BUMPS AND BABIES LONGITUDINAL STUDY (BABBLES):

an independent evaluation of the Baby Buddy app.

FINAL REPORT

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EXECUTIVE SUMMARY

Introduction: Developments in information and communication technologies have enabled and supported the development and expansion of electronic health in the last decade. This has increased the possibility of self-management and care of health issues.

Objectives: To assess the effectiveness of on maternal self-efficacy and mental wellbeing three months post-birth in a sample of mothers recruited during the antenatal period. In addition, to explore when, why and how mothers use the app and consider any benefits the app may offer them in relation to their parenting, health, relationships or communication with their child, friends, family members or health professionals.

Design: A mixed methods approach, including a longitudinal cohort study, a qualitative study and detailed analysis and synthesis of data from the Baby Buddy app about the way in which mothers accessed and used the app content.

Setting: The study was conducted in five geographically separate sites in England: Coventry, Lewisham, Bradford, Blackpool and Leicester. These areas were chosen as they were geographically, ethnically and socio-economically diverse and where the Baby Buddy app was reported to be well-embedded, both formally and informally, into the maternity and child health pathways by the relevant healthcare staff.

Participants: Pregnant women who were aged 16 years and over, had no previous live child, were between 12-16 weeks and six days gestation and booked with the maternity services in each of the five study sites were invited to take part.

Interventions: Self-reported use of the Baby Buddy app at one of the three data collection time-points: $12\text{-}16^{+6}$ weeks gestation, 35 weeks gestation and three months post-birth.

Outcome measures: The primary outcome measure was parental self-efficacy at three months post-birth using the Tool to measure Parenting Self-Efficacy (TOPSE). The main secondary outcome was maternal mental well-being at three months post-birth using the Warwick and Edinburgh Mental Wellbeing Scale (WEMWBS).

Results: Recruitment took place between September 2016 and February 2017. A total of 488 participants provided valid data at baseline (12-16 weeks gestation), 296 participants also provided valid data at 3 months post-birth, 114 (38.5%) of whom reported that they had used the Baby Buddy app at one or more of the data collection time-points ('app user'). Seventeen first-time mothers participated in the qualitative arm via telephone interviews (n=9) and a focus group (n=8). Twenty healthcare professionals participated in interviews (n=5) and two focus groups (n=15). Consent was gained from 98 participants who gave permission for their in-app

data to be made accessible but just 61 participants could be identified from the database provided, of whom 51 were included in the analyses.

At recruitment there were no differences between Baby Buddy app users and non-app users in respect to: age, IMD, ethnicity, highest education, employment, relationship status. Baby Buddy app users were more likely to use pregnancy or parenting apps (80.7% vs 69.6%, p=.035), more likely to have been introduced to the app by a healthcare professional (p=.005) and have a lower median score for perceived social support (81 vs 83, p=.034) than non-app users. The Baby Buddy app did not illicit a statistically significant change in TOPSE scores from baseline to 3 months post-birth (adjusted OR 1.12, 95%CI 0.59 to 2.13, p=.730). Finding out about the Baby Buddy app from a healthcare professional appeared to grant no additional benefit to app users compared to all other participants in terms of self-efficacy at three months post-birth (adjusted OR 1.16, 95%CI 0.60 to 2.23, p=.666).

Apps were popular; Baby Buddy app users were more likely to use other pregnancy-related apps than non-Baby Buddy users and the most frequent source from which Baby Buddy app users found out about the app was a midwife. A *post-hoc analysis* found that Baby Buddy app users were more likely to breastfeed than non-Baby Buddy app users. This was a consistent pattern for both exclusive breastfeeding and any breast feeding: there was a 9% increase in exclusive breastfeeding at any time up to 3 months post-birth in Baby Buddy app users and a 12% increase in any breastfeeding up to three months post-birth, compared to non-app users. Whilst this is an important finding, this needs to be used with care due to the post-hoc element of the analysis.

First-time mothers who participated in the qualitative arm of the study found that the Baby Buddy app worked well due to its accessibility and that the information was concise and easy to find. They liked that it followed the progress of pregnancy with appropriately-timed information and that different aspects could be accessed as and when needed. The app was designed to be an adjunct to service delivery not a replacement for healthcare. The importance of this was demonstrated by many first-time mothers reporting that they preferred in-practice support from a healthcare professional.

The qualitative data indicated that the four preconditions of normalisation process theory: implementation, adoption, translation and stabilisation were met in regard to healthcare professionals' use of the Baby Buddy app. This suggests that the healthcare professionals were actively integrating the Baby Buddy app into clinical practice with other professionals and first-time mothers, therefore embedding the Baby Buddy app into their service delivery.

The in-app data from the sub-sample of participants (n=51) suggest that there was a difference in the amount of time participants spent accessing elements of the app; the median time spent using the app per session was 8.3 minutes (SD 5.8 minutes). The most popular features that

were used were ‘Today’s Information’, videos, ‘Bump/Baby Booth’, ‘Ask Me’ and ‘What does that mean?’. Participants used the app most often between 9-10am with another peak in the evening around 8-9pm. There were also a broad range of topics and issues that the participants searched for, of which the most searched words included: ‘labour’, ‘form’, ‘birth’, ‘pregnant’ and ‘developing’. In the sub-sample for whom we had in-app data, there was a large range for the number of times the app was used, from 0-593 times. The median number of times the app was opened was 146.5 but the data were positively skewed (LQ 52.5 – UQ 329). This indicates that the data are bunched towards the smaller number of times opened. Within this sub-sample, 21.6% of the engaged type of user used the app up to 25 times and 47% of this type of user used the app more than 100 times. This contrasts with the highly engaged type of user where 43% used the app 25 or less times and just 9.8% of this proactive type of user used it more than 100 times.

We found no statistically significant difference in the TOPSE or the WEMWBS scores between the type of user who was engaged with the app and non-app users (adjusted OR 0.69, 95%CI 0.22 to 2.16, p=.519 and adjusted OR 1.54, 95%CI 0.57 to 4.16, p=.329, respectively). Similarly, we found no statistically significant difference between the type of users who were highly engaged users and non-app users (TOPSE: adjusted OR 0.48, 95%CI 0.14t o 1.68, p=.251; WEMWBS: adjusted OR 1.40, 95%CI 0.52 to 3.76, p=.509).

Strengths and limitations: The primary objective was to explore the impact of the Baby Buddy app on parental self-efficacy and the Tool for Parenting Self-Efficacy (TOPSE website, Kendall, Bloomfield and Nash 2009), a validated measure, was selected to measure the primary outcome. The retention rate of 60.7% from baseline to three months post-birth demonstrates the difficulty of engaging new mothers during this demanding period of their lives. Nevertheless, in the initial and final samples, app users and non-users remained generally comparable and relevant confounders were adjusted for. Mothers were invited to take part in interviews and/or focus groups, the latter of which were held in a baby-friendly, welcoming environment for women and babies. Telephone interviews were offered for greater convenience for the women. Analysing the in-app data, we were able to compare outcomes for both the high versus low or non-user app groups and for those mothers who were the type of highly engaged users versus those who were a less engaged type. This was for a relatively small number of mothers but was a new method of analysing the in-app data.

The Baby Buddy app was publicly available, meaning randomisation was not possible and therefore participants were only asked about their specific use of the app after the 35 weeks gestation data collection point to avoid directed app use. The participants were a self-selected group, especially those for whom we had in-app data and this is reflected in the higher than the national average for women who were degree holders (58.6% in final sample versus 42% nationally). The overall TOPSE scores were high at baseline which meant there was little room

for improvement. Nevertheless, there was no difference between the Baby Buddy app users and those participants who did not use the app.

Conclusions: First-time mothers in the study found the app accessible and the information concise. The quantitative results, including those from the in-app data, found no evidence of impact from the Baby Buddy app on the primary outcome of parental self-efficacy or mental well-being (secondary outcome) at three months post-birth. The participant mothers had lower social support scale scores, which might suggest that the app attracted mothers who had a smaller social support network. Both mothers and healthcare professionals valued the fact that the Baby Buddy app was professionally endorsed which encouraged the women to trust the contents and the healthcare professionals to use it in their everyday practice. The most frequent source from which Baby Buddy app users found out about the app was a midwife, which suggests that the embedding of the app into service delivery by Best Beginnings was beneficial. A *post-hoc* finding was that women who used the Baby Buddy app were significantly more likely to exclusively breastfeed, or ever breastfeed, than those not using the app. The Baby Buddy app has gone some way to help to 'Make Every Contact Count' for both first-time mothers and healthcare professionals.

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ABBREVIATIONS

AE	Adverse Event
BaBBLeS	Bumps and Babies Longitudinal Study
CEQ	Childbirth Experience Questionnaire
CI	Confidence Interval
CRF	Case Report Form
CV	Curriculum Vitae
DAP	Data Analysis Plan
GCP	Good Clinical Practice
HCP	Healthcare professional
HV	Health visitor
ICF	Informed Consent Form
ICH	International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use
IMD	Index of Multiple Deprivation
IQR	Interquartile Range
LQ	Lower Quartile
MSPSS	Multidimensional Scale of Perceived Social Support
MTUAS	Media and Technology Usage and Attitudes Scale
MW	Midwife
NHS	National Health Service
NIHR	National Institute for Health Research
NRES	National Research Ethics Service
ONS	Office for National Statistics
OR	Odds Ratio
PI	Principal Investigator
PIS	Participant Information Sheet
PPI	Patient and Public Involvement
REC	Research Ethics Committee
R&D	Research and Development
SE	Standard Error
TOPSE	Tool to Measure Parenting Self-Efficacy
UIC	Unique Identifying Code
UQ	Upper Quartile
UWE	University of the West of England, Bristol
WEMWBS	Warwick-Edinburgh Mental Well-Being Scale

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

In the last 10 years there has been a huge increase in electronic health (e-health) and mobile health (m-health) solutions that aim to increase self-management and self-care of health and health problems in high, medium and low-income countries (Goetz *et al*., 2017). This has been made possible by developments in information and communication technologies. Mobile phones have capabilities that were, previously, only available by using computers and portable devices, such as laptops (Mosemghvollishvilli *et al.*, 2013).

Use of smartphones has increased such that the smartphone is the most widely owned 'internet enabled device' and used by seventy percent of adults. Smartphone use ranges from 85% for the 45-54 year-olds to 93% for the 16- 24 year-olds (Ofcom 2017). Access to the internet across portable devices, such as smartphones and tablets, is now widespread with these devices enabling sophisticated information transfer via texts, videos, voice, and pictures, which can also be triggered by date and location. This widespread accessibility and ease of communication has underpinned the development of 'applications' or apps which have led to a fundamental change in the methods that people use to access information and potentially gain confidence in doing so. This transformation has extended across all areas. It is estimated that health-related apps number over 325,000 (https://research2guidance.com/325000-mobile-health-apps-available-in-2017/). These apps not only offer convenience, connectivity, flexibility and efficiency for the user, but also wider opportunities for the provision of healthcare and information than have ever been known before (Johnson, 2014). Whilst this is the case, users will not use a smartphone app simply because it is innovative or readily available, it needs to be convenient and provide help for a specific health-related issue (Lee & Moon, 2016). Around 1500 pregnancy apps were found to be available in 2014 on the Google Play app store and the Apple iStore (Tripp *et al.,* 2014) and there are likely to be many more if this search was repeated.

The population of app users includes expectant and new mothers with whom internet-based information about pregnancy has been popular for over a decade (Bernhardt & Felter, 2004, Declerq *et al.,* 2013). Mobile apps for pregnancy, childbirth and child care are some of the most common healthcare apps that are used by women (Lee & Moon, 2016). A recent survey of 522 women (O'Higgins, 2014) identified 95% of women used the internet for pregnancy information, of whom 79% had smartphones and 59% used a smartphone app. Descriptions of the women who use these apps suggest that they are likely to be younger, in their first pregnancy (Lee & Moon, 2016), feeling less healthy and more likely to be influenced by the information provided by the app (Wallwiener *et al*., 2016). In addition, a recent study of pregnant and young mothers

indicated that women in middle and lower-income families used smartphones and their apps more frequently than women from upper middle- and high-income families (Jayaseelan *et al*., 2015).

Another dimension to the increasing use of the internet is the ability it offers to communicate with others who are sharing the same life experiences. This might be through informal internet based social networks as well as the more formal information-based sites and apps where different groups connect through these links (the strength of weak ties theory, Granovetter,1973). One systematic review suggests that, in relation to general health-related topics, patients use social media mainly for social support, which, in more detail, can be classified as information support, emotional support, esteem support and network support (Smailhodzic *et al*., 2016). They also identify negative effects of social media including diminished subjective wellbeing. Within pregnancy and early parenthood, women report using digital and social media for similar reasons including: easily and readily accessible information and to share their experiences and questions with others through blogs or other social media sites. Such access and communication with other women in a similar position, friends and family may have positive effects on women's emotional wellbeing, for example providing reassurance (Lupton, 2017) but possibly also negative effects such as increased birth anxiety (Fleming *et al*., 2014).

Use of mobile health technology, while still a relatively recent global phenomenon, has brought about changes in people's involvement in their own health and the demands that patients make of healthcare services (Hussain *et al.,* 2015) with consequent greater efficiency of health and economic resources. It is already impacting on the information-seeking practices of pregnant women (Johnson, 2014), with mobile technology being cited as an influential information source in pregnancy (Tripp *et al.,* 2014) and one which has the potential to affect current interactions with health professionals as well as facilitate new forms of communications and networking opportunities (Rodger *et al.,* 2013). Pregnancy apps offer a variety of content and various modes and level of user involvement. They provide information about pregnancy but also offer pregnant women the opportunity to monitor fetal or child development as well as changes in their own bodies, provide reassurance (Lupton and Pederson, 2016) and the possibility of sharing their experiences with family and friends (Lupton, 2017).

The availability of interactive and personalised information delivered by a smartphone may reduce the reliance on healthcare professionals thus 'modifying maternity care and experiences of pregnancy' (Tripp *et al.,* 2014: 67). In addition, the current and expanding use of digital media may also provide new platforms and opportunities for communication and provision of health

care for both pregnant women and new mothers. Health professionals are expected to 'act in partnership with those receiving care, helping them to access relevant health and social care, information and support when they need it' (NMC Code of Conduct, 2015: 6) and 'to encourage and empower people to share decisions about their treatment and care' (NMC Code of Conduct, 2015: 5) so that 'no decision about me without me' become the norm (DH, 2010: 13).

As pregnant women increase their use of on-line health information resources (Hearn *et al*., 2014), this may be seen as an opportunity to develop new initiatives in health promotion (Rodger *et al*., 2013). There have been suggestions that maternity services should incorporate social media into routine midwifery services (RCM, 2017) and that, given the extensive use of digital media for pregnancy information (O'Higgins *et al.*, 2014), all maternity services should have a digital media strategy. The Maternity Review, 'Better Births', recommends that the use of websites and apps should be encouraged, with the Baby Buddy app cited as one example (NHS, 2016).

Women in pregnancy and early parenthood, as well as health professionals, often view pregnancy and parenting apps from different perspectives. In a recent qualitative study of women and health professionals (Wilcox, 2015), some health professionals were found to view the emergence of digital technologies as shifting control of information provision away from trusted sources. For some, their lack of familiarity with and fear of m-health was perceived as limiting their engagement with and comprehension of the new technologies that could support antenatal care. One of the challenges for midwives is to become fully engaged with young, adolescent mothers who reportedly prefer to consult internet apps to obtain information and education about pregnancy, birth and parenthood (Hendricks *et al.,* 2016).

The picture of how women use apps is complex. Some women appear to be disengaging from more traditional healthcare, whilst others report using their online knowledge to complement the information that they receive from their health professionals (Wu Song *et al.,* 2012; Lagan *et al.,* 2011) or encourage the development of a new form of 'shared care' as women feel more empowered within their relationship with health professionals (Tripp *et al*., 2014)

App usage is also linked to the desire to improve clinical outcomes including maternal and infant health outcomes, particularly for 'at risk groups' such as low-income pregnant and single parents (O'Higgins *et al.,* 2014; Foster *et al.,* 2015). App content can be targeted to focus on maintaining a healthy lifestyle through the perinatal period including tracking weight, diet, physical activity, emotional wellbeing, sleep patterns linked to the developmental stage of their child (Hearn *et al*., 2014) as well as supporting areas such as breastfeeding initiatives (Asiodu

et al., 2015). Apps have also been used to evaluate depression and anxiety symptoms during pregnancy and after birth (Osma *et al*., 2014).

Whilst e-health (accessed through internet platforms) and m-health (accessed via smartphones) have the potential for enhancing traditionally delivered healthcare services (Tripp *et al*., 2014; Lau *et al.,* 2015), less is known about the current use and effectiveness of pregnancy- or perinatal-related smartphone apps (Rodger *et al*., 2013). A systematic review of apps for women's health concluded that more research was needed, especially in relation to the use and embedding of apps in healthcare settings (Derbyshire & Dancey, 2013). Most expectant women access the internet daily (Waring *et al*., 2014) and pregnant women who were asked about using the internet for searching for information perceived the information that they accessed to be reliable. However, they had not discussed the information with their midwife (Larsson, 2009) nor had they used the midwife to solely confirm facts that they had discovered (Johnsen, 2014). Consumer ratings found the most popular apps were those that were interactive and allowed women to track their pregnancy and access information at any time of the day or night (Tripp *et al.,* 2014).

1.1.1: The Baby Buddy app

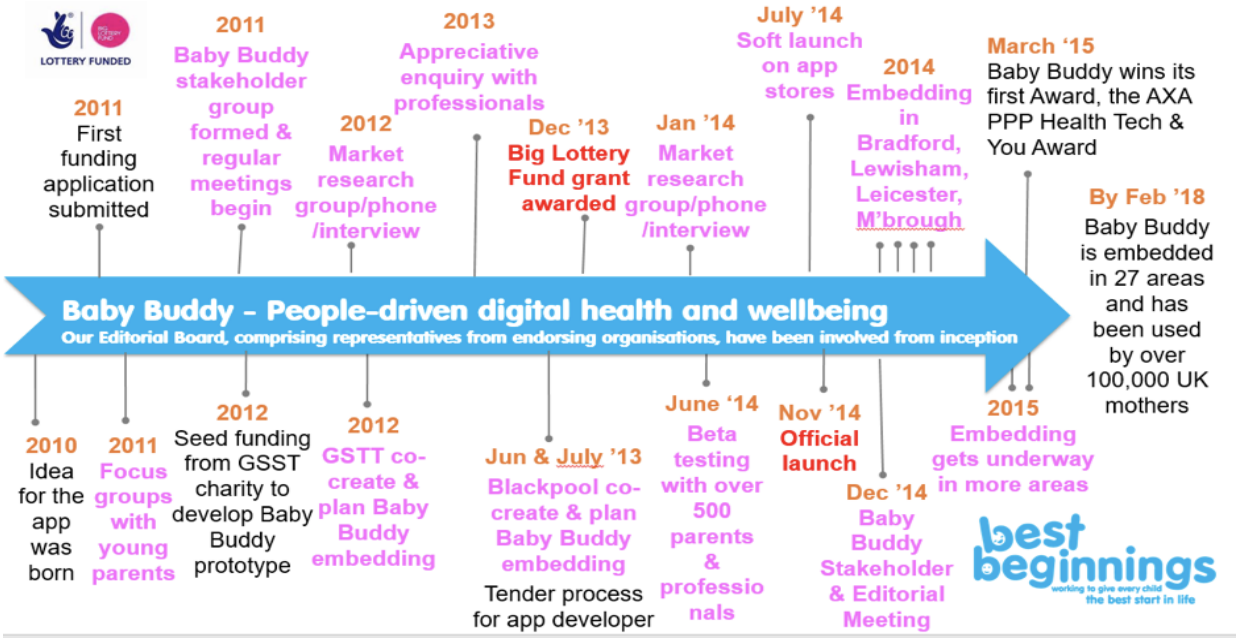
The Baby Buddy app was funded by the Big Lottery Fund and the Guys' and St Thomas' Charity and launched in England in November 2014. The app is described by Best Beginnings as a complex intervention, to inform and empower parents and to enhance bonding with their child, to sustain relationships between mothers and their babies, mothers and their partners and mothers and multi-disciplinary professionals. The aim of this national, freely available app is to improve outcomes and reduce inequalities, to give every child the best start in life. It was designed to inform parents from all backgrounds, to enhance and augment standard maternity and early years' service delivery and promote self-care.

