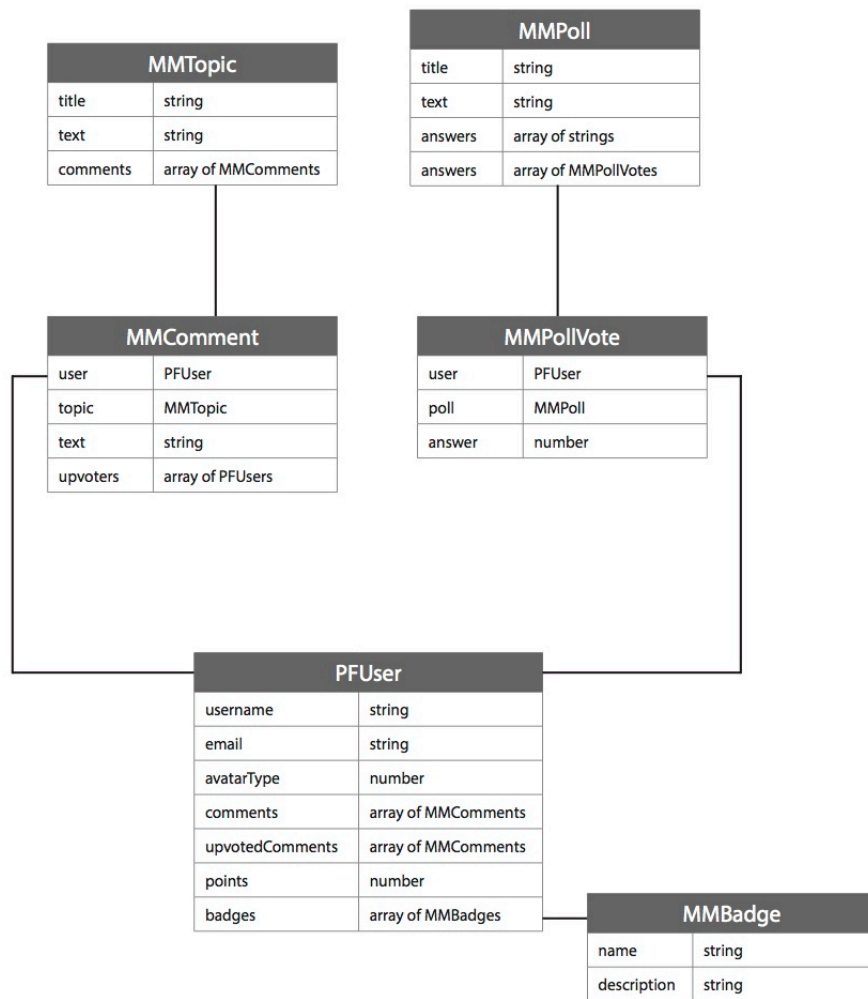
- Who's your Daddy (app) – Australia. This application is targeted at Australian men who are expecting a baby. It has consistently been a high grossing app and has received much success and media in its first year since launch. It embodies the essence of what we are looking for. It is light hearted, funny, uses high quality, iconic, quirky, flat images that are male relevant.
- Quick tips for new dads (app) – UK
- Man therapy campaign (Beyond Blue) Australia - www.mantherapy.org.au
- 24 hr cribside assistance (videos / website) Canada -www.newdadmanual.ca
- Project breastfeed (photos / website) – US - www.projectbreastfeeding.com
- How to be a dad (website) UK - www.howtobeadad.com
- New dads survival guide (website) UK - www.newdadssurvivalguide.com

Key words

Fresh, professional, flat, quirky, contemporary, male-focussed, light hearted, fun.

E.2 App specification document

Provisional data model



Data model

- MMUser
 - username
 - password
 - real name
 - email address
 - score
 - badges
- MMTopic
 - type (question or poll)
 - comment (array, MMComment)
- MMComment
 - text
 - upvotes
 - MMUser

User:

- Create account
 - Username
 - Password
 - real name
- Forgotten password
- Be notified of new topics
 - question
 - poll
- Contribute to topic
 - comment (questions)
 - answer (polls)
- Respond to other user comments
 - reply? (cf. just another comment)
 - upvote
 - report as inappropriate
 - view stats of other contributors?
- View own stats
 - scores
 - badges
- View leaderboard
 - scores
 - badges?
- View library items
- Submit a topic idea

Server/client:

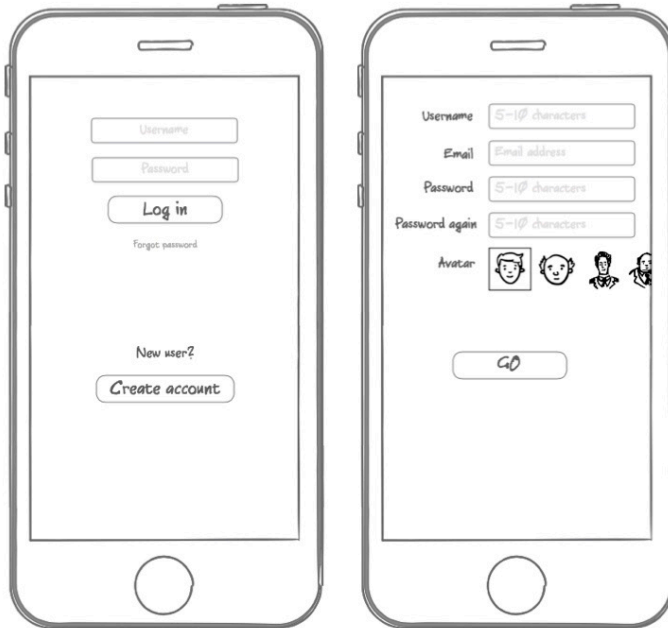
- Assign scores
 - per comment/answer
 - per upvote
- Award badges

- Maintain leaderboard
- Per user analytics
 - usage time
 - articles read
 - opens from notifications
 - length of time between topic being posted and commenting

Administrator:

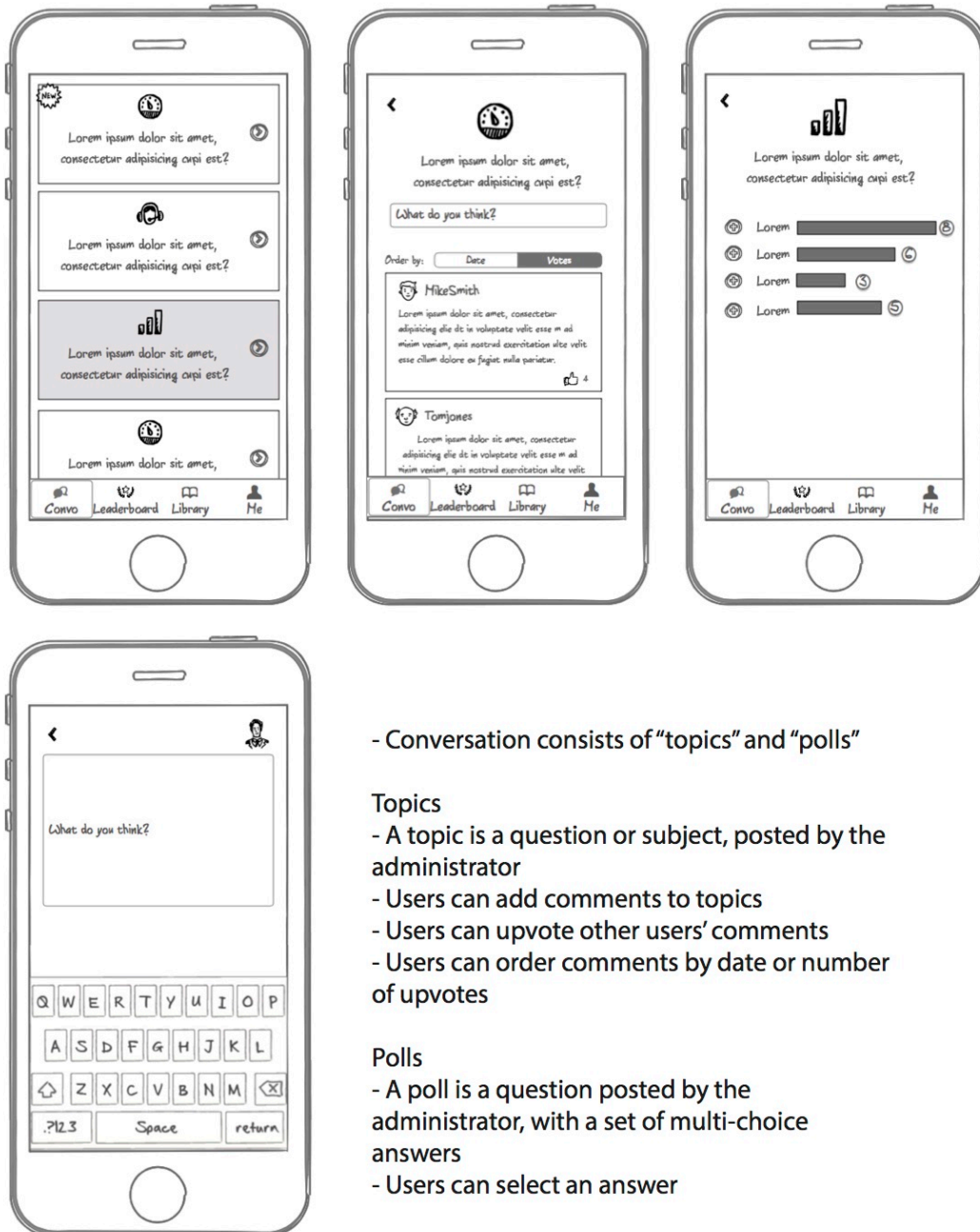
- Post topics
- View leaderboards
- View user stats and badges
- Remove inappropriate
- Contribute