Best Beginnings works nationally to reduce inequalities in child health and to inform and enable parents to give their children the best start in life. The charity has three guiding principles that underpin their work: evidence, collaboration and innovation and their work is informed by behaviour change theories and implementation science. A 'proportionate universalism' approach is used (Marmot review 2010) to create resources and interventions for all families, with a particular focus on engaging groups at higher risk of poorer outcomes.

Best Beginnings worked closely with health professionals and used an iterative approach in the development of the Baby Buddy app, which was grounded in co-creation (diagram 1) and informed by behaviour change theory, to ensure that Baby Buddy provides evidence-based,

trustworthy information (https://www.bestbeginnings.org.uk/vision). The core idea was to create a resource that could be used by parents as a stand-alone intervention but also integrated into health service delivery to support the relationships between parents and health care professionals (DH 2012). In addition, Best Beginnings used a process whereby they worked with multi-disciplinary healthcare staff and the local community to integrate Baby Buddy into local care pathways. This embedding process has taken place in 67 areas in England. The model of embedding that Best Beginnings undertook was not available to the research team and the definition of 'embedded' is unclear and appears to be variable.

Diagram 1: Development of the Baby Buddy app



The Baby Buddy app has been developed specifically to target expectant mothers who are under 25 years-old but also be attractive to a wide range of mothers. Young (teenage) mothers in the UK are less likely to both engage with formal maternity service provision early in their pregnancy and attend their appointments (Department of Health, 2009; Bradshaw *et al*., 2014); these are risk factors for maternal and infant mortality (Confidential Enquiry into Maternal and Child Health, 2007). The app provides interactive information to help parents look after their own physical and mental health during pregnancy and early parenthood and support them with caring for the physical and emotional health and wellbeing of their child. As stated above, it was designed to complement maternity and postnatal services. The content of the app is written so that is can be understood by anyone with a reading age of 11 years or above with a 'read aloud' element available. Baby Buddy provides personalised daily information covering many aspects about the transition to parenthood. It also includes interactive features including goal setting and

more than 300 films. At present it covers the period from conception until the baby is six months old.

The analytics system behind the Baby Buddy app enables Best Beginnings to track uptake and usage by locality, age, gender, ethnicity, language, education, employment and training. It also allows the charity to identify which videos Baby Buddy users are watching, what questions users are asking and which features they are using, as an anonymised data set.

Baby Buddy was used as an exemplar of digital information that increases choice and improves care in the National Maternity Review (NHSE, 2016). It has been endorsed by a number of organisations: the Royal Colleges of Midwives, Nursing, Paediatrics and Child Health, Speech and Language Therapists, Obstetricians and Gynaecologists and Psychiatrists. Also, the Community Practitioners' and Health Visitors' Association, the Institute of Health Visitors, UNICEF BFI and the Society for Reproductive and Infant Psychology.

1.2. THE BABBLES STUDY (BUMPS AND BABIES LONGITUDINAL STUDY)

The BaBBLeS study aims to assess the effectiveness of the Baby Buddy app on parenting self-efficacy and mental wellbeing. It also aims to understand when, why and how mothers use the app and any benefits the app may offer them in relation to their parenting, health, relationships or communication with their child, friends and family members or health professionals.

1.2.1 Study Objectives

For those mothers:

- who used the Baby Buddy app at any time compared to those who did not report using the app
- who were high app users compared to those who were low/non-app users

1. To assess the effectiveness of the Baby Buddy app, at three months post-birth, on parental self-efficacy and well-being in those mothers who heard about the app from a healthcare professional compared to those who did not hear about it from a healthcare professional or did not use it.

2. To explore how the app has affected the day-to-day lives of participant mothers, specifically around their self-efficacy, parenting ability, health behaviour, interactions and communications with their friends, family and health professionals.

3. To obtain in-depth information from health professionals around their awareness of the Baby Buddy app and barriers and facilitators to integration of the app into routine health care.

4. To describe data on the uptake, patterns of usage and detailed analytics of key factors within the app.

CHAPTER 2: PLAN OF INVESTIGATION

2.1: INTRODUCTION

Using a longitudinal framework, the study was conducted in five geographically separate sites in England: Coventry, Lewisham, Bradford, Blackpool and Leicester employing a mixed methods approach. These areas were chosen as they were geographically, ethnically and socio-economically diverse, included at least one Big Lottery funded Better Start Sites (The Big Lottery, 2015) and areas where the Baby Buddy app was, or reported to be, well-embedded into the maternity and child health pathways by the relevant healthcare staff.

The study has three component parts that address the stated objectives:

1. Longitudinal cohort study
2. Qualitative: one-to-one interviews with mothers in three geographical areas and focus group discussions with app users in these three areas (mothers, partners/supporters and health professionals)
3. Detailed analysis and synthesis of data of the in-app data.

1. Cohort Study

The cohort study compared the self-reported parental self-efficacy and mental wellbeing of mothers, at three months post-birth, who had reported using the Baby Buddy app at any time compared to those who did not use the app. The study controlled for baseline characteristics including demographic characteristics, use of technology, social support and baseline levels of parental self-efficacy and mental wellbeing.

2. Qualitative: focus groups and interviews with mothers and health professionals.

This component of the study included mothers and health professionals taking part in focus groups or one-to-one interviews to discuss in more depth their perceptions of using the Baby Buddy app.

3. In-app data

Data on the uptake, patterns of usage and detailed analytics of key factors within the app was collected from downloads provided by Best Beginnings and Despark, the app developer.

2.2: METHODS

2.2.1: RECRUITMENT

Participants were recruited from across the five sites. The sites, the respective maternity unit(s) and their total number of births in the administrative year 2014/2015 were:

- Coventry; one unit – University Hospital, 6126 births;
- Lewisham; one unit – University Hospital, 4015 births;
- Bradford; one unit – Bradford Royal Infirmary, 5878 births;
- Blackpool; one unit – Blackpool Victoria Hospital, 3149 births;
- Leicester; one unit –Leicester Royal Infirmary, 6098 births.

Maternity unit administrative clerks, with support of the research midwives (as the project was accepted onto the NIHR Portfolio), in each of the five geographical areas undertook a database search for women who fulfilled the inclusion criteria (see below). Recruitment began in September 2016 and was completed by February 2017.

2.2.2: STUDY POPULATION

All pregnant women who were booked with the maternity services in one of the five sites (Coventry, Bradford, Lewisham, Blackpool and Leicester) and who fitted the inclusion criteria below were approached.

Inclusion Criteria

- Aged 16 years and over
- No previous live child
- Between 12-16 weeks + 6 days gestation

Exclusion Criteria

- Younger than 16 years old
- Already has one or more children
- Before 11 weeks + 6 days or after 17 weeks gestation
- Those unable to provide informed consent.

2.2.3: WOMEN

A participant information booklet combining the study invitation letter and Participant Information Sheet (PIS), was given or posted to pregnant women by the midwifery services staff. Women were able to discuss the study with a research midwife or member of the research team by telephone, text or email. The information booklet also contained a participant flow diagram summarising and outlining each option below. Women could choose to participate in one of the following methods:

- **Online:** by requesting a link by TEXT, or by emailing Babblesteam@uwe.ac.uk; or by following the link on the paper version of the questionnaire. Online completion included a link to the Informed Consent Form (ICF) and a brief form to complete if they would like to receive a £5 thank you voucher and/or would like to receive the results of the study. If the participant was in the Coventry, Lewisham or Blackpool study sites, this form also asked her to indicate if she would like to take part in further, nested qualitative studies. Participants were not able to access the questionnaire until they had completed the ICF.

- **On Paper:** by being given or asking the study site research midwife or study team for a questionnaire pack. This pack contained the baseline questionnaire, ICF; a brief form to complete if they would like to receive a £5 thank you voucher and/or would like to receive the results of the study. If the participant was from the Coventry, Lewisham or Blackpool study sites, this form also asked her to indicate her interest in further, nested qualitative studies. The pack also contained a SAE for return of the three study documents.

2.2.4: CONSENT

Women were asked to complete, sign and date the Informed Consent Form (ICF) and return it by post to the research team in a pre-paid envelope. All paper ICFs were signed and dated by the mother and member of the research team. A completed questionnaire received by the research team indicated women's participation in the study. A signed ICF from the participant was sought in all cases. Online completion included a link to the ICF and participants were not able to access the questionnaire until they had completed the ICF.

Mothers who took part in a focus group, one-to-one interview or agreed for their in-app data to be made available to the research team, signed an additional ICF or their consent was recorded prior to commencement of any telephone interview. Consent to access the women's in-app data was sought at the 35 weeks gestation data collection point.

2.2.5: HEALTH PROFESSIONALS

Health professionals from the study sites were invited to take part in a focus group between March 2017 and October 2017. All health professionals in three of the five study sites, Coventry, Blackpool and Lewisham who had regular and current contact with women from the target age group (e.g., teenage pregnancy midwives, family-nurse practitioners, community midwives in preference to midwifery managers, hospital-based midwives) were invited to take part. Health professionals who agreed to participate in a focus group and/or one-to-one interview signed an ICF or their consent was recorded prior to any data collection taking place.

2.2.6: WITHDRAWAL OF PARTICIPANTS FROM STUDY

Mothers and health professionals could withdraw from the project at their own request. The mothers were made aware that this would not affect their future care or support from the health professionals. Participants, both mothers and health professionals, were informed (via the information sheet and consent form) that should they withdraw, the data collected to date could not be erased and may still be used in the final analysis. Mothers were not followed up with the 35 weeks gestation questionnaire or three months post-birth questionnaire if they had miscarried, the pregnancy was terminated, if there had been no live birth at term or a neonatal death.

2.2.7: RANDOMISATION

The study compared those mothers who reported they had used the Baby Buddy app with those who had not used the app, by three months post-birth, controlling for baseline characteristics. As the Baby Buddy app was freely available on the app store, there could be no randomisation. Parental self-efficacy and mental wellbeing were also assessed in terms of their app use status

2.2.8: PARTICIPANT/PUBLIC INVOLVEMENT

The measures and methods described in the study were discussed with groups of midwives and pregnant women at the Newcastle and Coventry University sites to assess acceptability and appropriateness of the study methodology. A few minor changes to wording and layout were made in consultation with relevant authors, to facilitate completion of the study measures by participants.

2.2.9: STUDY MANAGEMENT

Coordination

The study had a central coordination centre, led by the Chief Investigator, Dr Toity Deave (UWE), with the roles of ensuring data quality and coordination across the study sites and the synthesis

of information to formulate the final report. The University Hospitals Coventry & Warwickshire NHS Trust was the lead Research and Development site.

Ethical and regulatory aspects

This study received a favourable opinion from the NHS Research Ethics Committee (NRES) West Midlands-South Birmingham REC (16/WM/0029), the University of the West of England, Bristol Research Ethics Committee (HAS.16.08.001), and the respective study site's National Health Service (NHS) Research & Development (R&D) departments.

For the qualitative work, ethical approval was sought and approved for both components of the evaluation from the Research Ethics Committee at the Faculty of Health and Life Sciences, Coventry University, where the 'medium to high risk' procedure was adhered to. This also included seeking university approval of Participant Information Sheets; informed consent forms and data collection methods. Good governance systems were put in place. For example, all data were stored securely on password protected databases and all members of the team had DBS clearance.

2.2.10: DATA MANAGEMENT

Anonymity and data protection

All participants were assigned a unique identity code (UIC) to facilitate the conduct and analysis of the study. These were applied to all paper and electronic versions of questionnaires, interview transcriptions and databases.

Recruitment logs served as a separate confidential record of the participants' details, permitting identification of all participants recruited to the study, in accordance with regulatory requirements and for follow-up, as required. Two logs were created: one for women participants and one for the health professionals.

In addition, the following data were collected and stored on a separate database: participant's UIC, name, address, telephone and other relevant contact details, including date that the follow-up questionnaires were due, preferred format for administration of follow-up questionnaires, email address.

For the interview data, with the permission of the interviewees, interviews were digitally audio-recorded, anonymised, transcribed verbatim and stored with the other study data. The transcribed

interviews are treated as confidential documents, held securely with no identifiable information on the transcripts and stored on a secure password protected university server.

All data collected are held securely, in a locked room or locked cupboard or cabinet, with access to the information limited to the study research team. Computer held data, including study databases, are held on secure, password protected university or NHS servers and backed up as a minimum, every 24 hours. Personal laptops were not used. Where university or NHS laptops were used, these were password protected and data transferred to the university or NHS server as soon as possible.

At the close of the study, data from all centres will be archived by the University of the West of England, Bristol (UWE) for a period of seven years or longer, if required, as set out in UWE's Code of Research Conduct.

2.3 COHORT STUDY

2.3.1 STUDY DESIGN

A cohort study design was used to assess the impact of the Baby Buddy app on parental self-efficacy and mental well-being at three months post-birth. First-time pregnant mothers were recruited from five maternity sites across England. Data were collected from these women at three time-points:

1. Baseline (between 12-16 weeks gestation)
2. 35 weeks gestation,
3. Three months post-birth.

2.3.2 BASELINE DATA

Baseline and follow-up data (35 weeks pregnancy and 3 months post-birth) were collected through maternal self-completion questionnaires. Baseline data were collected between September 2016 and February 2017.

The baseline questionnaire covered questions about the mothers' socio-demographic details, validated tools to measure parental self-efficacy (TOPSE)(Kendall and Avril, 2009), mental well-being (WEMWBS)(Tennant *et al*., 2007), anticipated feeding practices, pregnancy dates (EDD) use of the internet, apps and social media, sources of information about pregnancy and motherhood and social support.

2.3.3 FOLLOW-UP DATA

The 35-week gestation questionnaire repeated the validated tools included at baseline. At three months post-birth the questionnaire repeated the validated tools and also included questions relating to app usage, health service use, experience of childbirth, feeding practices and interaction with health services. The final 3 months post-birth data that were included in the analysis was January 2018.

All baseline participant study materials including the patient information sheet, consent form and baseline questionnaires are in appendices 1-3. The three months post-birth questionnaire can be found in appendix 4.

2.3.4 VARIABLES

Data were collected as described in detail below.

Reported app use (exposure variables)

The main exposure variable of interest was the reported use of the Baby Buddy app at any of the three data collection time-points. This is the definition of a Baby Buddy app user that has been employed throughout this study. Participants were asked if they used or had used any apps specifically about pregnancy and/or parenthood, and which ones, at the three time-points. In addition, at 35 weeks gestation and at three months post-birth, those who reported using pregnancy/parenthood apps were then asked if the Baby Buddy app was one of the apps they were using, or had used.

A secondary exposure variable collected was whether those participants who had used the Baby Buddy app at least once had heard about the Baby Buddy app from a health professional (midwife, health visitor, GP or other health professional) or through other sources (e.g. family, Internet, friends). We asked this question at 35 weeks gestation and at three months post-birth, as part of a multiple-choice question.

Outcome variables

The primary outcome variable was parental self-efficacy, measured with the 36-item Tool to measure Parenting Self-Efficacy (TOPSE)(Kendall and Avril, 2009) to assess mothers' and fathers' beliefs about their ability to parent their child. TOPSE is a relatively straightforward measure to complete, it measures change in self-efficacy between time-points and is therefore ideally placed to measure outcomes in this evaluation. It has been selected above other tools because it responds directly to the primary outcome requirement of the brief, it is highly

acceptable to parents, easy to administrate, it has been used both in the UK and internationally, its' external and construct validity is well demonstrated and feedback from users both clinically and in research has been highly positive. TOPSE is available in several versions: the standard tool for parents of children aged 0-6 years, infant version for parents of children aged 0-6 months and the version for learning disabled parents. The standard version is also available in eight languages. All versions have been utilised both in the UK and internationally. The 0-6 month version, which will be used for this study is already available in SurveyMonkey format.

The original scale was used at three months post-birth; for use in the antenatal period (at baseline and at 35 weeks gestation) it was adapted in consultation with the tool developer (SK, one of the co-authors of this report). For the antenatal TOPSE, all 36 statements were reworded to the future tense, e.g., 'I am able to have fun with my baby' to 'I will be able to have fun with my baby'. No other changes were made to the structure, content or scoring of this tool.

The TOPSE is divided into six sections, each section containing six items and addressing a different domain of parenting, such as 'emotion and affection', or 'play and enjoyment'. Participants were requested to select how much they agreed with each item, from 0 (completely disagree) to 10 (completely agree) on a Likert scale. Five items were reverse-scored (items 6, 19, 20, 21 and 27). A total sum score was calculated from the 36 items, ranging from 0 to 360, where larger scores indicated greater self-efficacy. The 0-6 month postnatal scale has shown very high internal consistency (alpha 0.96) as well as good content and convergent validity (Kendall and Avril, 2009; Benzies *et al.* 2013).

The main secondary outcome variable: the other area the Baby Buddy app was trying to influence was maternal mental well-being. The research team chose the Warwick-Edinburgh Mental Well-Being Scale (WEMWBS) as a validated measure of maternal mental well-being (Tennant *et al*., 2007). This scale covers subjective well-being and psychological functioning, comprising of 14 statements describing feelings (e.g., 'I have been feeling useful') and functional aspects (e.g., 'I've been dealing with problems well') over the previous two weeks. Items were scored from 1 (none of the time) to 5 (all of the time) and summed to provide an overall score between 14 and 70, where higher scores corresponded to higher levels of well-being.

This scale has shown good content and criterion-related validity, as well as high test-retest reliability (0.83), in various groups and public health contexts, including parenting programmes (Stewart-Brown et al. 2011) and WEMWBS has been validated for use in the UK.

2.3.5 Background information and potential confounders

We collected information on the background characteristics of our sample, some of which could potentially explain the association between exposure and outcomes. These potential confounding factors included social support, generic technology use and sociodemographic characteristics.

Social support was measured using the Multidimensional Scale of Perceived Social Support (MSPSS)(Zimet *et al*., 1988). This scale consists of 12 statements about the support received from family (4 items), friends (4 items) and a significant other (4 items), e.g., 'My family really tries to help me' or, 'There is a special person in my life who cares about my feelings'. Participants rated their level of agreement with each statement on a seven-item Likert scale, from 1 (very strongly disagree) to 7 (very strongly agree) (range 1-7). Item scores were summed to provide total scores, both overall (range 12-84) and for each of the three subscales (range 4-28). Higher scores indicated perception of greater social support. The validity and internal reliability of the MSPSS have been demonstrated in a number of studies, with alpha scores from 0.87 to 0.93 (Zimet *et al.* 1988; Eker and Arkar, 1995; Canty-Mitchell and Zimet, 2000), including amongst pregnant women (alpha 0.92) (Zimet *et al*., 1990).

Technology use was assessed using the Media and Technology Usage and Attitudes Scale (MTUAS) which has shown high internal consistency, from 0.61 to 0.96 across all 15 subscales (Rosen *et al.*, 2013). To avoid respondent fatigue, following discussion with the author, nine items were selected for inclusion from the original. Feedback from new parent pilot respondents supported the appropriateness of these changes (section 2.2.8).

The nine items selected described general aspects of technology use and assessed the frequency of text messaging, phone calls, smartphone use, internet searching and social media use. Smartphone use includes browsing the web and using apps of any type on a smartphone or tablet. Internet searching includes searching the web for news and information. General social media use comprises checking page, posting photos or commenting on Facebook or other social networks.

Participants indicated the frequency of each of these behaviours, e.g., 'Check your Facebook page or other social networks', from 1 (Never/Not applicable) to 6 (Several times a day). Average scores were calculated and ranged from 1 to 6, where 6 corresponded to the highest frequency of technology use. The adapted MTUAS scale was compared between pregnancy app users and non-pregnancy app users as a test of content validity. The premise underlying this content validity test was that pregnancy app users would show a higher frequency of technology use than non-pregnancy app users; this analysis is presented here to increase understanding of the tools used. As hypothesised, participants who reported using pregnancy apps had significantly higher general technology use (mean=5.12, SD=.03) compared to participants who reported not using

pregnancy apps (mean=4.94, SD=.07), *t* (487) = -2.84, *p*= 0.005, supporting the content validity of the shorter MTUAS scale used.

Sociodemographic variables assessed were women's age, ethnic group, socio-economic deprivation, highest level of formal education, relationship status and employment. Index of multiple deprivation (IMD) decile, a common indicator of socioeconomic deprivation in the UK, was obtained by searching participants' postcodes using a standard online tool (DCLG, 2017). The geographical site where participants were recruited was also noted. Questions and responses relating to sociodemographic information were identical to those from previous Census surveys (ONS, 2009).

In addition, the following information was collected:

Participants' intended baby feeding methods at baseline and at 35 weeks gestation and their actual baby feeding methods at three months post-birth.

Participants' childbirth experience using the Childbirth Experience Questionnaire (CEQ) (Dencker *et al*., 2010). This scale contains 22 items on four dimensions: own capacity (e.g., 'Labour and birth went as I had expected'), professional support (e.g., 'My midwife devoted enough time to me'), perceived safety (e.g., 'I felt scared during labour and birth') and participation (e.g., 'I felt I could have a say whether I could be up and about or lie down'). All items are scored from 1 (totally agree) to 4 (totally disagree); higher scores reflect more negative childbirth experiences. Three questions are visual analogue scales, rated from 0 to 100, which are then converted to a 1 to 4 score. Pain related items are reversed scored. The CEQ has been validated for use in the UK, showing acceptable to excellent internal consistency across the four dimensions (Walker *et al*., 2015).

2.3.6 Data entry and cleaning

Questionnaire data were entered on an online survey platform (Qualtrics, 2017) directly by participants in the case of online respondents or by members of the research team in the case of paper questionnaires. There were three surveys, one for each data collection time-point. A random 10% sample of paper questionnaires were double data entered to ensure accuracy of data entered. We found an error rate of less than 0.4% suggesting an excellent level of data entry accuracy. Anonymised data were imported to Stata for data cleaning and analysis (StataCorp, 2015). The process of data cleaning included range and consistency checks, the removal of duplicate rows and variables, converting variables to numeric (including categorical) or string, as appropriate. When necessary, queries were resolved by checking the original questionnaires. Standard dates of birth were created and new variables were computed from the data e.g., summed scores. Cleaned data sets were created for each time-point and combined into the final

data set for analysis in which participants' unique identifying codes (UICs) were the common matching variable.

2.3.7 STATISTICAL ANALYSIS

The plan of the statistical analysis for the BaBBLeS study is presented in appendix 5, including descriptive data, primary analysis and secondary analysis.

Descriptive data

Descriptive data for participant background information and outcome data are presented (section 3.1). We report medians (lower quartile – upper quartile) in the case of continuous variables; normality tests suggest that most continuous variables had a skewed distribution. In the case of categorical variables, we present numbers and percentages; the percentage denominator corresponds to the number of participants with valid data for that specific variable. These descriptive data are presented by Baby Buddy app use[1]: app users versus non-app users. In addition to being described in relation to app use, to compare the initial and final samples, sociodemographic information was compared between baseline and three months post-birth. We performed chi-squared tests for categorical variables and Mann-Whitney tests for continuous variables, to assess any differences between groups.

Primary analysis

The primary analysis assessed the association between reported maternal Baby Buddy app use and parental self-efficacy at three months post-birth, adjusting for potential confounders. Participants were considered app users if they had reported using the Baby Buddy app at one or more time-points (baseline, 35 weeks gestation or three months post-birth). We developed linear regression models to assess the association between app use and parental self-efficacy. This was based on the assumption that the TOPSE data would be normally distributed, as suggested previously (Bloomfield and Kendall, 2012). We analysed assumptions of the linear model via standardised residual and leverage plots and these suggested a non-normal distribution; the data were negatively skewed (appendix 6). Log transformation of the TOPSE data was carried out but the distribution remained non-normal. As a result, we developed logistic regression models, in which TOPSE scores were converted into a binary variable: (1) low self-efficacy, to represent those in the lowest quartile of TOPSE score data and (0) reference levels of self-efficacy, which corresponded with those with TOPSE scores above the lowest quartile. In this analysis, we reported the odds ratio of low TOPSE scores (i.e., low self-efficacy) amongst Baby Buddy app

[1] The definition of a Baby Buddy app user that has been employed throughout this study is the reported use of the Baby Buddy app at any of the three data collection time-points.

users, compared to non-app users. This logistic regression analysis comprised of two models: i) unadjusted model and, ii) model adjusted for potential confounders, including baseline levels of the outcome.

Our pre-specified selection of confounding variables comprised of: maternal age, ethnic group, education, relationship status, employment, recruitment site, IMD score (based on postcode), baseline levels of social support, propensity to use technology (measured at baseline) and baseline levels of the outcome. We reduced the number of confounding variables in our analysis, in line with existing recommendations (Peduzzi *et al*., 1996). We retained four key potential confounders: IMD scores, social support, propensity to use technology and baseline levels for the outcome. In addition, we investigated the association between each of the other potential confounders and Baby Buddy app use, based on the tests of difference between app users (women who had reported using the Baby Buddy app at one or more data collection timepoints) and non-app users. The potential confounders significantly associated with app use were also controlled for in the main regression analysis.

Secondary analysis

We carried out a secondary analysis to assess: the association between Baby Buddy app use and each of the six TOPSE subscales at three months post-birth; the association between app use and maternal WEMWBS at three months post-birth; the association at three months post-birth between health professional assisted app user (i.e., if the app was introduced to the participant by a health professional) and overall TOPSE; the association at three months post-birth between health professional assisted app user and overall WEMWBS. Mental well-being (WEMWBS) data were also non-normally distributed (negatively skewed), therefore we created a binary variable of mental well-being similar to that created for self-efficacy, i.e., (1) low mental well-being (WEMWBS scores falling in the lowest quartile), and (0) reference levels of mental well-being (WEMWBS scores above the lowest quartile). In this analysis, we report the odds ratio of low WEMWBS (i.e., low mental well-being) amongst Baby Buddy app users compared to non-app users.

For each of the main analyses, we developed an additional third model, similar to model 2, where the outcome levels at 35 weeks gestation were used also adjusted for. These additional analyses did not change the main results and are presented in the tables in appendix 7. The length of time elapsed between Baby Buddy app download and the data collection time-point (or, in the case of those who had already stopped using the app, the date when they stopped) was omitted from the list of potential confounders that were controlled for due to collinearity with app use. We performed an additional regression analysis and scatter plot to investigate the association

between the time since Baby Buddy app download and outcomes: a wider interval implies a greater length of time in which the participant had access, and could therefore use, the app. This is presented in appendix 8.

In another set of secondary analyses, we assessed the impact of being introduced to the Baby Buddy app by a healthcare professional (midwife, health visitor, GP or other health professional). Logistic regression models were used to compare parental self-efficacy and well-being in app users (women who had reported using the Baby Buddy app at one or more data collection timepoints) and had heard about it through a healthcare professional (HCP) with women who had not used the app or had not been introduced to the app by a HCP. All tests were two-sided and the nominal level of alpha was 5% ($p<.05$) (see appendix 7, tables 6 & 7).

Post hoc analysis

Findings from the qualitative study (chapter 4) suggest that the Baby Buddy app influenced breastfeeding choices. As such we carried out a **post-hoc analysis** on the association between Baby Buddy app use and breastfeeding (both exclusive breast feeding and any breast feeding) at one week post-birth, at one month post-birth and at three months post-birth. In the adjusted model, we controlled for IMD decile and education level, which are known to be associated with reported breastfeeding (Brown *et al.*, 2009; Mangrio *et al.*, 2011). We adjusted for baseline intentions to breastfeed and also general technology use and use of pregnancy/parenthood apps; these variables are possible confounders in this analysis.

Sample size

We had estimated that the total number of women at follow-up needed to detect a minimum difference of a half standard deviation in TOPSE total scores between app users (women who had reported using the Baby Buddy app at one or more data collection timepoints) and non-app users, with a power of 90%, varied between 170 and 392 for 50.0% and 12.5% app use rates, respectively (table 1).

Table 1: Sample size calculation for final sample at 90% power

% app use	Ratio*	Total sample size
12.5%	7	392
14.3%	6	350
16.7%	5	306
20.0%	4	265
25.0%	3	228
33.3%	2	192
50%	1	170
* Ratio of app users: non-app users		

The outcome of parenting self-efficacy (TOPSE) was treated as a dichotomous variable, lowest quartile compared to the upper three quartiles and therefore we would have 80% confidence in being able to detect a 14% difference in the proportion of participants in this lowest quartile with a sample size of 100 intervention subjects (i.e. Baby Buddy app users) and 150 controls (i.e. non-app users) at the 5% level (Dupont and Plummer, 1990).

2.4 QUALITATIVE STUDY

2.4.1 INTRODUCTION

The purpose of the qualitative arm of the study within BaBBLeS was two-fold:

- To explore how the Baby Buddy app has affected the day-to-day lives of participant mothers, specifically around their self-efficacy, parenting ability, health behaviour, interactions and communications with their friends, family and health professionals

- To obtain in-depth information from health professionals around their awareness of the Baby Buddy app and barriers and facilitators to integration of the app into routine health care.

2.4.2 RATIONALE

The qualitative arm of the study aimed to understand when, why and how first-time mothers use the Baby Buddy app and the benefits that they feel the app gives them in relation to their parenting, health, relationships and communication with their child, friends and other family members.

Nested within the overall approach, qualitative data were primarily obtained by the lead team for the qualitative strand (Coventry University) from two sources:

- First-time mothers
- Healthcare professionals.

2.4.3 Methods

Overall framework

Appreciative Inquiry (AI) was chosen as the most appropriate philosophy to underpin the qualitative work. AI is an emerging research methodology that has theoretical and philosophical underpinnings in action research and organisational change (Cooperrider and Whitney, 1999). It has been used effectively by the team in Coventry University within a variety of complex structures including health and social care settings, it also lends itself well to a pragmatic discovery of information. Fundamental to this approach is the desire to discover, 'what works well' in organisations/systems and 'why it works well'. Therefore, the researcher works from a position of positivity of *what works well* and *what could work better* to highlight perceptions. AI has been used effectively within a variety of complex, organisational structures, including health care settings; it lends itself well to this study so that it can capture the voices of the women and health professionals. Findings are presented using this approach.

2.4.4 First-time Mothers

Data collection method

One-to-one interviews and focus groups were offered and took place in the postnatal period (participants were 3-9 months post-birth). Throughout the focus group, we ensured women were aware that they could prioritise their babies' needs by holding the session in a sensory soft play room. Within the room, we also provided changing mats and nappy changing items, play mats and age appropriate toys.

A flexible interview style with prompts was developed by the research team and telephone interviews were offered as these are less demanding upon the participant's time (Sturges and Hanrahan, 2004:113).

Semi-structured telephone interviews were decided on and were conducted by experienced health researchers who were registered midwives, which enabled the women to talk about pregnancy and new born care issues. If women had any questions or concerns unrelated to the research, this was deferred with the offer of a conversation at the end of the interview. Telephone interviews were flexible, which was particularly important when considering participants that included first-time mothers and professionals, who often work long and irregular hours. The flexibility of the interview schedule made discussions more interactive, which in turn helped to build rapport between the interviewer and the interviewee (appendix 9). With consent of the participants, the interviews were audio-recorded.

To maintain consistency and to collect comparable data, the interview schedule for the telephone interviews was developed by the research team alongside the schedule used for the focus groups. This element aimed to explore when, why and how mothers used the app and the perceived benefits the app gave them in relation to their parenting, health, relationships and communication with their child, friends and other family members. It specifically explored how the app is used by mothers to enhance communication with healthcare providers to make "every contact count" (PHE, 2016) and the reasons behind differences in rates of usage, including what makes the app enjoyable to use and experiences of responses to embedding activities.

Both the first-time mothers' and the health care professionals' focus groups took place over a two-hour period during which they were encouraged to work in groups and discuss amongst themselves. The participants were given materials including comment cards, sticky notes and coloured pens and asked to discuss the issues presented by the research team. In practice, this meant writing or drawing bullet-points to help them to explain their thoughts. Visual prompts included laminated screenshots of the Baby Buddy app's key features and sections. The Baby Buddy app was also made available on iPads in case they wished to remind themselves of any areas within the Baby Buddy app. In line with the Appreciative Inquiry approach (Cooperrider and Whitney, 1999) and to encourage participation and add some levity, women were given cards

with Teddy Bears on for the positive, ‘what worked well’ comments and cards with Nappies on for, ‘what could have been better’.

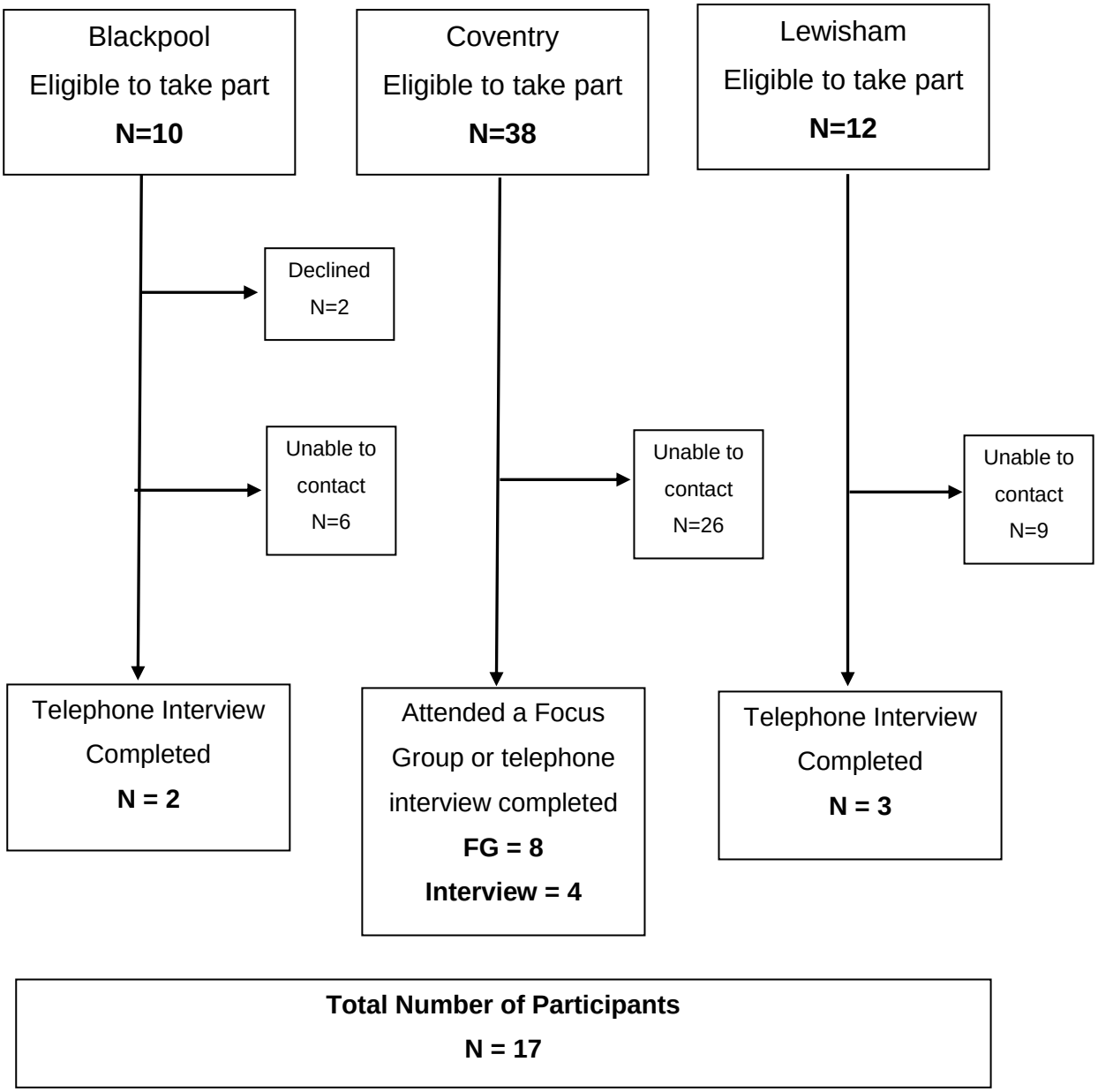
Mothers: sample and recruitment

The total sample size for the cohort study was 488 Baby Buddy app users who provided valid TOPSE or WEMWBS data across the five sites of Blackpool, Lewisham, Coventry, Leicester and Bradford. For the qualitative study, we recruited from three sites (Blackpool, Lewisham and Coventry) and, considering Blackpool had the highest Baby Buddy app download rate (35.3%), (as per data collected at the 35 weeks gestation point and local download rates) we anticipated approximately 100-150 potentially eligible mothers for the qualitative arm.