1. Login / sign up



- Parse user management
- Sign up with: username, email address, password
- Select from a set of avatar images
- Password reset via Parse system

2. Conversation



- Conversation consists of "topics" and "polls"

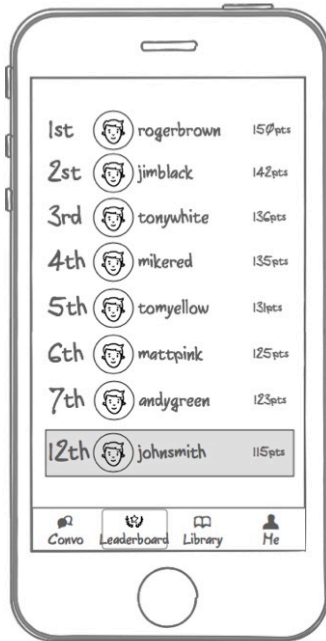
Topics

- A topic is a question or subject, posted by the administrator
- Users can add comments to topics
- Users can upvote other users' comments
- Users can order comments by date or number of upvotes

Polls

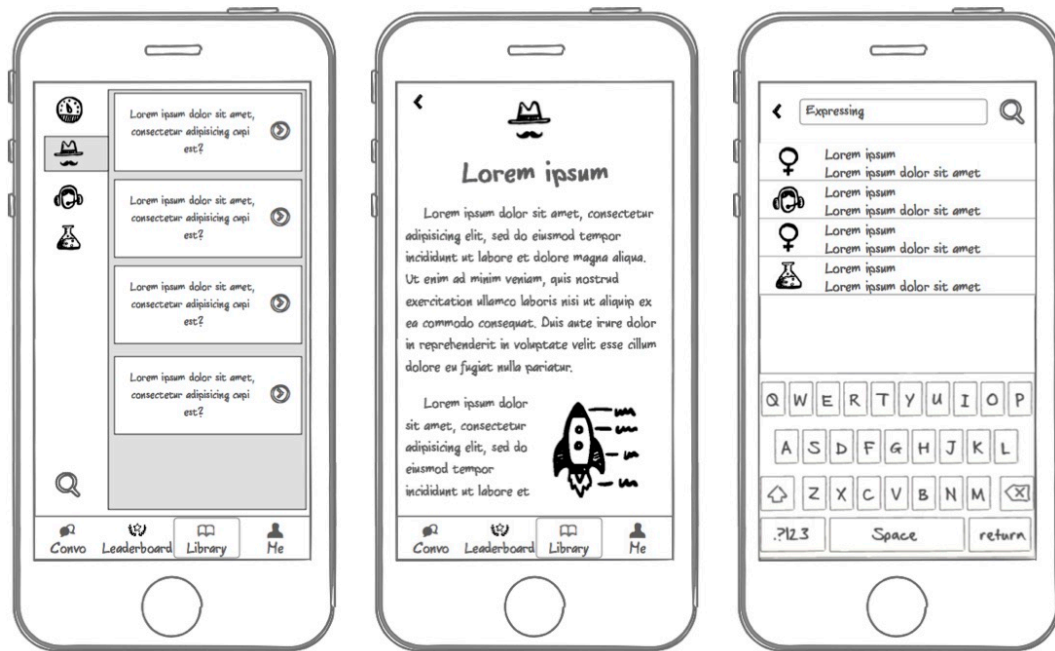
- A poll is a question posted by the administrator, with a set of multi-choice answers
- Users can select an answer