The sample sizes for the qualitative arm of the study were then based on an estimate to expect saturation of data on themes emerging from the study. A maximum of 30 in-depth interviews or focus group attendees (n=30, 10 from each of three sites: Coventry, Lewisham and Blackpool) were planned with women who had used the Baby Buddy app and who had consented to participate or agreed to be contacted. The data from interviews were validated within the focus groups with exploration of themes emerging from interviews. It was intended that a balanced group of recruits to interviews and focus groups would be spread across the three sites to allow for local differences in experience with the app use and professional encounters.

This qualitative study was part of the mixed methods approach. Inclusion and exclusion criteria were the same as those described above (section 2.2.2, page 22). Overall, 17 first-time mothers participated in the qualitative arm via telephone interviews (n=9) or a focus group (n=8), the distribution across sites is described in figure 1. At the time of interviews and first-time mothers’ focus group, women ranged from 12 weeks to 37 weeks (3-9 months) post-birth. Following an initial round of thematic analysis, it was apparent that thematic saturation had been met and no further participants were sought and full in-depth analysis commenced.

Figure 1: Recruitment for first-time mothers



First-time mothers were first asked how they had discovered the Baby Buddy app, with a range of answers that were provided by them (see below):

- Searched in pregnancy related apps
- Poster within the hospital they attended
- Information given by Health Care Professional
- Information given when recruited to be part of the study
- App information given in birth pack

Participants were asked what they felt worked well within the Baby Buddy app, in line with Appreciative Inquiry Framework (Cooperrider and Whitney, 1999).

The number of first-time mothers from the cohort study who identified themselves as having used the Baby Buddy app and who had agreed to be contacted for interview was 60. There was a higher proportion of mothers who had downloaded the Baby Buddy app from the Coventry site; this differed from what was anticipated. According to the Baby Buddy app download rate, Blackpool had a higher download rate than the other two sites. There were also some women who had initially agreed to be contacted but proved difficult to contact. We received feedback indicating that women were unsure or unhappy to answer their phones to unknown numbers. Therefore, to facilitate recruitment, text messages were sent out to participants via the Greentext online text messaging system (http://www.gntext.com/) to highlight that the BaBBLeS study team was contacting them. The Greentext method increased our success in contacting women. We contacted 34 women to attend the focus group using Greentext and had 8 replies and confirmations of attendance. This response rate indicates the amount of work that was required to recruit women for the interview or focus group sessions. Greentext gave participants the opportunity to reply at a time that was convenient to them, at a life stage that we know is busy and exhausting for first-time mums.

Data analysis approaches

Due to the detailed nature of the data, an emergent approach to analysis took place; this identified themes from the rich data. A thematic analysis enabled a clear presentation of the findings with regards to meeting the broad objectives. The thematic analysis used took its guidance from the analysis practised commonly in social research, as described by Boyatzis (1998). Principally, this method involves manually sifting through the transcription data and looking for common themes in relation to the problems posed. The data were then framed into grids and tables according to themes and interpreted and understood at a deep level. Once themes were coded and substantiated with primary evidence, they were stored in a final matrix.

2.5 Health Care Professionals

Data collection method

The invitation to health care professionals (HCPs) was to attend a focus group with the option of telephone or face-to-face interviews if they were unable to attend a group and to ensure the target sample size was achieved. The option of either an interview or focus group was to facilitate data saturation being reached amongst the backdrop of ‘real world’ demands on professionals’ time and their availability. Overall, two focus groups took place, one in Coventry and one in Lewisham.

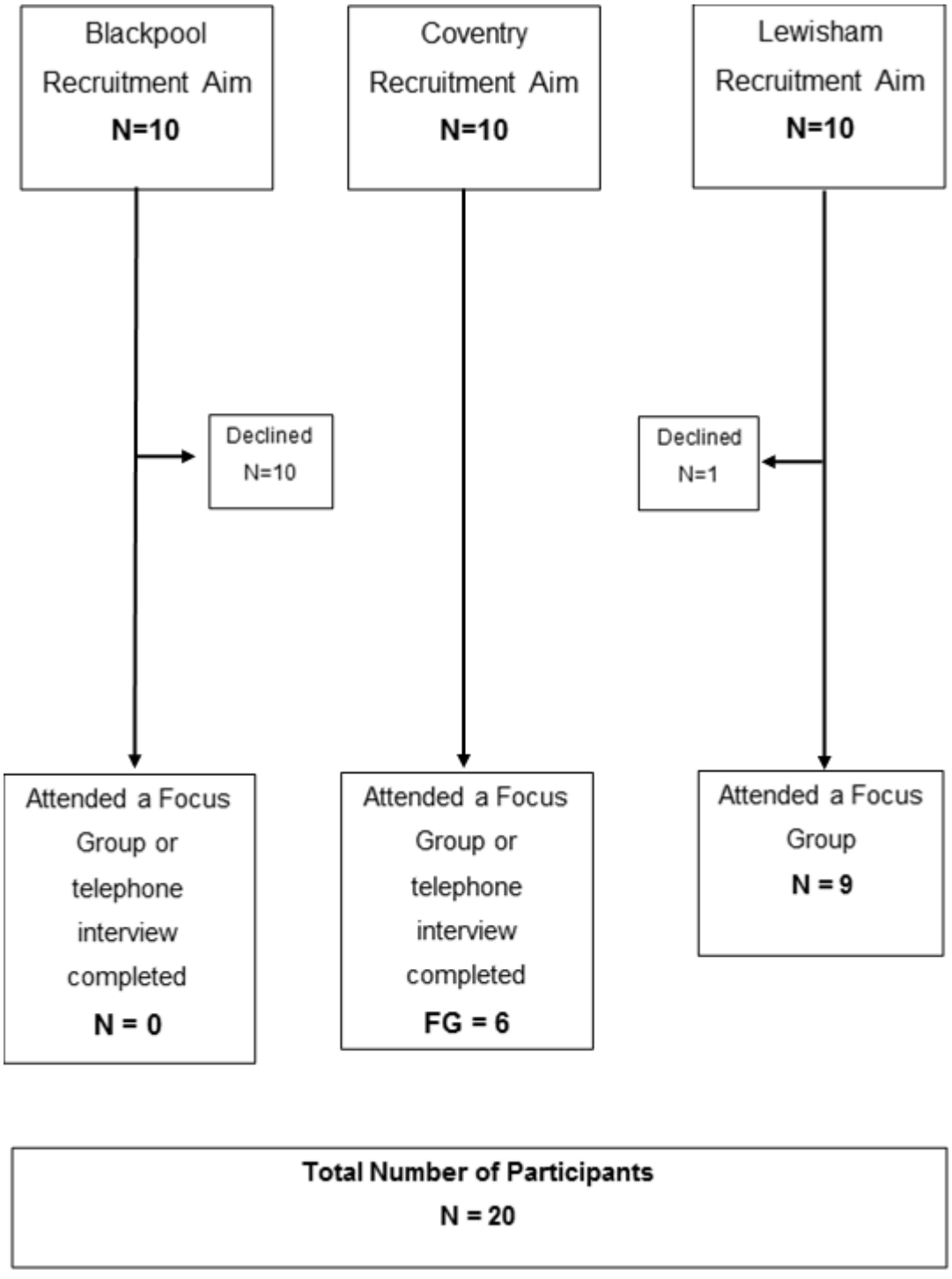
Sample and recruitment

The same rationale was used for gaining HCPs' views (n=30, 10 from each of three sites) as that for first-time mother participants. Overall 20 HCPs participated (figure 2) and the distribution across sites is also described in figure 2. Rich data were collected and data saturation was evident.

Five participant interviews and two focus groups were held consisting of six HCPs from University Hospital Coventry and Warwickshire and nine participants from Lewisham; a breakdown of professional roles per area can be seen in figure 2 below.

To explore any 'added value' of the Baby Buddy app in supporting mothers, partners/supporters and their babies, views from HCPs were sought. Awareness of the Baby Buddy app and the barriers and facilitators to the integration of the app to usual service delivery was also explored. Participants were encouraged to contribute to a shared, integrated perspective in evaluating the app of 'what works well' and 'what could work better' in integrating the use of the app into healthcare encounters. This was an important aspect of the study, in which the process and potential of using the app to augment and enhance service delivery was explored.

Figure 2: Recruitment of HCPs



Barriers to recruitment

There were difficulties in engaging HCPs with this element of the research study. Whilst communication with all three sites was maintained and information about the study was distributed to practitioners via managers, it was very difficult for midwifery teams to release staff. This was especially true for attendance at the focus group session. In Lewisham, we negotiated to hold a focus group alongside a regular team meeting, which made it convenient for staff to attend. Attempts were made to replicate this in Blackpool but, due to service demands, we were unable to achieve this. All options were offered to Blackpool, however a solution was not able to be negotiated to meet with HCPs. Blackpool also asked for backfill costs for their staff to attend the focus groups or interviews which we were unable to provide.

It could be suggested that HCPs in Coventry were more available to the local Coventry University team which, in turn, facilitated contact and professional relationships, due to local networks.

Data analysis approaches

In contrast to the emergent approach taken in analysing the data from first-time mothers, interview and focus group data for the HCPs were analysed via the Normalisation Process Theory (NPT) Framework (May *et al.,* 2009). This theory aims to understand social processes through new or modified practices of thinking and acting in organising work operationalised into healthcare settings.

This approach proposes four preconditions for successful integration of e-health systems into routine practice, which includes Implementation, Adoption, Translation and Stabilization (May *et al.,* 2003)(table 2). May *et al* (2003) suggest that these four factors are preconditions of success or failure of implementation. The theoretical constructs that support the generalisability of findings in qualitative investigation are outlined as the four propositions below leading to the fifth proposition of normalisation, which underpins the theory.

Table 2: The five propositions leading to normalisation of a healthcare delivery system (May *et al*., 2003)

P_1: Implementation	Depends on a positive link with a (local or national) policy level sponsor so that telemedicine is defined as an appropriate means of delivering care and appropriate infrastructures are developed.
P_2: Adoption	Depends on successful integration at the level of structural legitimation so that it is supported and thus practically incorporated into health care delivery through the development of organizational structures.
P_3: Translation	Depends on the enrolment of heterogeneous actors into relatively cohesive cooperative groups in which functional identities are negotiated and established *a priori* and powers relatively well defined.
P4: Stabilisation	Depends on integration at the level of professional knowledge and practice where clinicians are able to accommodate telemedicine in their clinical activities through the development of new procedures and protocols
P5: Normalisation	A means of health care delivery (in whatever setting and at whatever level of health care provision) is conditional on $P_1 + P_2 + P_3 + P_4$.

This NPT provided the analysis framework for analysing how HCPs successfully integrated the Baby Buddy app into practice to identify the elements of success or failure in normalisation of the app in practice. Consequently, the flexible interview tool was mapped to NPT to ensure that the data captured would support this analysis. The analysis informed understanding of the mechanism of change from a practitioner perspective and allowed for consideration of key barriers to the successful delivery and integration of the Baby Buddy app at the level of the system. The NPT findings were then underpinned with the Appreciative Inquiry approach for the overall qualitative arm of this report.

The result of the research approaches that we implemented, was a dataset of rich and detailed data. The two data collection methods provided two rich sets of data which were directly comparable due to the consistency of the interview schedules the team employed. The same themes were explored for each collection method. Therefore, the data could be analysed using the same methods.

2.5: IN-APP DATA

2.5.1: INTRODUCTION

The purpose of collecting the Baby Buddy in-app data within BaBBLeS were two-fold:

- To explore how the first-time mothers in the study used the Baby Buddy app
- To explore the Baby Buddy in-app data for the uptake, patterns of usage and detailed analytics of key factors within the app was collected from downloads provided by Best Beginnings and Despark, the app developers
- To examine Baby Buddy users' in-app data to investigate whether levels of app usage affected the outcomes (TOPSE and WEMWBS).

2.5.2: METHODS

As described above (section 2.2.4), at the 35 weeks gestation data collection time-point, all participants were sent a specific consent form to complete if they were willing to have their in-app data made available to the research team. A signed consent form was received from 98 participants which gave permission for their entire history of the Baby Buddy in-app data to be analysed. Of these, just 61 participants could be identified in the Best Beginnings' Baby Buddy app database. The participants' email addresses were used as one method by which to link the in-app data with each participant, some of these had changed from when they downloaded the Baby Buddy app and had to give an email for registration purposes. Ten participants were either inactive in the app after registration or there were too many missing fields, therefore 51 participants were included in the in-app regression analyses. These were participants who had provided valid outcome data at baseline (i.e. TOPSE or WEMWBS data) and who also responded at 3 months post-birth (providing valid outcome data).

Barriers to accessing the in-app data

The Baby Buddy in-app data were provided by Best Beginnings and Despark using an anonymised coding system to prevent participants' identifiable information being recorded in any dataset but still enabling the research team to match a unique identification code with data collected from the questionnaires. The research team provided Best Beginnings and Despark with a list of email addresses and unique identification codes for the participants who had given consent for their in-app data to be made available to the research team. The data provided by BB included only unique identification codes and, for some participants, the email address they had used to register with the Baby Buddy app was different to the one that they had given the research team when recruited and therefore it was impossible to retrieve their data.

The raw Baby Buddy in-app data were provided in two separate files which were (1), user properties which included information such as: overall and average frequency of use, some user information (e.g., avatar type selected, signup date, or and specific information about mobile platform and app version, and (2) user events with specific in-app activities including participants' searches, URLs opened, questions and videos viewed. All data were cleaned for empty values and consistency, pre-processed, analysed and visualised in R statistical programming language.

Data analysis

An exploratory analysis of the in-app activity was conducted using the methods described below:

- The average amount of use of the app measured in minutes/seconds (note: raw data were provided in average session durations per full day or week, depending on participants' frequency of app use). The duration of time spent using the app could not be retrieved from the time stamps in the activity data due to the lack of a timestamp that would indicate the end of the usage. The aim had been to describe the amount of time spent on the app each time it was accessed. In place of this, the median and standard deviation was calculated to reflect the average use of the app per time period. We calculated median instead of mean because the frequency of app use data was normally distributed. Pearson's correlations were undertaken to explore the relation between average use of the app and the total number of sessions

- The following aspects were explored: the number of times the Baby Buddy app was used by specific users, the times of the day when the app was used and the features that were used most frequently and at what times of the day

- The frequency of the specific types of in-app options and features were identified for each participant

- A sentiment analysis and frequency analysis was also undertaken on the words used by the participants for in-app searches. Text mining was conducted with the R statistical programming language on the entire in-app search text, with tokenisation to brake it into separate words, remove the contextually irrelevant words (e.g. baby, week), punctuation and capitalization. Two sentiment lexicons were used to quantitatively score the words: binary sentiment lexicon from Bing and collaborators (Bing Liu *et al.*, 2005; Bing, 2012), and NRC Word-Emotion Association Lexicon (Mohammad and Turney, 2010; 2013).

Additional analysis

As requested by the funders, an additional analysis was undertaken to investigate how levels of app usage affected outcomes (i.e. TOPSE and WEMWBS scores). As described above (section 2.2.4), participants interested in taking part in this additional "in-app study" provided informed consent at the time of the 35 weeks gestation data collection. This extra analysis included quantifying the following elements of the Baby Buddy app usage: 'Today's Information', 'Videos', 'Ask Me', 'Remember to Ask', 'You can Do it', 'Bump Around/Baby Around', 'Baby Book/Bump Book', 'Baby Booth/Bump Booth', and 'What does it Mean?'. Based on advice from a team member who has expertise in the analysis of in-app data, 'session count,' or number of times the app was opened, was considered to be the most suitable indicator of app usage. This is the variable that has been used for overall app usage.

For the total app usage, the TOPSE scores were plotted against the overall difference in TOPSE scores. In addition, to assess the distribution of TOPSE data, a separate file was created with three columns: i) time point, ii) TOPSE scores, iii) in-app participant. The first column (i) included three groups: (1) baseline, (2) 35 weeks gestation and (3) 3 months post-birth. The second column (ii), containing all TOPSE scores across the three time points, was a scale variable. The third column (iii) included two groups: (1) those participants from the final sample (n=296) and those from the in-app study (n=48). Thus, the rows on this file were TOPSE scores reported throughout the study (n=888). Scatter plots of these variables across the three time points were created.

Within each of the app elements, there were various possible activities; for example, for the app element 'You can do it', we took into account a), whether this app element was opened b), whether a goal was created and c), whether a goal was completed. The session counts of each app element's activities were summed and the following two overall aggregated scores were derived for the data analysis to describe two different types of app user:

- ‘Engaged’ type of user overall score: based exclusively on the Today’s Information’ element, including whether this feature had been opened, whether links were followed, and whether participants tapped on, ‘Read more’. This was an engaged type of use of the app mostly involving viewing and clicking and therefore less goal-oriented than highly engaged

- ‘Highly engaged type of use of the app: based on the overall score from all the other app elements decribed above. This was a more proactive type of interaction with the app; for example, users had to specifically search for information or videos, or set up reminders.

Logistic regression models were developed to compare the outcomes (TOPSE and WEMWBS) of higher/low app users and high versus non-app users. This was undertaken for each of the above aggregated scores (the two types of app usage) but, due to the data being negatively skewed, the same binary outcomes from previous analyses were used. As described for the survey analysis, two regression models were undertaken, one unadjusted (model 1) and one that adjusted for potential confounders (model 2)(see section 2.3.7 for details). The number of participants included in this analysis were relatively small (n=51). To ensure that the viability of the model was maximised, care was taken when considering which confounding variables were to be included. Therefore, differences between high/low and high versus non-app users were tested and those which were shown to be significant were selected. The baseline outcome levels, for TOPSE and WEMWBS, were variables that were maintained in the model since they needed to be controlled for.

CHAPTER 3: COHORT STUDY RESULTS

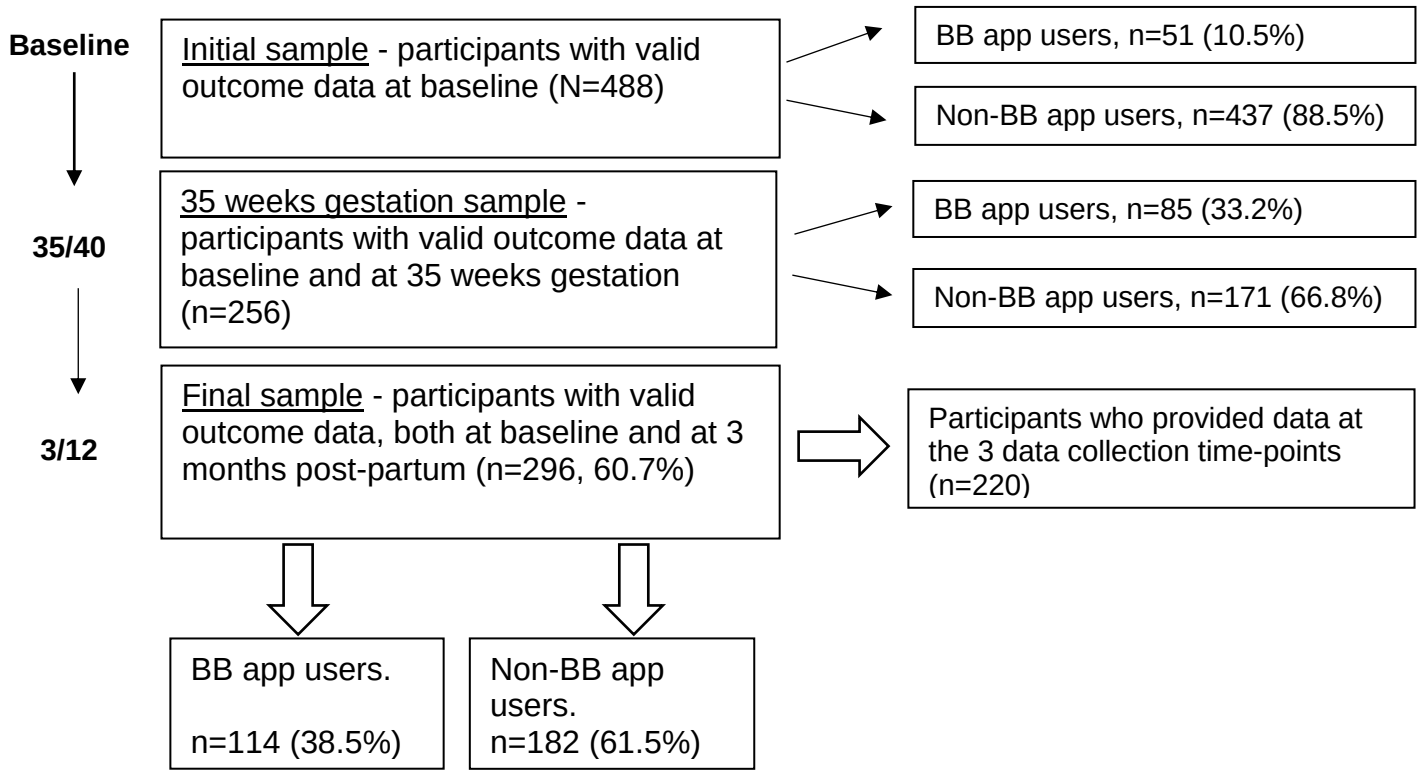
3.1: PARTICIPANTS

3.1.1: FLOW OF PARTICIPANTS

A total of 488 participants provided valid data at baseline, i.e., TOPSE data and/or WEMWBS data (initial sample). Of this initial sample, 256 participants (52.5%) provided valid data at 35 weeks gestation. Of the initial sample, 296 (60.7%) provided valid data at 3 months post-birth; this was the sample used in the main analysis, hereinafter referred to as the final sample. There were 220 participants (45.1%) who provided data at all three data collection time-points. The participant flow is presented in figure 3.

Of the 296 participants followed to 3 months post-birth, 114 reported to be Baby Buddy app users (38.5%), i.e. they had reported using the Baby Buddy app at one or more of the three data collection time-points. This 38.5% corresponds roughly to a ratio of 1 to 2, i.e. one reported app user for every two non-app users.

Figure 3: Participant flowchart



3.1.2: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS BY RECRUITMENT SITES

The distribution of participants in the initial sample (N=488) by recruitment site was as follows: 168 were from the Coventry area (34.4%), 139 from Lewisham (28.5%), 66 from Bradford (13.5%), 62 from Blackpool (12.7%) and 53 from Leicester (10.9%)(table 3).

Socio-demographic characteristics of participants by recruitment site are summarised in table 3. There was considerable variation in age, socio-economic deprivation (IMD), ethnicity, education and employment status of participants across the five sites. The average age ranged from 25 years old in Bradford to 31 years old in Lewisham and the average IMD decile score varied from 2 in Bradford to 6 in Leicester (lower IMD deciles mean higher levels of deprivation). Blackpool was the site where most participants identified themselves as White British (n=56, 94.9%) whereas Lewisham was where most women identified themselves as being from an ethnicity other than White British (n=73, 54.1%). In Bradford, 22 women held a degree (34.4%), half the rate of Lewisham (n=96, 69.6%). The majority of participants were in paid employment (from 73.4% in Bradford to 90.3% in Lewisham) and were married or in a relationship (between 80%-90% across all sites)(table 3).

Table 3: Baseline characteristics of initial sample by recruitment site (N=488)

	Blackpool	Bradford	Coventry	Leicester	Lewisham	**Total across sites**
Median (LQ-UQ) [a]*:*						
Age	27 (23-32)	25 (22-28)	28 (24-31)	28 (25-32)	31 (27-34)	**28 (24-32)**
IMD decile [b]	5 (2-6)	2 (1-4)	5 (2-7)	6 (4-8)	4 (2-5)	**4 (2-6)**
n (%):						
Ethnicity						
- White British	56 (94.9%)	32 (52.5%)	115 (70.6%)	40 (75.5%)	62 (45.9%)	**305 (64.8%)**
- Other	3 (5.1%)	29 (47.5%)	48 (29.5%)	13 (24.5%)	73 (54.1%)	**166 (35.2%)**
Highest education						
- Degree or higher	25 (41.0%)	22 (34.4%)	77 (46.7%)	25 (48.1%)	96 (69.6%)	**235 (49.0%)**
- No degree	36 (59.0%)	42 (65.6%)	88 (53.3%)	27 (51.9%)	42 (30.4%)	**245 (51.0%)**
Employment						
- In paid employment	50 (83.3%)	47 (73.4%)	144 (86.8%)	50 (94.3%)	121 (90.3%)	**412 (86.4%)**
- Not in paid employment	10 (16.7%)	17 (26.6%)	22 (13.3%)	3 (5.7%)	13 (9.7%)	**65 (13.6%)**
Relationship						
- Married or living with partner	49 (80.3%)	53 (80.3%)	141 (83.9%)	43 (81.1%)	122 (87.8%)	**408 (83.8%)**
- Not married or not living with partner	12 (19.7%)	13 (19.7%)	27 (16.1%)	10 (18.9%)	17 (12.2%)	**79 (16.2%)**

[a] Med: Median; LQ-UQ: Lower quartile – Upper quartile.
[b] IMD: Index of Multiple Deprivation, based on postcode. Decile 1=most deprived; decile 10=least deprived.

3.1.3: BASELINE DATA OF THE FINAL SAMPLE BY BABY BUDDY USE

Baseline characteristics of participants included in the final sample are presented by app use in table 4. App users (n=114) were comparable to non-app users (n=182) in age, IMD decile, ethnicity, highest education attained, employment and relationship status.

Table 4: Baseline characteristics of the final sample by reported app use (n=296)

	Baby Buddy users [a] (n=114)			Non-Baby Buddy users (n=182)			Differences between app users and non-app users [b]
Variable	n missing	n (%)	Med (LQ-UQ) [c]	n missing	n (%)	Med (LQ-UQ) [c]	
Age (continuous)	4		29.5 (26-33)	3		29 (25-33)	Z=-0.85, p=.396
By group:							
16 – 24 years		17 (15.5%)			41 (22.9%)		
25 – 34 years		77 (70.0%)			115 (64.3%)		
35 years or above		16 (14.6%)			23 (12.9%)		
IMD decile (continuous) [d]	1		4 (2-6)	4		4 (3-7)	Z=1.36, p=.176
By group:							
1 to 3 (most deprived)		49 (43.4%)			67 (37.9%)		
4 to 6		42 (37.2%)			64 (36.0%)		
7 to 10 (least deprived)		22 (19.5%)			47 (26.4%)		
Ethnicity	3			5			
- White British		67 (60.4%)			125 (70.6%)		$X^2(1)=3.23$, p=.072
- Other [e]		44 (39.6%)			52 (29.4%)		
Highest education	1			3			
- Degree or higher		65 (57.5%)			106 (59.2%)		$X^2(1)=0.08$, p=.774
- No degree		48 (42.5%)			73 (40.8%)		
Employment	3			1			
- In paid employment		97 (87.4%)			163 (90.1%)		$X^2(1)=0.50$, p=.479
- Not in paid employment		14 (12.6%)			18 (9.9%)		
Relationship	1			0			
- Married or living with partner		102 (90.3%)			161 (88.5%)		$X^2(1)=0.23$, p=.628
- Not married or not living with partner		11 (9.7%)			21 (11.5%)		

[a] App users are those who reported using the app at one or more data collection time-points

[b] Z: based on Mann-Whitney test; X^2: based on chi-squared test; n missing=number of missing responses

[c] Med: Median; LQ-UQ: Lower quartile – Upper quartile.

[d] IMD: Index of Multiple Deprivation, based on postcode.

[e] Ethnicity: 'Other' includes White Irish (n=3), White Other European (n=32), White Other (n=9), Asian or Asian British Pakistani (n=17), Asian or Asian British Bangladeshi (n=3), Asian or Asian British Indian (n=13), Asian or Asian British Chinese (n=4), Asian or Asian British Other (n=6), Black or Black British Caribbean (n=3), Black or Black British African (n=4), and Mixed (n=2).

Table 5: Baseline technology use, information sources and social support for those in the final sample by reported app use (n=296)

	Baby Buddy users (n=114)			Non-Baby Buddy users (n=182)			Difference tests between app users and non-app users [a]
	n missing	n (%)	Med (LQ-UQ)	n missing	n (%)	Med (LQ-UQ)	
Use of mobile phone	0	114 (100%)		1	181 (100%)		-
Use of tablet	0	75 (65.8%)		2	119 (66.1%)		$X^2(1)=0.00$, p=.955
Access to internet on mobile	1	113 (100%)		2	180 (100%)		-
Access to internet at home	0	113 (99.1%)		1	179 (98.9%)		-
Pregnancy/parenthood apps §	0	92 (80.7%)		1	126 (69.6%)		$X^2(1)=4.46$, p.=.035*
Heard about pregnancy/parenthood apps from [b]:	1			0			
- Midwife		32 (35.2%)			22 (17.3%)		
- Health visitor		0 (0.0%)			0 (0.0%)		
- GP		5 (3.9%)			5 (5.5%)		$X^2(1)=7.84$, p=.005*
- Other HCPs		3 (3.3%)			2 (1.6%)		
- Partner		2 (2.2%)			4 (3.2%)		
- Friends		31 (34.1%)			45 (35.4%)		
- Posters at GP clinic/hospital		4 (4.4%)			2 (1.6%)		
- Internet search		43 (47.3%)			66 (52.0%)		
- Books or magazines		7 (7.7%)			4 (3.2%)		
- Other [c]		13 (14.3%)			22 (17.3%)		
Sources of information about pregnancy and parenthood [b]:	1			3			
- Midwife		84 (74.3%)			127 (71.0%)		
- Health visitor		4 (3.5%)			6 (3.4%)		
- GP		26 (23.0%)			51 (28.5%)		
- Other health professionals		1 (0.9%)			4 (2.2%)		
- Partner		22 (19.5%)			42 (23.5%)		$X^2(1)=0.12$, p=.729
- Friends		92 (82.4%)			137 (76.5%)		
- Posters at GP surgery/clinic/hospital		7 (6.2%)			14 (7.8%)		
- Apps		68 (60.2%)			79 (44.1%)		
- Internet search		100 (88.5%)			148 (82.7%)		
- Books or magazines		46 (41.7%)			66 (36.9%)		
- Other [d]		10 (8.9%)			31 (17.3%)		
MTUAS [e]:							
- Text messaging	0		6 (6-6)	1		6 (6-6)	
- Phone calling	0		6 (5-6)	1		6 (5-6)	
- Smartphone use	0		6 (6-6)	1		6 (6-6)	
- Internet searching	0		6 (5-6)	1		6 (5-6)	
- Social media	0		4 (3-5)	1		4 (3-5)	
- Overall	0		5 (5-5)	1		5 (5-5)	Z=-0.64, p=.524
MSPSS [f]:							
- Significant other	0		28 (27-28)	1		28 (28-28)	
- Family	0		28 (25-28)	0		28 (25-28)	
- Friends	0		26 (24-28)	1		28 (24-28)	
- Overall	0		81 (75-84)	1		83 (77-84)	Z=2.12, p=.034*

*p<.05;

[a] Z: based on Mann-Whitney test; X^2: based on chi-squared test.

[b] Pregnancy/parenthood apps: any pregnancy and/or parenthood- related apps reported by participants at baseline. Multiple responses allowed for the questions on how women heard about the apps and on sources of information about pregnancy and parenthood. Due to low number cells, a binary variable was created for each of these two variables and used for the difference tests, as follows: heard about apps from healthcare professionals (HCPs) vs did not hear about the apps from HCPs; HPs are a source of information vs HCPs are not a source of information.

[c] For how women heard about the apps: the most common source in 'other' responses was the app store.

[d] For sources of information: baseline - the most common 'other' source was the family, particularly the mother, which was unintentionally omitted from the list at baseline (it was added to the list after baseline).

[e] MTUAS: Media and Technology Usage and Attitudes Scale. Score range is 1-6; higher scores → higher technology use.

[f] MSPSS: Multidimensional Scale of Perceived Social Support. Sum score range is 12-84; sum score range for the three subscales is 4-28. Higher scores → higher perceived social support.

Baseline information on generic technology use for participants included in the final sample as an indicator of propensity to use technology, as well as baseline information about sources of information about pregnancy and/or parenthood and social support, are presented by reported app use (table 5).

In the final sample, terms of mobile phone use, tablet use, having access to the internet on a mobile phone or at home, there were no significant baseline differences between Baby Buddy app users and non-app users. There were also no significant baseline differences in the sources of information about pregnancy and parenthood between the two groups or in terms of general technology use. All participants used a mobile phone and had internet access. Nearly all had internet at home (app users 99.1%; non-app users 98.9%). Most participants used a tablet (Baby Buddy users 65.8%; non-Baby Buddy users 66.1%). In both groups, the three top sources of information about pregnancy and parenthood were the internet (app users 88.5%; non-app users 82.7%), friends (app users 82.4%; non-app users 76.5%) and midwife (app users 74.3%; non-app users 71.0%). For both Baby Buddy app users and non-app users, the overall median MTUAS score was 5. No threshold exists to distinguish 'high technology use' from 'low technology use' but scores can be used for comparison between groups as in the present study (Rosen *et al.*, 2013).

At baseline, Baby Buddy app users were significantly more likely to use any pregnancy/parenthood apps (not just the Baby Buddy app) than non-app users, 80.7% vs 69.6%, p=.035. Baby Buddy users were also more likely to have heard about the pregnancy apps they used from healthcare professionals (HCPs) than non-Baby Buddy app users (p=.005). On the overall MSPSS score, app users had a significantly lower median score (81) than non-app users (83), p=.034; this indicates lower levels of perceived social support amongst Baby Buddy app users.

As Baby Buddy app users were more likely to use other pregnancy apps than non-Baby Buddy app users, we adjusted for this in the analysis, in addition to adjusting for general technology use.

Baseline data for the outcome variables are presented on table 6. At baseline, Baby Buddy app users and non-app users scored very similarly on the antenatal TOPSE and on the WEMWBS. The median score for the TOPSE was 317 (range 0-360) for the Baby Buddy app users with a lower and upper quartile of 287 and 337, respectively (table 6). For the non-app users, the median was 320, with a lower and upper quartile of 295 and 337, respectively. For the Baby Buddy app users, the median score for the WEMWBS (range was 54 with a lower and upper quartile of 45 and 59, respectively. For the non-app users, the median score for the WEMWBS was 54 (range 14-70) with a lower and upper quartile of 48 and 61, respectively. All these are high for both the TOPSE and WEMWBS and therefore difficult to increase at later time-points.

The scores also indicate the nature of the data. There were no statistically significant differences between the Baby Buddy app users and non-app users for either the TOPSE or WEMWBS (table 6).

Table 6: Baseline scores of TOPSE and WEMWBS of participants in the final sample by reported app use (n=296)

Variable	**Baby Buddy users** (n=114)		**Non-Baby Buddy users** (n=182)		Difference tests between app users and non-app users [a]
	n missing	Median (LQ – UQ)	n missing	Median (LQ – UQ)	
TOPSE subscale [b]:					
- Emotion & affection	3	55 (50-58)	6	56 (52-59)	
- Play & enjoyment	2	59 (55-60)	4	59 (56-60)	
- Empathy & understanding	2	55 (48-58)	4	55 (50-60)	
- Pressures	4	42 (33-48)	2	40 (32-50)	
- Self-acceptance	2	54 (48-59)	6	55 (48-59)	
- Learning & knowledge	2	53 (49-58)	1	56 (51-60)	
TOPSE Overall	6	317 (287-337)	13	320 (295-337)	Z=1.03, p=.302
WEMWBS overall [c]	2	54 (49-59)	3	54 (48-61)	Z=0.45, p=.655

[a] based on Mann-Whitney test.

[b] TOPSE: Tool to Measure Parenting Self-Efficacy; 36 items, 6 subscales (6 items per subscale). Subscale score range is 0-60; Overall score range is 0-360. Items 6, 19, 20, 21, 27 were reverse scored. Higher scores → higher self-efficacy. An adapted antenatal version of the TOPSE was used at baseline and 35-40 weeks; the (already existing) postnatal TOPSE was used at follow up.

[c] WEMWBS: Warwick-Edinburgh Mental Well-being Scale. Only one overall score 14-70. Higher scores → higher well-being.

At three months post-birth, we collected data on childbirth experience using the Childbirth Experience Questionnaire (CEQ) (Walker *et al.*, 2015). There is no score threshold to distinguish a positive from a negative childbirth experience; scores are only used for comparisons between groups. We report the descriptive statistics for CEQ scores by Baby Buddy app use in table 7, together with data on self-reported breastfeeding, i.e., the intention to breastfeed at baseline and actual breastfeeding at post-birth.

Table 7: Childbirth experience and breastfeeding of participants in the final sample by reported app use (n=296)

	Baby Buddy user (n=114)		**Non-Baby Buddy user** (n=182)		
	n (%)	Med (LQ – UQ) [a]	N (%)	Med (LQ – UQ)	Differences between app users and non-app users
CEQ Subscales [b]: - Own capacity - Professional support - Perceived safety - Participation CEQ Overall score		 2.4 (2.1-2.5) 1.4 (1.0-2.0) 2.2 (1.8-2.5) 2.0 (1.0-2.3) 2.0 (1.7-2.3)		 2.4 (2.1-2.6) 1.4 (1.0-2.0) 2.0 (1.8-2.5) 2.0 (1.0-2.5) 2.0 (1.6-2.3)	 Z=-0.04, p=.969
Baseline intention to breastfeed [c] at 1 week post-birth	101 (88.6%)		149 (83.7%)		$X^2(1)=1.35$, p=.246
Baseline intention to breastfeed at 1 month post-birth	91 (84.3%)		135 (79.4%)		$X^2(1)=1.02$, p=.312
Baseline intention to breastfeed at 3 months post-birth	78 (78.0%)		116 (72.5%)		$X^2(1)=0.98$, p=.322

[a] Med – Median; LQ – Lower Quartile; UQ – Upper quartile.

[b] CEQ: Childbirth experience questionnaire; subscale and overall mean scores; score range 1 to 4; higher scores reflect a more positive childbirth experience.

[c] Breastfeeding includes both breastfeeding as the exclusive feeding method as well as breastfeeding in combination with formula milk, compared to formula milk only or not sure.