3. Leaderboard



- Users are assigned points for participation. Points are assigned for adding comments, voting on a poll, or receiving upvotes from other users
- Users can view a leaderboard showing the top ranked users, and their own position

4. Library



- An offline set of articles. No network operations - articles are immutable.
- Articles are arranged in categories
- User can search by keywords

5. Me



- Users can view their account information and achievements
- main view shows avatar, username and email, points and badges achieved, and the user's current point ranking
- Badges are awarded to users for a range of achievements (such as commenting a certain number of times or receiving certain numbers of upvotes)
- users can choose a badge and view details about it
- users can update their account information (email, password, or avatar)

E.3 Milk Man management protocols

Milk Man application – Management Protocols

The following protocols describe the management procedures for the duration of the implementation of the smartphone application intervention arm of the Parent Infant Feeding Initiative. The responsibility for the monitoring and adherence of these protocols belongs to **Becky White**, (referred to within as *the researcher*) with support, as needed from her supervisory team. This document describes the following:

- 1.0 Downloading the app
- 2.0 Moderation protocol
- 3.0 Managing user exit
- 4.0 High risk behaviour
- 5.0 Ad hoc topic protocol
- 6.0 Peer responder protocol

1.0 Downloading the app

1.1 Statement of intent

The application will need to be downloaded from the App Store or Google Play, onto the participant's device. The onus for this will be on the participant, but every aim will be made to ensure that this is as easy, and seamless as possible for the user.

1.2 Downloading procedure

1. Upon recruitment into the M2 or HI study arm, the participant will be given an information sheet with instructions on how to download the Milk Man app. This document will also explain the following procedure.
2. The information sheet will contain the participant's study identification number. This number will be their code to allow them to log in, and access the application. The application will allow any number to be used as a code, provided it is within the range (ie PIF10001 – PIF19999). This will enable the code to be used immediately upon receiving it. Participants will be manually allocated into a group once the researcher has access to the due date information.
3. If men are not at the initial recruitment session and their partners take home the consent form for them to complete, the participant will be emailed the information sheet once their questionnaire data has been entered into the database and the researcher is notified.
4. If users have not downloaded the application within a week, the first of two reminder emails will be sent out automatically. The email will contain their unique code, remind them to download the application, and provide a contact in case of any problems downloading it. A second, and final reminder will be sent via email after two weeks.
5. The researcher will call once after the reminder emails have been sent out to see if people have experienced any trouble, if they have lost their code, and to encourage them to download the app.

Last updated 7/1/16 by Becky White

2.0 Moderation protocol

2.1 Statement of intent

The application conversation forum is provided for men to connect, support and engage with each other. We will ask that everyone is respectful. Any comments attacking another user or using inflammatory or inappropriate language will be removed. We recognise that moderation can be a barrier to conversation flow and credibility and to that end we aim to make the application a safe and respectful space, but do not seek to stifle, or limit conversation.

2.2 Moderation procedure

1. The aim of the smartphone application is to socially connect men for conversations about breastfeeding and parenting.
2. Maintaining the integrity of the application as a safe space for men to share and engage is paramount.
3. The researcher acknowledges that over-enthusiastic moderation can be a deterrent to users, and will look to employ a relatively hands-off approach to moderation, only intervening when absolutely necessary.
4. The application employs a post-moderation approach, in that the comments will be published immediately on submission and will be reviewed after it has been made public to other users.
5. The researcher will review new comments added daily.
6. The application aims to stimulate discussion around breastfeeding, and we acknowledge that not all of this discussion will be positive.
7. The aim is facilitate genuine and worthwhile discussion, not to stifle and provide a one-sided view.
8. In consideration of this, comments will only be deleted when they:
 - a. Personally attack another user or other person or organisation
 - b. Are promotional or irrelevant in nature (ie marketing posts)
 - c. Are overtly anti-breastfeeding (see 10. below)
 - d. Make misleading claims (see 9. Below)
 - e. Contain high-risk content (see section 3.0).
9. Misleading claims can be easy to misunderstand and may need information provision, rather than moderation. The main strategy will be the peer-dad in the application replying to the claims with the correct information. If the misleading claims are dangerous, or repeatedly made, then they may be deleted.
10. In consideration of comments identified as overtly anti-breastfeeding, when a comment is identified as such, it will be raised with another member of the moderation panel and the deletion collaborated on before it is removed.
11. In the case of a deleted comment, the user will be emailed to explain why the post was inappropriate and not within the guidelines.