- N missing per variable amongst app users (N=113): CEQ own capacity (n=0), CEQ professional support (n=0), CEQ perceived safety (n=0), CEQ participation (n=3), CEQ overall (n=3), breastfeeding at 1 week post-birth (n=0), breastfeeding at 1 month post-birth (n=6), breastfeeding at 3 months post-birth (n=14). N missing per variable amongst non-app users (N=181): CEQ own capacity (n=0), CEQ professional support (n=0), CEQ perceived safety (n=0), CEQ participation (n=4), CEQ overall (n=4), breastfeeding at 1 week post-birth (n=4), breastfeeding at 1 month post-birth (n=12), breastfeeding at 3 months post-birth (n=21).

Data presented in table 7 describe comparable levels of satisfaction with participants' childbirth experience between Baby Buddy app users and non-app users in the overall score and across all four CEQ subscales. Levels of intended breastfeeding at baseline were found to be higher amongst Baby Buddy app users but differences were not statistically significant.

3.1.3 How Baby Buddy app users heard about the app

At baseline, in keeping with the observational nature of the study, we asked all participants how they had heard about the pregnancy/parenthood apps they were using, not specifically how they had heard about the Baby Buddy app. At 35 weeks gestation and at 3 months post-birth, we asked participants, if they had used the Baby Buddy app specifically how they had heard about the app. This information is presented in table 8.

Table 8: How Baby Buddy users heard about the app

	35 weeks Baby Buddy users (n =85)	**3 months post-birth Baby Buddy users** (n=114)
Heard about Baby Buddy from [a]:		
Midwife	47 (55.3%)	58 (56.3%)
Health visitor	5 (5.9%)	14 (13.6%)
GP	17 (20.0%)	30 (29.1%)
Other healthcare professionals (HCPs)	17 (20.0%)	7 (6.8%)
Partner or family	1 (1.2%)	8 (7.8%)
Friends	4 (4.7%)	5 (4.9%)
Posters at GP surgery/clinic/hospital	17 (20.0%)	27 (26.2%)
Internet	1 (1.2%)	8 (7.8%)
Books or magazines	0 (0.0%)	2 (1.9%)
Other sources [b]	27 (31.8%)	10 (9.7%)

[a] Multiple responses allowed.
[b] 'Other' sources at both time-points included the BaBBLeS questionnaire and hospital staff (non-HCPs).

Most app users had been told about it by a midwife, both at 35 weeks gestation (n=47, 55.3%) and at 3 months post-birth (n=58, 56.3%). GPs and posters at clinic were other sources reported by 20% to 30% of participants at both time-points.

3.1.4 Baseline differences between initial sample and final sample

To investigate how representative the final sample was of the initial sample, baseline differences between the initial sample (N=488) and the final sample were assessed (n=296). As explained earlier, the final sample is a subsample of the initial one. Baseline socio-demographic characteristics of participants in the two samples are presented in table 9.

At baseline, participants included in the final sample were older compared to those in the initial sample (median age 29 years vs 28 years, p=.040) and were more likely to be married or live with a partner (89.2% vs 83.8%, p=.037). The age of participants ranged from 16 to 46 years old in both samples. There were no differences between the initial and final samples in respect of IMD scores, ethnicity, education level or employment. Baseline characteristics at the three data collection time-points can be found in appendix 7, table 1.

Table 9: Baseline characteristics of the initial sample and of the final sample

	Initial sample (N=488)		**Final sample** (n=296)		Differences initial vs final samples [a]
Variable	n (%)	Med (LQ-UQ) [b]	n (%)	Med (LQ-UQ)	
Age		28 (24-32)		29 (26-33)	z=-2.06, p=.040*
By group:					
16 – 24 years	129 (27.3%)		58 (20.1%)		
25 – 34 years	284 (60.0%)		192 (66.4%)		
35 years or above	60 (12.7%)		39 (13.5%)		
IMD decile [c]		4 (2-6)		4 (3-6)	z=-1.29, p=.197
By group:					
1 to 3 (most deprived)	201 (42.5%)		116 (39.9%)		
4 to 6	173 (36.6%)		106 (36.4%)		
7 to 10 (least deprived)	99 (20.9%)		69 (23.7%)		
Ethnicity [d]					
- White British	305 (64.8%)		192 (66.7%)		$X^2(1)=0.26$, p=.607
- Other	166 (35.2%)		96 (33.3%)		
Highest education					
- Degree or higher	235 (49.0%)		171 (58.6%)		$X^2(1)=3.64$, p=.056
- No degree	245 (51.0%)		121 (41.4%)		
Employment					
- In paid employment	412 (86.4%)		260 (89.0%)		$X^2(1)=1.35$, p=.244
- Not in paid employment	65 (13.6%)		32 (11.0%)		
Relationship					
- Married or living with partner	408 (83.8%)		263 (89.2%)		$X^2(1)=4.36$, p=.037*
- Not married or not living with partner	79 (16.2%)		32 (10.9%)		

*p<.05.

Note: The final sample is a subsample of the initial sample.

[a] Z: based on Mann-Whitney test; X^2: based on chi-squared test.

[b] Med: Median; LQ-UQ: Lower quartile – Upper quartile.

[c] IMD: Index of Multiple Deprivation, based on postcode; from decile 1 (most deprived) to decile 10 (least deprived).

[d] Ethnicity: At baseline, 'Other' includes White Irish (n=5), White Other European (n=59), White Other (n=12), Asian or Asian British Pakistani (n=28), Asian or Asian British Bangladeshi (n=4), Asian or Asian British Indian (n=20), Asian or Asian British Chinese (n=5), Asian or Asian British Other (n=8), Black or Black British Caribbean (n=7), Black or Black British African (n=12), Mixed (n=3), Any Other (n=3). No one replied 'I do not wish to say'; 17 participants (out of 488) did not to answer this question.

- N missing per variable at baseline (N=488): age (n=15), IMD decile (n=15), ethnicity (n=17), highest education (n=1), employment (n=11) and relationship status (n=1). N missing per variable at 35-40 weeks gestation (N=256): age (n=6), IMD decile (n=4), ethnicity (n=6), highest education (n=4), employment (n=5) and relationship status (n=1). N missing per variable at 3 months post-birth (N=294): age (n=7), IMD decile (n=5), ethnicity (n=8), highest education (n=4), employment (n=4) and relationship status (n=1).

The differences at baseline between initial and final samples in terms of MSPSS scores, MTUAS scores, use of pregnancy/parenthood apps, use of the Baby Buddy app, TOPSE scores and WEMWBS scores were not statistically significant (table 10). At baseline, the

intention to breastfeed was higher in the final sample compared to the initial sample: this was marginally statistically significant with respect to the intention to breastfeed at 1 week post-birth (*p*=.045)(table 10).

Table 10: Baseline breastfeeding intentions, social support, technology use and outcome scores of the initial sample and of the final sample

	Initial sample (N=488)		**Final sample** (n=296)		
Variable	n (%)	Med [a] (LQ-UQ)	n (%)	Med (LQ-UQ)	Differences initial vs final samples [g]
Intention to breastfeed [b] at: - 1 week post-birth - 1 month post-birth - 3 months post-birth	 382 (79.9%) 353 (74.9%) 306 (65.4%)		 250 (85.6%) 227 (78.8%) 195 (67.9%)		 $X^2(1)=4.00$, p=.045* $X^2(1)=1.49$, p=.223 $X^2(1)=0.52$, p=.470
Social support (MSPSS) [c], subscales: - Significant other - Family - Friends - Overall		 28 (28-28) 28 (25-28) 27 (24-28) 81 (74-84)		 28 (28-28) 28 (25-28) 27 (24-28) 82 (76-84)	 Z=-0.92, p=.356
Technology use (MTUAS)[d], overall		5.1 (4.8-5.4)		5.1 (4.8-5.4)	Z=0.49, p=.626
Uses pregnancy/ parenthood app(s)	355 (73.1%)		218 (73.9%)		$X^2(1)=0.07$, p=.794
Uses or has used Baby Buddy app	51 (14.3%)		33 (15.1%)		$X^2(1)=0.07$, p=.796
Self-efficacy (TOPSE) [e], overall		319 (295-340)		318 (293-337)	Z=1.15, p=.250
Mental well-being (WEMWBS) [f], overall		54 (48-60)		54 (48-60)	Z=-0.38, p=.701

*p<.05;

Note: The final sample is a subsample of the initial sample.

- All variables as assessed at baseline.

[a] Med: Median; LQ-UQ: Lower quartile – Upper quartile.

[b] This includes intention to breastfeed only, as well as intention to breastfeed in combination with formula milk.

[c] MSPSS: Multidimensional Scale of Perceived Social Support. Sum score range is 12-84; sum score range for the three subscales is 4-28. Higher scores = higher perceived social support. Subscale data are reported due to the scale being the only one which differed significantly between baseline and 3 months post-birth.

[d] MTUAS: Media & Technology Usage & Attitudes Scale. Score range is 1-6; higher scores = higher technology use.

[e] TOPSE: Tool to Measure Parenting Self-Efficacy; Overall score range is 0-360. Items 6, 19, 20, 21, 27 were reverse scored. Higher scores = higher self-efficacy. An adapted antenatal version of the TOPSE was used at baseline and 35-40 weeks; the (already existing) postnatal TOPSE was used at follow up.

[f] WEMWBS: Warwick-Edinburgh Mental Well-being Scale. Score range 14-70. Higher scores = higher well-being.

[g] Z: based on Mann-Whitney test; X^2: based on chi-squared test.

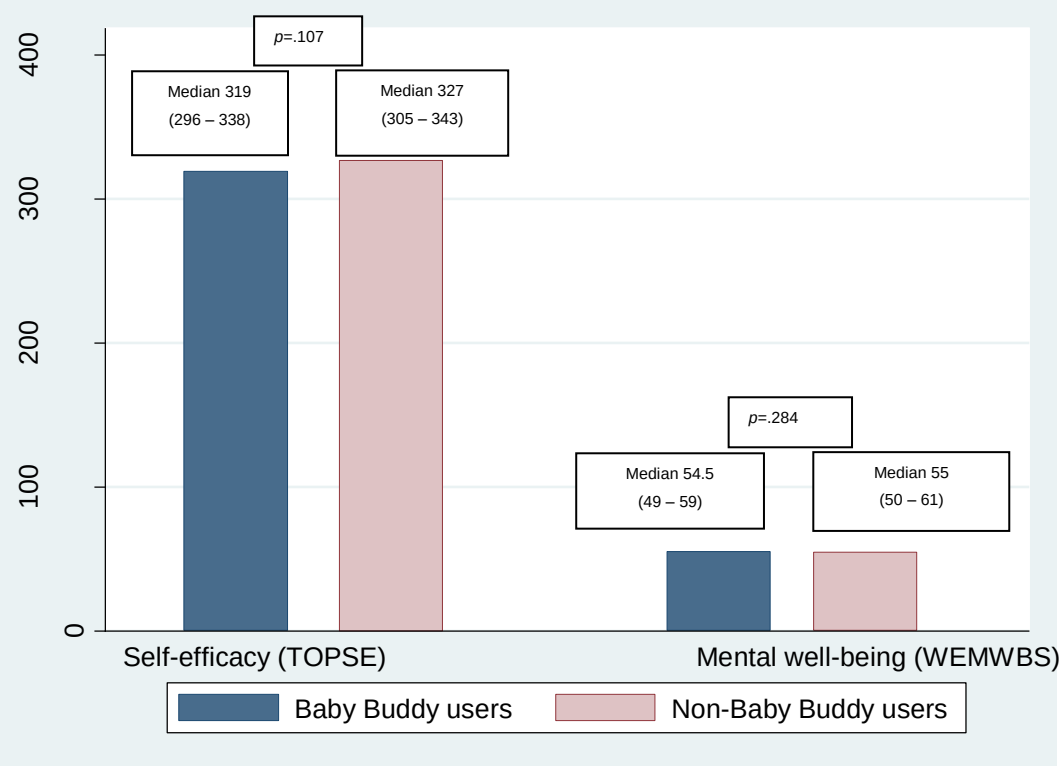
- N missing per variable at baseline (N=488): breastfeeding at 1 week post-birth (n=10), breastfeeding at 1 month post-birth (n=17), breastfeeding at 3 months post-birth (n=20), MSPSS Overall (n=5), MTUAS overall (n=1), use of pregnancy app(s) (n=2), use of Baby Buddy (n=0), TOPSE overall (n=37), and WEMWBS overall (n=10). N missing per variable at 35-40 weeks gestation (N=256): breastfeeding at 1 week post-birth (n=9), breastfeeding at 1 month post-birth (n=13), breastfeeding at 3 months post-birth (n=12), MSPSS Overall (n=5), MTUAS overall (n=3), use of pregnancy app(s) (n=7), use of Baby Buddy (n=0), TOPSE overall (n=16), and WEMWBS overall (n=5). N missing per variable at 3 months post-birth (N=294): breastfeeding at 1 week post-birth (n=4), breastfeeding at 1 month post-birth (n=5), breastfeeding at 3 months post-birth (n=3), MSPSS Overall (n=1), MTUAS overall (n=1), use of pregnancy app(s) (n=0), use of Baby Buddy (n=0), TOPSE overall (n=14), and WEMWBS overall (n=2).

3.2: ANALYSIS

3.2.1: PRIMARY ANALYSIS

In the final sample, the median TOPSE and WEMWBS scores were very similar between Baby Buddy app users and non-Baby Buddy users at 3 months post-birth (figure 4). App users had a median TOPSE score of 319 (Lower Quartile (LQ) 296 – Upper Quartile (UQ) 338), compared to non-app users who had a median TOPSE score of 327 (LQ 305 – UQ 343) (p=.107). Similarly, Baby Buddy app users had a median WEMWBS score of 54.5 (LQ 49 – UQ 59) compared to non-app users who had a median score of 55 (LQ 50 – UQ 61) (p=.284). Neither of these were statistically significant.

Figure 4: Median scores of parental self-efficacy (TOPSE) and maternal wellbeing (WEBWMS) in reported app users compared to non-app users (final sample)



The unadjusted odds ratio for low TOPSE score (i.e. lower self-efficacy) was 1.17 (95% CI 0.68 to 2.03, p=.564) amongst Baby Buddy app users compared to non-Baby Buddy app users. Adjustment of this association for IMD decile, technology use (baseline MTUAS total mean

score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score) and baseline TOPSE score resulted in a very similar result, adjusted odds ratio of 1.12 (95%CI 0.59 to 2.13, p=.730)(table 11). Again, after adjusting for the TOPSE scores at 35 weeks gestation, there were no statistically significant differences between Baby Buddy app users and non-app users (appendix 7, table 3).

Table 11: Odds ratios for low TOPSE scores and reported Baby Buddy use

		Baby Buddy use		
	n	**OR (SE)**	95% CI	**p value**
Model 1	282	**1.17 (0.33)**	0.68 to 2.03	**.564**
Model 2	263	**1.12 (0.37)**	0.59 to 2.13	**.730**
OR: Odds ratio; SE: Standard error Model 1 – Baby Buddy use (at any time) and TOPSE overall sum score at 3 months, unadjusted. Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), baseline TOPSE overall sum score.				

The best fit lines of TOPSE scores across time points for the final sample (n=296) has been calculated. There was a slight decrease from baseline to 35 weeks (medians 322 (LQ 299 - UQ 340) to 314 (LQ 297 - UQ 329), respectively) but this increased at three months post-birth to median of 329 (LQ 310 - UQ 343) (see appendix 7, table 2 and figure 2). Previously, we reported a lack of association between using the Baby Buddy app and the TOPSE scale and these results are consistent with our previous findings.

To investigate further the effect of using the Baby Buddy app, we assessed the association between the length of time since the download of the app and TOPSE scores through a scatter plot (x axis) and TOPSE overall scores (y axis). There was no association between number of months since initial app use and TOPSE scores (adjusted R^2=0.00%). Details of this analysis are presented in appendix 8.

Logistic regression diagnostics using Hosmer and Lemeshow's goodness-of-fit test indicated a good fit of the above and next adjusted models (p>.05).

An analysis involving Baby Buddy users' in-app data and the TOPSE scores has been undertaken in section 5.2.

3.2.2 SECONDARY ANALYSIS

Maternal mental wellbeing (WEMWBS)

The odds ratios for low maternal mental wellbeing (WEMWBS score) at 3 months post-birth associated with Baby Buddy use are presented in table 12. The Baby Buddy app had no significant effect on maternal mental wellbeing, with an unadjusted odds ratio for low WEMWBS of 1.10 (95% CI 0.64 to 1.89, *p*=.719). Adjustment for confounding factors again made no difference to this association adjusted OR 1.02 (95% CI 0.55 to 1.89, *p*=.943).

There were no statistically significant differences between Baby Buddy app users and non-app users after adjusting for the 35 weeks gestation levels of WEMWBS (appendix 7, table 4).

Table 12: Odds ratios for low WEMWBS and reported Baby Buddy use

		Baby Buddy use		
	N	**OR (SE)**	95% CI	**p value**
Model 1	294	**1.10 (0.30)**	0.64 to 1.89	**.719**
Model 2	283	**1.02 (0.32)**	0.55 to 1.89	**.943**
OR: Odds ratio; SE: Standard error Model 1 – Baby Buddy use (at any time) and TOPSE overall sum score at 3 months, unadjusted. Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), baseline WEMWBS overall sum score.				

An analysis involving Baby Buddy users' in-app data and the WEMWBS scores has been undertaken in section 5.2.

TOPSE subscales

We assessed the odds ratios for low TOPSE scores using each of the six TOPSE dimensions (subscales) at 3 months post-birth with Baby Buddy app use (Table 13). 'Play & enjoyment' and 'Learning & knowledge' were statistically significantly lower amongst Baby Buddy app users than amongst non-app users in the unadjusted model (model 1, p<.05) but the differences were no longer statistically significant in the adjusted model 2. In all other models and sub-scales the differences in scores between Baby Buddy app users and non-users were not statistically significant (table 13). There were no statistically significant differences between Baby Buddy app users and non-app users after adjusting for 35 weeks gestation levels of each of the TOPSE subscales (appendix 7, table 5).

Table 13: Odds ratios for low TOPSE subscale scores and reported Baby Buddy use

			Baby Buddy use		
		N	OR (SE)	95% CI	p value
TOPSE emotion & affection	Model 1	290	1.58 (0.41)	0.95 to 2.62	.080
	Model 2	275	1.57 (0.48)	0.87 to 2.87	.136
TOPSE play & enjoyment	Model 1	296	1.80 (0.47)	1.07 to 3.02	.025*
	Model 2	283	1.65 (0.49)	0.92 to 2.97	.092
TOPSE empathy & understanding	Model 1	292	1.62 (0.43)	0.96 to 2.73	.070
	Model 2	280	1.38 (0.42)	0.76 to 2.52	.289
TOPSE pressures	Model 1	289	1.14 (0.31)	0.66 to 1.96	.635
	Model 2	277	1.32 (0.43)	0.70 to 2.49	.395
TOPSE self-acceptance	Model 1	291	0.90 (0.24)	0.53 to 1.53	.697
	Model 2	278	0.83 (0.26)	0.46 to 1.52	.547
TOPSE learning & knowledge	Model 1	294	1.80 (0.49)	1.06 to 3.05	.031*
	Model 2	285	1.45 (0.44)	0.80 to 2.64	.226

OR: Odds ratio; SE: Standard error
Model 1 – Baby Buddy use and TOPSE subscale sum score at 3 months, unadjusted.
Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline TOPSE subscale sum score.