Last updated 7/1/16 by Becky White

12. The user will be given two chances. On the third posting of an inappropriate comment, the users commenting privileges will be revoked, although they will retain access to the rest of the application while they remain on the study.

13. A record will be kept of all deleted posts.

3.0 Managing user exit

3.1 Statement of intent

The application is to be used for the M2 and HI intervention groups only. The user will have access to the app for six months post the birth of their baby.

3.2 User exit procedure

1. At around six months post birth of their baby, or if men choose to withdraw from the study, men will be contacted to indicate their time using the application has finished.
2. Men will be contacted by email telling them that their time participating in the app study is complete and that their access to the app will now be restricted, and their commenting ability removed, although they are free to keep using the app.

4.0 High-risk behaviour

4.1 Statement of intent

The application is provided for men to connect, support and engage with each other, around the central theme of breastfeeding. It is not anticipated that the content will lead to, or lend itself to the disclosure of any high-risk behaviour. Nevertheless, should high-risk behaviour be identified, the researcher will have a duty to respond appropriately.

4.2 High-risk post procedure

1. The aim of the application is to provide a safe space for men to share and engage with each other.
2. It is understood that conversations will vary, and that researcher moderation and intervention will remain minimal.
3. Where high-risk behaviour is identified, the researcher will take appropriate action.
4. High-risk behaviour may include:
 - Threats of harm to the baby, self or partner
 - Suicidal disclosure
 - Disclosure of sexual abuse
 - Any other identified behaviour
5. When such behaviour is identified, the following action will be taken:
 - The post will be removed
 - The researcher will consult with another member of the research team to determine appropriate action in consultation
 - The user will be contacted and / or other professionals engaged.
6. Reports will be kept of all high-risk posts and actions taken.

Last updated 7/1/16 by Becky White

5.0 Ad hoc topic protocol

5.1 Statement of intent

The conversation topics are sent out to facilitate conversation among users. While most topics will be developed ahead of time, current events may be used to inform topics and provide relevant, up-to date discussion.

5.2 Ad hoc topic procedure

1. Most topics will be verified and reviewed prior to the application being made available to users, and a post schedule developed.
2. Current events offer relevant, timely opportunities to engage with users. These topics and events will not be known until they arise, and as such, will require different review procedures.
3. Relevant current events may include:
 - New research
 - News articles such as public breastfeeding, health benefits, celebrity claims etc
4. If the post is potentially controversial in any way, a prompt will be drafted by the researcher, and sent to one other member of the research team for review and approval.
5. Records will be kept of all ad-hoc posts, and a media log maintained in relation to these posts.

6.0 Peer responder protocol

A peer-dad commenter will be engaged throughout the study. The role of peer-dad will be minimal, and unobtrusive. It will be clear that the poster is involved with the study, as opposed to being another study participant.

The aim of the peer-dad is to:

- Provide information when misleading claims are raised, or direct for information.

6.2 Peer dad guidelines

1. Peer-dad will be identifiable through his avatar (Milk Man logo) and username (MacDaddy), and it will be clear to participants that he is connected with the study, as opposed to another dad participating in the trial.
2. Peer-dad's involvement will be minimal.
3. A key function of Peer-dad will be to identify any misleading claims and provide accurate advice – this will be done in consultation with the researcher. An example may be a user telling another user that his wife needs to stop breastfeeding while smoking as she is poisoning the baby. Peer-dad can enter the conversation with appropriate information, and links to follow for further reading.

E.4 User testing information sheet and consent form



Parent Infant Feeding Initiative

PARTICIPANT INFORMATION SHEET

Introduction

My name is Becky White and I am a PhD researcher at Curtin University. I am developing a smartphone application about breastfeeding that is targeted at fathers. This application will be used as part of a wider research project looking at the support of fathers on breastfeeding duration and exclusivity. I am asking people to test the application to help us identify any usability and functionality issues, and to ensure we have the best quality, and most usable app that we can.

What will I have to do?