Introduced to The Baby Buddy app

Baby Buddy app users who had heard about the app from a healthcare professional (HCP) had slightly higher odds of a low self-efficacy TOPSE scores compared to all other participants (Baby Buddy app users who had not heard about the app from a HCP, as well as non-app users). These differences were not statistically significant, in either the unadjusted model 1 (OR 1.16, 95%CI 0.66 to 2.04, p=.596) or the adjusted model 2 (OR 1.16, 95%CI 0.60 to 2.23, p=.666) (table 14).

Table 14: Odds ratio for low TOPSE and introduced Baby Buddy use

		Introduced use of the Baby Buddy		
	N	OR (SE)	95% CI	P value
Model 1	282	1.16 (0.33)	0.66 to 2.04	.596
Model 2	263	1.16 (0.39)	0.60 to 2.23	.666

OR: Odds ratio; SE: Standard error
Model 1 – Introduced use of the Baby Buddy by a health professional and TOPSE overall sum score at 3 months, unadjusted.
Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline TOPSE overall sum score.

Similarly, there were no differences in the odds ratios for low WEMWBS scores between Baby Buddy app users who had heard about the app from a HCP and all other participants (i.e. Baby Buddy users who had not heard about the app from a HCP as well as non-app users), either in the unadjusted model (OR 1.03,95%CI 0.59 to 1.79, p=.924) or in the adjusted model (OR 1.00, 95%CI 0.53 to 1.87, p=.990) (table 15).

Table 15: Odds ratios for low WEMWBS and introduced Baby Buddy use

		Introduced use of the Baby Buddy		
	N	OR (SE)	95% CI	P value
Model 1	294	1.03 (0.29)	0.59 to 1.79	.924
Model 2	283	1.00 (0.32)	0.53 to 1.87	.990

OR: Odds ratio; SE: Standard error

Model 1 – Introduced use of the Baby Buddy by a health professional and WEMWBS overall sum score at 3 months, unadjusted.

Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline WEMWBS overall sum score.

There were no statistically significant differences between Baby Buddy app users and non-app users after adjusting for outcome levels at 35 weeks gestation for both the TOPSE and WEMWBS. Details of this analysis are presented in appendix 7, tables 3 and 4.

3.2.3 POST-HOC ANALYSIS

Baby Buddy app users were more likely to anticipate they would breastfeed or reported breastfeeding (both exclusive breast feeding and any breastfeeding) at all three time-points (table 15). At 1 month post-birth, this difference was statistically significant ($X_2(1) = 10.68$, p=.001) (table 16). Across the three time-points, there was a 12% increase in any breastfeeding in the Baby Buddy app users compared to non- app users and a 9% increase in exclusive breastfeeding. Whilst this is an important finding, this needs to be used with care due to the post-hoc element of the analysis: the analyses were not specified before seeing the data.

Table 16: Childbirth experience and participants' reported breastfeeding* in the final sample by reported app use (n=296)

	Baby Buddy user (N=114)	**Non-Baby Buddy** user (N=182)	Differences between app users and non-app users
	n (%)	n (%)	
Any breastfeeding at 1 week post-birth	100 (87.7%)	141 (79.2%)	$X^2(1)=3.49$, p=.062
Any breastfeeding at 1 month post-birth	95 (84.8%)	121 (67.6%)	$X^2(1)=10.68$, p=.001*
Any breastfeeding at 3 months post-birth	69 (61.6%)	93 (51.4%)	$X^2(1)=2.93$, p=.087
Exclusive breastfeeding at 1 week post-birth	65 (57.0%)	91 (51.1%)	$X^2(1)=0.97$, p=.325
Exclusive breastfeeding at 1 month post-birth	55 (49.1%)	67 (37.4%)	$X^2(1)=3.86$, p=.050
Exclusive breastfeeding at 3 months post-birth	49 (43.8%)	61 (33.7%)	$X^2(1)=2.98$, p=.084
*Breastfeeding includes both breastfeeding as the exclusive feeding method as well as breastfeeding in combination with formula milk, compared to formula milk only or not sure. - N missing per variable amongst app users (N=113): CEQ own capacity (n=0), CEQ professional support (n=0), CEQ perceived safety (n=0), CEQ participation (n=3), CEQ overall (n=3), breastfeeding at 1 week post-birth (n=0), breastfeeding at 1 month post-birth (n=6), breastfeeding at 3 months post-birth (n=14). N missing per variable amongst non-app users (N=181): CEQ own capacity (n=0), CEQ professional support (n=0), CEQ perceived safety (n=0), CEQ participation (n=4), CEQ overall (n=4), breastfeeding at 1 week post-birth (n=4), breastfeeding at 1 month post-birth (n=12), breastfeeding at 3 months post-birth (n=21).			

At all time-points, Baby Buddy app users had increased odds of breast feeding (table 17), an exciting finding. Due to the wide confidence intervals, the differences between groups were only statistically significant for any breastfeeding, both unadjusted (OR 2.68, 95%CI 1.46 to 4.90, p=.001) and after adjusting for confounding variables (OR 3.08, 95%CI 1.49 to 6.35, p=.002), and for adjusted exclusive breastfeeding at 3 months post-birth (OR 1.79, 95%CI 1.02 to 3.16, p=.044).

Table 17: Odds ratios for breastfeeding and Baby Buddy use

			Baby Buddy use		
		N	OR (SE)	95% CI	p value
Any breastfeeding at 1 week post-birth	Model 1	292	1.87 (0.64)	0.96 to 3.65	.065
	Model 2	280	2.25 (0.93)	1.00 to 5.06	.051
Any breastfeeding at 1 month post-birth	Model 1	291	2.68 (0.82)	1.46 to 4.90	.001*
	Model 2	275	3.08 (1.14)	1.49 to 6.35	.002*
Any breastfeeding at 3 months post-birth	Model 1	293	1.52 (0.37)	0.94 to 2.45	.088
	Model 2	276	1.72 (0.49)	0.99 to 2.99	.054
Exclusive breastfeeding at 1 week post-birth	Model 1	292	1.27 (0.31)	0.79 to 2.04	.325
	Model 2	280	1.13 (0.30)	0.67 to 1.90	.649
Exclusive breastfeeding at 1 month post-birth	Model 1	291	1.61 (0.39)	1.00 to 2.60	.050
	Model 2	275	1.65 (0.45)	0.97 to 2.80	.067
Exclusive breastfeeding at 3 months post-birth	Model 1	293	1.53 (0.38)	0.94 to 2.48	.085
	Model 2	276	1.79 (0.52)	1.02 to 3.16	.044*

*p<.05; OR=Odds ratio; SE=Standard error

- Baby Buddy users are those who reported using the Baby Buddy app at one time-point or more.

- Any breastfeeding includes both breastfeeding as the exclusive feeding method and breastfeeding in combination with formula milk; exclusive breastfeeding refers to those women who reported breastfeeding as the only feeding method.

Model 1 – Breastfeeding and Baby Buddy use, unadjusted

Model 2 – Same as model 1, adjusted for IMD decile, education, technology use (MTUAS total mean score), use of pregnancy/parenthood apps (any), and baseline intention to breastfeed.

CHAPTER 4: FOCUS GROUPS AND INTERVIEWS FINDINGS

4.1: FIRST-TIME MOTHERS

Four overriding themes were collated via thematic analysis including Accessibility of information, Knowledge, Reassurance and Reliability, and Confidence. In line with the Appreciative Inquiry (AI) approach used to gather this data; where women were asked specifically what worked well for them with regards to use of the Baby Buddy app and also what could have been better. The findings are presented under the subheadings of 'what worked well' and 'things that could be better' to represent the AI approach as reported by the participants.

4.1.1: WHAT WORKED WELL

Accessibility of information

Overall, the first-time mothers all agreed that, once they had downloaded the Baby Buddy app, the information was easily accessible. They were able to track their daily progress, read daily updates via pop ups and find information related to specific topics with ease. They particularly liked the daily pop ups, which were useful for women who worked and did not often have the time to search through information regarding their pregnancy, as shown:

"*It just helped make the journey easier, because I travel for work, and it was nice to be in a different country and still get the alert to say this is what's happening today*." (P24)

"*...the updates would come, and they didn't like override, some apps pregnancy things coming all the time, this one just gave you one simple answer a day, so nice and easy and not too much…" (P26)*

Having information readily available for women, regardless of where they were that day and at a reasonable level of detail, provided a steady flow of information for women via the Baby Buddy app. This suggested information could be accessed at a rate that suited women and increased engagement with the app to explore pop ups further, if they so wished. Many first-time mothers also explained that, by having access to information on a daily basis, they could then delve in to specific areas of pregnancy they wished to learn more about, at any time throughout their pregnancy as illustrated in the following extract:

"*.....because you're getting information every day, it will provide you with links, the app was the foundational platform for looking up more stuff, it would give you like a summary of what to expect, so one thing I liked about the app was, you didn't necessarily have to wait to say 7 months pregnant to tell you about pain relief options, it would make suggestions about that early on, so that when I did go to my antenatal classes where they teach you about that stuff I kind of had an idea and then you knew you could ask more questions*." (P36)

This in turn led to first-time mothers watching films about specific topics and accessing their individual avatars. They particularly liked videos regarding breastfeeding, suggesting that the videos and Avatars helped to give another layer of depth of information to the women as indicated:

"*(talking about breast feeding and latching) Yes, people can tell you how to do it, but actually seeing on the video it being done was much clearer*," (P65)

"*I think the cartoon characters that you create yourself directs you and signposts you to things, I thought it was really accessible*." (P18)

In addition to being able to access daily information, films and update and personalise avatars, the first-time mothers reported that they could share areas of the Baby Buddy app with partners and their families and friends, as highlighted:

"*I like the fact that the app allows you to put your husband's name in, so it says you can talk to "****" about this, and he could have downloaded the app, I thought it was really nice*" (P59)

"*...and it refers about your husband or partner by name if you put that information in, I really like that. I would definitely recommend it to other people, my sister's just got pregnant and I recommended it to her*." (P60)

Findings indicated that by having easily accessible varieties of information at hand women may have been able to engage with the app better. Having the ability to share information with partners also gives women the chance to involve, and update them, with information that mothers/women may not have thought their partners had access to.

Knowledge

Throughout the interviews and focus groups, first-time mothers spoke about how they liked the amount of information they received from the Baby Buddy app. They suggested it was just the right amount of information, topics were concise and easy to understand which helped them to increase their knowledge in a manageable way. First-time mothers also reported that they enjoyed finding out information about different topic areas as one extract shows:

"*I like the information about what size it was and what to think about in terms of my health, and how the baby was growing and getting ready."* (P6)

The first-time mothers also discussed that the information on the Baby Buddy app gave them more knowledge about their pregnancy, particularly when engaging with HCPs. This was evident, specifically when accessing key words which they may have been unfamiliar with, as shown here in the following quote:

"*So sometimes my midwife would say certain things, and I would like, if it was something medical, go and look at what was going on, and what words meant, and also like for areas, like GPs and different …. I'd go and look for information there*..." (P33)

The increased knowledge and confidence given by the Baby Buddy app continued from pregnancy through to post-natal information with first-time mothers suggesting it was nice to still have notifications regarding their baby's development up to a month after birth.

Breastfeeding was a particular feature that first-time mothers felt they had learnt a great deal from as highlighted in a number of quotes:

"Gosh there's loads, I think I learned that you can restart your milk supply, and different ways of feeding her so, I struggled a little bit at first because she was taking too much too quickly, but I read that if I leant back a little bit it would slow the flow down." (P102)

"from the community, the community one helped quite a lot, when the baby was first born I was told to look at it for like breastfeeding bits and stuff, by my midwife and the breastfeeding team…that was useful." (P103)

This demonstrates how first-time mothers were not only actively using the information they had found to support their decisions in the postnatal period but also how well HCPs and first-time mothers were interacting via the Baby Buddy app, keeping lines of communication open.

First-time mothers also enjoyed learning about the size and development of their child throughout pregnancy via the Baby Buddy app as suggested:

"How much is your baby, for example at 36, you see a picture and your baby, what is doing your baby, with the eyes, the mouth. For vomiting, it tells you when your vomiting will stop, or what you feel when your baby is coming in the last few months." (P104)

"Probably more about the fetus's growth, yes what it was actually doing at certain points, as opposed to the birth, because I think a lot of my friends already had children and I've done a lot of work with mothers and babies in my job, I think I was quite aware of certain stories and options, yes but it was definitely the fetus's growth.... Which is really exciting to know especially in a first pregnancy isn't it." (P105)

Mothers reported that by having this additional knowledge regarding the size and development of their baby, first-time mothers may have felt reassured in between appointments with their midwife. It suggests that first-time mothers may also feel more in control and confident about their pregnancy and closer to their developing child, increasing engagement with the Baby Buddy app.

Overall, the data suggest that first-time mothers were enjoying using the Baby Buddy app both during the antenatal and post-natal periods to access knowledge and inform decision making along their journey as a first-time mother.

Reassurance and Reliability

The data extracted indicated very strongly that first-time mothers felt reassured by the information provided in the Baby Buddy app and this came down to the issue that the reliable sources of information provided. Quotes below highlight these common responses:

"*and I think that the baby buddy one because you know that it's been tried and tested by midwives it's not just generic information, every day you're getting something to think about*" (P58)

"*yes, because you feel confident knowing that it's tried and tested by midwives, in the videos you have the midwives perspective, I liked that*" (P66)

When first-time mothers compared the Baby Buddy app to other sources of information, such as Google, they felt similar apps may not be as reliable. Watching a film given by a fully qualified midwife on topics such as breastfeeding helped first-time mothers feel reassured that they were receiving the correct information on how to care for their child and what to expect in pregnancy. The fact that these mothers trusted the information they were receiving helped to reassure them of their progress as exemplified in the following quote:

"*...and at the end of the week it would say the measurements of the child and what kinds of things you should be going through, so it really helped you in the pregnancy just to know what was happening, instead of like panicking about things, so like that's normal..*" *(P4)*

The comments above highlight that the Baby Buddy app acted as a source of comfort for some of the first-time mothers and helped them to stay calm and positive about their pregnancy rather than worrying. Participants also enjoyed the short videos given by parents about their first-time accounts of motherhood:

"*Thinking about it I did watch some of the films with the mums talking, about their experiences, I did watch those as well, a few of them, just interesting really, I don't think I necessarily got anything I didn't know from it, but it's nice to see, with other mums*" (P14)

This first-time mother's comment suggests that, although she did not gain any new information from the parent's films, she did find it a very positive experience. In turn, this might suggest that the Baby Buddy app offered some peer support, giving first-time mothers reassurance from other mothers who have experienced similar thoughts and feelings. These mothers could also use the app to set reminders for appointments, dates to remember and an exercise tool which they appreciated as highlighted:

"*You could use it to remind yourself to do things, like your pelvic floor exercises*." (P29)

"*Yes, and if you have appointment for my baby or my appointment, so I go to the application and I know*." (P30)

By having the ability to add information to the app such as appointments with midwives as well as receive information gave first-time mothers the opportunity to use the app to its full potential throughout pregnancy and post birth. This suggests it also acted as an organisational tool for first-time mothers, keeping lines of communication open between them and their HCP.

Confidence

It was clear that the more first-time mothers felt the information they were accessing within the app was reliable, the more they used it to support their pregnancy and postnatal care. First-time mothers felt that being prepared with the knowledge they had accrued from the app gave them more confidence to plan their care with a HCPs, as evident:

"*I think I used it to make choices, I used it together with parent-craft classes, I used them together because I liked that you had the video of the midwife explaining different types of pain relief options, and you had the script that you could read about the different options, so it just meant you could really think about it, one of the things I did was I downloaded the NHS birth-plan template and wrote mine out in pencil so that when went to the actual classes, I could ask questions, I could change my plan, it gave you confidence that you weren't going off to something with nothing*." (P37)

Participants from the focus groups also agreed that they would use the information from the Baby Buddy app to support their discussions around choice with partners and family members, knowing they had the confidence to do so. This might imply that by having access to knowledge and information it gave them more confidence to make choices around their care. The information they were receiving was reliable, first-time mothers then felt confident to relay this information to family, friends and HCP, giving them control over the choices and decisions they made. It also suggests that the Baby Buddy app may have helped first-time mothers to feel in control of their health care, empowering them to feel confident about the care they are receiving from the HCP and the decisions they are making for the health of their child. One extract is shared here:

"*I just thought it was a good platform, because as a new mum you know you're pregnant but you don't know what to expect, so it's always nice to have this foundational knowledge to make you feel confident about decisions that you are making. It wasn't complicated to use*." (P64)

Overall, findings from what worked well for first-time mothers appear to show a cyclical movement between the themes presented in figure 5. First-time mothers suggest the app worked well because of the accessibility of the information, which opened up a vast amount of knowledge available to them in concise, easy to understand platforms. These platforms showcased information endorsed by midwives, which then, in the mothers' eyes, increased the reliability of the Baby Buddy app and therefore the knowledge learned. This had a snowball effect: in which it reassured these mothers that the information they were receiving was correct

which then increased their confidence in the app and their knowledge of pregnancy and encouraged them to continue using it throughout pregnancy and post-natal care with the HCP.

Figure 5: Cyclical movement of themes given on what worked well for first-time mothers who used the Baby Buddy app

A word cloud was generated using the responses from first-time mothers to the question 'What did you like about the app?' and is presented below. Information was the term used most frequently and associated words to information included to 'know', simple and easy.

4.1.2: THINGS THAT COULD BE BETTER

As outlined in section 4.1; in line with the methodology of Appreciative Inquiry, as well as exploring what worked well, participants were asked to suggest 'things that could be better'. Nevertheless, 77% of the mothers interviewed did not think anything needed improving in the Baby Buddy app.

Participants preferred face to face support with professionals (indirect barriers to app usage)

First-time mothers valued the information provided in the Baby Buddy app and felt it was from a trusted source, however, findings suggest that participants also appreciated the opportunities to meet with HCPs such as their midwife, health visitor or GP. In part, the Baby Buddy app was developed to support and engage HCP engagement and in this way participants expressing a preference for face to face engagement was a positive finding. First-time mothers also suggested, that when they needed specific information regarding breastfeeding or general advice for their child they would often seek out advice from a HCP in preference to the Baby Buddy app's featured films, as indicated below:

"*but if we think we're doing something wrong then I tend to ring the doctors, or the health visitor…because we're first-time parents and we don't want to do anything wrong, and we don't want to go by the book, like, in case it's not the right decision, I think it depends on your baby's development as well I think*." (P80)

"*No it was more what the midwives and health visitors were saying about breastfeeding*." (P85)

These quotes highlight that, although first-time mothers enjoyed interacting with the Baby Buddy app, they still sought reassurance and advice from HCPs. This could be because they preferred face-to-face contact with a qualified HCPs, valuing the satisfaction of a personal interaction, compared to the more general information available in an app (not necessarily the Baby Buddy app) or because they were first-time mothers and may have needed further reassurance about the decisions they were making for their baby.