Fathers who are expecting a baby, or who have a baby aged under six months of age, and own a smartphone are invited to take part. If you agree to participate, you will be asked to use the application for a minimum of ten minutes. During this time, you will be asked to 'think-aloud', to talk us through your thought processes as you navigate the app. We may ask you to do specific functions (such as, 'go to the library section'). Once you have completed your testing of the application, we will ask that you please complete a questionnaire scale on the app for us. The think-aloud section of the session will be recorded to ensure we don't miss anything. The whole testing session will run for approximately 40 minutes.

Will my identity be protected?

All of the information you provide will remain confidential. Data will be stored on computers that are password protected. Your name will not be identified in any publication or any report. All responses will be de-identified.

Are there any risks in participating?

There are no anticipated adverse effects from your participation in this research. Your participation is voluntary and you have the right to withdraw at any time with no further questions asked. You also have the right to participate in the focus group, and to refuse to answer any of the questions asked that you chose to.

Are there any benefits to me?

You will be taking part in research that is designed to help other families. Once you have completed the testing, you will be given a \$25 voucher as a thank you for your time.

Who can I contact for more information?

If you have any questions you can contact Becky White, PhD Candidate, Phone: 0450 169 891, or via email: becky.white@postgrad.curtin.edu.au, or her supervisor, Professor Jane Scott, Phone 9266 9050 or via email jane.scott@curtin.edu.au.

Should you wish to make a complaint about the manner in which the research is conducted, you can contact the Secretary, Human Research Ethics Committee, Curtin University by phone: 9266 2784 or hrec@curtin.edu.au or in writing C/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth WA 6845);

This research has been approved by the Curtin University Human Research Ethics Committee (approval Number: 82/2014).

Parent Infant Feeding Initiative

APP TESTING CONSENT FORM

I _____ (print your full name) been given, and have read the information sheet provided. I have had the purpose and details of the study explained to me. I understand I can ask any questions at any time, and that I have the right to withdraw at any time without prejudice, or to decline to answer any particular questions.

I understand that data gathered from this research may be published, but that my name, and any other identifying features will be removed.

I agree to participate in the study as outlined to me.

Participant's Signature

Date

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number 82/2014). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth WA 6845, or by telephoning 9266 2784 or by emailing hrec@curtin.edu.au.

Parent Infant Feeding Initiative

Demographic questionnaire

First name: _____

Suburb: _____

Age: _____

Occupation: _____

Marital status (please circle):

Never married

Married

Defacto

Divorced or seperated

Widowed

Age of children or expected due date:

Baby Due on: _____

Child 1 Date of Birth: _____

Child 2 Date of Birth: _____

Child 3 Date of Birth: _____

Child 4 Date of Birth: _____

Any Breastfeeding (please circle)?

Y/N

Y/N

Y/N

Y/N

E.5 User testing instructions

PIFI App testing phase.

Instructions to the participant

Thank you for agreeing to test our app for us. We are interested in your thoughts on the functionality (how easy it is to use), the aesthetics (the overall 'look and feel' of the app), the information (the content within the app) and how engaging you think it is.

We will ask you to do two things within this testing phase.

1. That you spend some time using the application. We ask that you do this for at least ten (10) minutes. Explore the app, try out the functions and see how you move through it. While you are doing this, we ask that you please 'speak-aloud' your thought processes as you do so. This will help us to identify any functionality and intuitability issues.

<The researcher to provide a verbal example of a think aloud walk through, and ask the participant to practice for one specific task>

Depending on how the user is finding the self-directed walk though, they may be prompted by the researcher to complete some specific tasks. For example:

- Go to the library
- Find articles on expressing
- Find your position on the leaderboard
- Enter a comment for last weeks conversation.

2. Please complete a questionnaire on the application (attached)

Appendix F Milk Man presentations

Date	Conference of seminar name	Lead Presenter/s	Title	Presentation type
29 April 2015	SJG Murdoch Breastfeeding in-service training day	Jane Scott	Dads can make a difference: The Parent Infant Feeding Initiative (PIFI)	P
1 July 2015	Curtin University school of Public Health Research Seminar	Jane Scott and Becky White	Rationale and development of the Milk Man app	P
12 Nov 2015	St John of God and Curtin University Research Retreat. Rendezvous Hotel Scarborough	Becky White and Jane Scott	Breastfeeding – Dads can make a difference: Demonstration of Milk Man the first breastfeeding app for men	P
12 Dec 2015	Breastfeeding Research Network meeting UWA	Becky White and Jane Scott	The Parent Infant Feeding Initiative (PIFI) and Demonstration of Milk Man the first breastfeeding app for men	P
16 March 2016	King Edward Memorial Hospital Breastfeeding Study Day	Yvonne Hauck	The Parent Infant Feeding Initiative (PIFI)	P
20 May 2016	33 rd National Conference of the Dietitians Association of Australia, Melbourne (Seminar)	Jane Scott	Using mobile devices (mHealth) for dietary interventions in pregnancy and early childhood: Milk Man – a breastfeeding app for fathers	C
21 June 2016	Australian Health Promotion Association Conference	Becky White	Making Milk Man: The theory-based development of a breastfeeding mobile application	C
20 July 2016	Fatherhood Research Symposium (Newcastle)	Jane Scott	Milk Man developing a smartphone app for fathers, about breastfeeding	P
27 July 2016	Telethon Kids Institute research seminar	Becky White	The Making Of Milk Man A Socially Connected Gamified Breastfeeding Mobile App For Fathers	P
Sept 2016	Mark Liveris Research Seminar, Curtin University	Becky White	The Making Of Milk Man : A Socially Connected Gamified Breastfeeding Mobile App For Fathers (best paper award)	C
Sept 2016	Curtin 3 Minute Thesis (3MT)	Becky White	Milk Man: A breastfeeding app for fathers (Finalist and winner of heat 1)	P

Sept 2016	Telethon Student Circle	Becky White	The Making Of Milk Man: A Socially Connected Gamified Breastfeeding Mobile App For Fathers	CB
Sept 2016	Curtin University 2 nd year Health Promotion students	Becky White	Mobile health as a method for reaching individuals	CB
Sept 2016	Curtin University 3 rd year Health Promotion students	Becky White	mHealth and health promotion	CB
14 Sept 2016	WA Breastfeeding Stakeholders Group	Jane Scott	Milk Man a breastfeeding app for men	P
4 Nov 2016	Dietitians Association of Australia WA Research Symposium	Jane Scott	Supporting the supporter: Milk Man a breastfeeding app for men	P
30 Nov 2016	Curtin University HDR Digital Health research group	Becky White	Developing evaluation plans for mHealth interventions	CB
4 Feb 2017	Midwifery Moving Forward conference	Becky White	Making Milk Man: The theory-based development of a breastfeeding mobile application	C
17 Feb 2017	Philips-Avent Scientific Symposium <i>More breastmilk for more babies: from physiology to practice</i> (Royal College of Surgeons, London)	Jane Scott and Becky White	Impact of digital technologies on breastfeeding <i>Milk Man was used in this presentation as a case study example of the best practice approach for developing and testing mobile apps.</i>	C
23 Feb 2017	3 rd CBC Digital Health Conference: <i>Harnessing digital technology for behaviour change</i> (University College London)	Becky White	Engaging fathers with a breastfeeding app: Preliminary process evaluation from the Milk Man mobile app intervention	C
8 Mar 2017	Curtin University HDR Digital Health research group	Becky White	Reflections from the 2017 Digital Health behaviour change conference	CB
3-7 April 2017	15 th World Congress on Public Health. Melbourne	Becky White	Process evaluation of the Milk Man app: A breastfeeding app for fathers (Winner Best Oral Presentation Early Career Researcher)	C

3-7 April 2017	15 th World Congress on Public Health. Melbourne	Becky White	Panel Discussion: Using technological approaches to promote health across the life-course	C
12-14 th June	Nutrition and Nurture in Infancy and Childhood: Bio-Cultural Perspectives. Grange over Sands, England	Jane Scott	Milk Man, a breastfeeding smartphone app for fathers.	C
25 th Aug 2017	Curtin University HDR Digital Health research group	Becky White	Engagement and digital health interventions	CB
Sept 2017	Curtin 3 Minute Thesis (3MT) Curtin winner	Becky White	Milk Man: A breastfeeding app for fathers	P
Sept 2017	Asia-Pacific 3MT Semi-finals Finalist	Becky White	Milk Man: A breastfeeding app for fathers	P
Sept 2017	Curtin University 3rd year Health Promotion students	Becky White	mHealth and health promotion	CB

*P=Professional presentation or seminar; C=Conference; CB= Capacity Building seminar