Furthermore, first-time mothers who participated in this study also spoke of their preference of scheduled antenatal classes towards the latter half of their pregnancy. It appeared that, although the Baby Buddy app was used, the amount they used it slowed down once antenatal classes were attended as suggested:

"….*towards the end when I started NCT classes I used it less, but it was definitely very helpful in the first 6 or 7 months I'd say*." (P6)

"*Not as much cos I went to NCT lessons, so it was like more group work and group sessions, and about labour*." (P7)

This could suggest that this group of first-time mothers preferred talking to other first-time mothers in a group via antenatal classes and used it as a means of social support throughout their pregnancy. This seems to in turn suggest that social interaction with other peers increases engagement, knowledge and reassurance during antenatal classes therefore decreasing the amount of the Baby Buddy app usage. This is indicative of how mothers who are able to seek additional support and utilise networks become less reliant on the Baby Buddy app. This may not be the same for all mothers, some of whom may find antenatal classes difficult to access or feel unable to create social networks.

Attendance at NCT antenatal classes is a choice that is often made, in a culture where spending money in preparation for the arrival of a baby is often undertaken by many families, for example 4D scans and baby showers. The demographic of our sample of working and educated women are likely to have wanted the opportunity to meet other like-minded parents to be, to build new supportive networks. NCT is the most commonly available organisation currently doing this as many NHS antenatal education programmes are outsourced to private providers with variability in availability. The Baby Buddy app is underpinned by the principal of

proportionate universalism, meaning reliable information is still freely accessible to those who cannot access formal antenatal education and is designed to be ‘as well as’ rather than ‘instead of’ other sources of support.

Improving specific features of the Baby Buddy app

First-time mothers spoke positively about the daily information, knowledge and support they received via the Baby Buddy app but there were particular areas throughout pregnancy and post-natal birth that participants would have liked more detail on. These included:

- Longer post birth support
- Pregnancy and labour progress
- Birthing plans
- Check list of items to have ready for giving birth

Participants had enjoyed receiving daily updates about their pregnancy week by week and during the first few weeks after birth, but they were disappointed this did not continue for longer. One quote is used here to highlight this:

“*The thing I was sad about with the Baby Buddy app was that it finished I think a month after giving birth, it would be nice if it followed you for one year after you’ve had your baby, because it’s a really useful simple app*.” (P66)

Some parents admitted that, because of this, they decided to use other pregnancy apps that incorporated parenting as well as pregnancy. First-time mothers suggested increasing the amount of detail given during their pregnancy specifically, further information about their child’s development and information on labour progress and what to expect, as they felt this area could have been explored further as indicated:

“*the only things that I would have liked more of was like the week by week update, as they’re growing, the fetus, a bit more detail in it*” (p92)

Although the features were accessible, expanding on detailed information for the week by week pregnancy journey would have been beneficial for some first-time mothers. It seemed that this feature was directly compared to other pregnancy apps suggesting the Baby Buddy app may not have as much detail around pregnancy detail as others. This was also the case when first-time mothers expressed an interest in items that they had seen on other pregnancy apps such as a check list as below:

"*I think the other one had things like shopping lists, and things you'll need for baby, and I found that really helpful, because I was a first-time mum I didn't know exactly what I needed, whereas that was like this is the types of things you will need, so things like muslin squares, it had like different sections on it, so it had like a feeding section and a sleeping section, and a travel section, and all that sort of stuff, I found that helpful. I think for me the big thing is the checklist on the things you'll need*..." (P95)

This may suggest that first-time mothers would benefit from some sort of organisational tool within the Baby Buddy app in order to plan and make decisions for their new baby. First-time mothers also suggested a contraction counter and accessible birthing plan would have been beneficial leading up to and during the early stages of their labour..

Individual Considerations

Whilst indirect and direct barriers to the Baby Buddy app were analysed, it still raises the question as to why some first-time mothers downloaded the Baby Buddy app yet did not actively use its features. This may be due to individual differences between first-time mothers who participated in this study. This includes ethnic considerations as some mothers struggled to fully interpret or understand the information available as English was not their first language and there was no option to change this which became problematic as indicated:

"*If you could put in this application the Greek language, or different languages, you know, because sometimes I can't read it, I can't understand it, sometimes I need to copy paste and translate. So put in more languages. I have friends from Poland, and they use this application and they tell me to translate for them, and I may be working or something like that*." (P96)

We cannot categorically assume but it may be that first-time mothers who do not have English as their first spoken language could be seeking alternative means of support such as face-to-face contact with HCPs or social groups rather than using the Baby Buddy app for support.

Another reason why the mothers in this study may not have used the Baby Buddy app after downloading it could be due to their own existing knowledge prior to accessing the information in the app. This was particularly evident when they were asked if the information and films on breast feeding had helped guide their decisions around the topic area as the following women suggested:

"*I always knew that breastfeeding was what I wanted to do, but it set my mind in that mind-set, this is what I'm going to do, I was determined to do it.*" (P97)

"*No I don't think so, no I was always going to breast feed*." (P99)

"*No, I used the infant feeding team, I was always quite adamant I was breast feeding, so I used their support for that*." (P100)

The above comments highlight that although the Baby Buddy app supplied sufficient information to help support first-time mother's choices and decisions around certain areas of their pregnancy and postnatal care, pre-existing thinking ultimately played a key factor in helping the mothers decide on what actions they would take, regardless of what the Baby Buddy app may suggest. This also seemed to be the case when accessing other areas of information such as when a woman is in labour as suggested here:

"I didn't get a lot of information on the labour because I think ignorance is bliss sometimes". (P101)

The above extract suggests that first-time mothers may not have accessed information which may have been more nerve-wracking for them such as labour or mental health support as they would rather not confront them at that time. It may be that some of the featured information needs further signposting to ensure expectant mothers do engage and use the full potential of the Baby Buddy app.

4.3: HEALTH CARE PRACTITIONERS

4.3.1: Normalisation Process Theory

As outlined in the above methods section, the HCPs data were analysed according to the Normalisation Process Theory which encompasses the four elements of Implementation, Adoption, Translation and Stabilisation (page 43). If all four preconditions are met, then normalisation of the Baby Buddy app into clinical practice is achieved. These findings explore to what degree each element is evident in the data obtained from HCPs.

4.3.2 IMPLEMENTATION

To successfully implement the Baby Buddy app into healthcare systems it requires a positive link with policy level sponsors with a full underpinning and potential financial support. Participants were asked what their experience of the embedding process of the app had been within their areas. Their responses included: an initial meeting with Best Beginnings on how to use the Baby Buddy app and the materials needed to support HCPs with its' implementation within their areas of practice. In particular, HCPs enjoyed receiving updates on how many women were downloading the app, and in which areas, suggesting it helped to motivate HCPs to implement the Baby Buddy app within their areas. Two extracts are used here:

"Yes they came and joined in with some of the team meetings and looked at the app, so, and because they were in constant contact with us, they made sure we had enough of the things (promotional materials). The statistics were given to us, either weekly or monthly on how many women were downloading the app, in different areas, so there was a bit of competition with different areas...." (HCP1)

"Initial focus from Best Beginnings, BB attended meetings and pregnancy evenings, Familiarity with functions, Promotional material eg posters/leaflets/cards, Statistics on download rates (competition between teams)" (HCP2)

The data suggests that, by implementing these initial meetings with teams it created competition within areas, motivating midwives to actively implement the Baby Buddy app within areas of the community, therefore engaging professionals. Participants suggested that to help other HCPs to keep woman engaged with the Baby Buddy app they needed monthly updates to help remind and inform midwives of the Baby Buddy app and keep momentum of the app high within the community, as shown:

"So personally I feel that maybe it's had a slight drift in some areas particularly…. yes an ongoing drip drip effect is needed really…. (How well cascading worked?) I think it depends who you speak to, for my area we cascaded it down really well, and people seemed really keen to utilise it, but I guess like with everything, it needs that constant, every few months or so reminder, because there are new things coming out, and new things in the booking packs etc." (HCP3)

"Reminders to staff "every so often", need nudges to remember to promote and use, more email promotion to staff, Promotional material not engaging/dark colours, Not all staff are aware of BB app, eg staff turnover/rotation, missed embedding process, and no ongoing follow up." (HCP4)

Health Care Professionals in the main suggested that in order for the Baby Buddy app to be successfully implemented on a long-term basis a constant link with Best Beginnings regarding its usage would be beneficial in cascading information down to first-time mothers. When HCPs. were asked for their experience of using the app in providing lifestyle information findings suggested having more directed information about the App from Best Beginnings would be useful. This would ensure midwives were all receiving similar information regarding what is available for first-time mothers.

Overall, HCPs suggested that a positive aspect of the Baby Buddy app were the launches by the charity and clear information distributed when the Baby Buddy app was first released. However, to continue this Best Beginnings may have to consider refresher or follow up sessions for HCPs. This would ensure HCPs are engaged and up to date with the Baby Buddy app and its contents.

4.3.4 Adoption

Adoption occurs when there is successful integration at the level of structural legitimation that it is supported and thus practically incorporated into health care delivery through the development of organizational structures. Interview and focus group data were analysed to explore whether the development of organisational structures and integration had been successful when promoting the Baby Buddy app.

During adoption HCPs felt that the Baby Buddy app was a good fit to supporting their service. When communicating public health and lifestyle choices to first-time mothers, HCPs spoke very positively about using the Baby Buddy app within their roles as shown:

"*yes, with young parents yes, in the initial visit particularly, when you're talking about a broad spectrum of health, diet, exercise smoking, normally I'd see if they want to download it at the time of the visit, so we can both talk about it a little bit, only a few minutes, but to signpost them to sections on the app that are relevant to them, umm, get partners to download it as well, so they're aware of particular health messages, so it maybe that they smoke as well, and the lady doesn't etc*. " (HCP 5)

"*visual aids yes, I think it covers, yes there's a lot of written information, but the videos are very well laid out so that you don't need a good level of literacy to understand them, but I wouldn't use the whole of the app, I would signpost, if you knew they had a particular problem with literacy or understanding you would signpost them to a particular part of the app*." (HCP 6)

Overall, HCPs also felt that the Baby Buddy app worked well in signposting first-time mothers to further information, which can ultimately help when faced with short appointment times. Health Care Professionals used the Baby Buddy app to access specific pieces of the information that were suited to the individual such as breast feeding, which not only worked well in individualising care choices for first-time mothers but also reinforced information given in practice. The following quote highlights this:

"*I do yes..... you can go through everything with them quite quickly, but if they need a little bit more time, you can direct them to things on the app, and next time you see them go through it again, and it sort of reinforces what you've said*." (HCP 8)

Using the Baby Buddy app as a reinforcement tool for information links with data on what worked well for first-time mothers within the app; in themes 'accessibility' and 'knowledge'. By having the opportunity to reinforce HCPs information given in practice through the Baby Buddy app when they leave their appointment, it further reassured first-time mothers that the information they were reading from the app was correct (themes - Reliability and reassurance, confidence). This suggests the Baby Buddy app worked well for both HCPs and first-time mothers to build on information shared in appointments in line with *'Every Contact Counts'*.

By adopting this process within practice, HCPs believed this helped with their encounters with first-time mothers, particularly when keeping communication pathways open and providing information such as:

"*communication, your appointment is really good, if they're known to confuse appointment times, particularly if you've gone out because they've missed a community MW appointment or*

struggling to remember all the appointments they've got I'll signpost them to that, and most when they start to use it, engage well with it, as a reminder." (HCP9)

"*I do use the appointments section if they're the kind of people who do forget their appointments, and also what does that mean, so if they've got a question that they may not have asked at all or they don't want to forget for next time, remember to ask that bit, and then also the look up section, so I certainly encourage them to use that*." (HCP10)

Overall, it was clear from the findings that HCPs have actively adopted areas of the Baby Buddy app into their service delivery which has had a positive effect on their relationship with first-time mothers. We believe this suggests that HCPs view the Baby Buddy app as a reliable tool, often using it as a signpost to information thus reassuring first-time mothers that the information they were receiving from the app was genuine, unlike other online sources. This then helps to keep lines of communication open between both HCPs and first-time mothers, whilst continuing to engage with the Baby Buddy app.

4.3.4: TRANSLATION

Data were analysed to see if and how the Baby Buddy app had been translated into local clinical practice in the study sites. Interestingly, the Baby Buddy app was well used and had been translated to local practice it was specific features, particularly around breast feeding that were most favoured. These were found to work very well especially the 'simple yet clear' visual representations in the Baby Buddy as indicated:

"*so it's really about helping them to understand the fundamentals of lactation, and feeding their baby, I think a lot of the other health information, general health information, I've given from my own knowledge, umm, I wouldn't have used the app for that, but that's only because I'm using the app for the purposes of breast feeding*." (HCP11)

Nevertheless, it appears that, when using the Baby Buddy app to support choice and care, HCPs were less likely to use it for specific detail, as implied here:

"*I tell the staff about the BB app on the teaching, and I make them aware of the videos, but I don't use the videos for teaching, because I have resources that I already use for that which are UNICEF resources, so sometimes it is useful to kind of show a snippet of a video if we're talking about a certain subject, for example explaining poor positioning, I might go straight to that challenging situations video, and show a little bit of it, but generally, no I just tell them about the app*." (HCP12)

We believe that this remains a positive finding because HCPs are aware of the Baby Buddy app but use a range of resources as would be expected in clinical practice.

4.3.5: STABILISATION

This theme is when there is real integration at the level of professional knowledge and practice in the activities. This theme very much depends on the integration of professional knowledge, skills and confidence with practice. In terms of the Baby Buddy app, when HCPs were asked about how this helped them integrate knowledge and practice, they all felt that they were using the knowledge provided. It helped them developed confidence and in so doing skills. One participant was able to list very quickly all the attributes of the Baby Buddy app as shown here:

"*Attractive and fun, Good Colours, Avatar is engaging, interactive, talks to you, tailored to you, customable, Videos, real women, can relate to real people and experiences, Use ability, straight forward to navigate, Free, with no pop ups or adverts, Breast feeding sections helpful, good information, Research based, reliability of content, endorsement of professional bodies, Easily accessed information, Questions answered, makes appointments easier as not asking so many questions, Pregnant mums like the daily updates, Young women use the appointment reminders, Breast feeding graphics, Reassurance day to day, reduced anxiety, a safety net*." (HCP13)

The above quote suggests that this HCP reflected on aspects that they felt first-time mothers' felt worked well within the app, including accessibility of daily information, increased knowledge and reassurance. Health Care Professionals also liked that the Baby Buddy app was professionally endorsed, the content was felt to be more reliable for first-time mothers. In particular, HCPs found the Baby Buddy app was most useful during postnatal support for first-time mothers as indicated:

"*particularly because the app is all evidence based, they might show you some random app because it looked free and they'd seen it, then I would tend to signpost them to that app, and get them to utilise it for the postnatal period*….(HCP14)

"Yes, and common breastfeeding problems, and for those who want to bottle feed safely making up feeds, bathing, changing nappies, and they are particularly helpful for those who don't speak English because they can watch and learn." (HCP13)

Although this shows good use of professional knowledge and practice around postnatal care, it does suggest that the information about antenatal and labour subjects within the app was not signposted to the same degree by HCPs, but some first-time mothers were still accessing this content through general app browsing. This was also reflected in what these first-time mothers felt could be improved on in the Baby Buddy app: they implied birthing plans and labour progress could be more detailed.

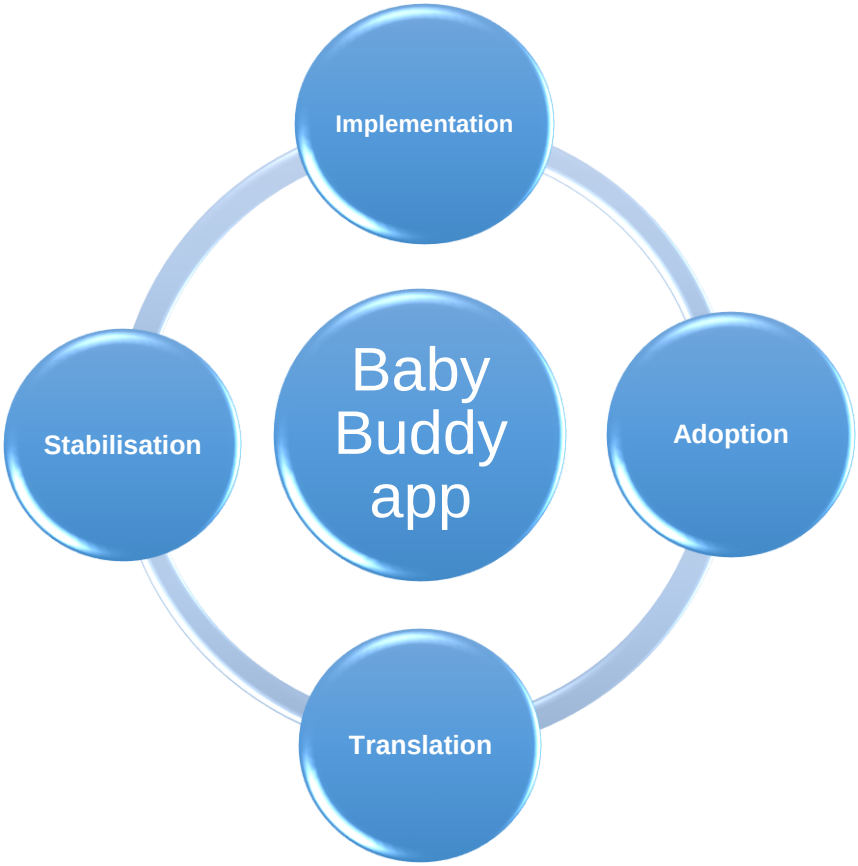
Healthcare Professionals also suggested that the app would be more accessible within their practice if they did not have to set up an account in as much detail as the first-time mothers as this extract below highlights:

"*I think from a HCPs point of view, you want to download the app, you don't want to go through the whole set up, of choosing a name for your character, and all of that because that's not relevant, I don't really want to know any of that, I just want to be able to get the app log on and not register and just use it, I'm happy to put on my email address, so they've got that information, but I don't want all of the what I call "flannel", in order to be able to actually, because what often happens is I'll tell the mums about it and I'll say have you heard of this app, and they'll say oh no I haven't, so I say well lets download the app, and I want to be able to cut straight to the chase, I want to be able to, when you've got more time you can register properly and use a person and what have you, but for the purposes of now, we're going to skip that and I'm going to show you where the video is*." (HCP15)

This suggests that HCPs may want a more flexible registering process when showcasing the Baby Buddy app to mothers, this would save time and allow for a more manageable approach to presenting the features available to mothers. Whilst it goes beyond the scope of this evaluation, it might also indicate that HCPs may utilise the Baby Buddy app more within community settings if they could signpost mothers to specific features, such as videos, without having to spend extra time setting up an avatar and repeatedly add information that is not necessary for the purpose of in-practice support.

Overall it appeared that the four preconditions of Normalisation Process Theory (NPT) are being utilised for the Baby Buddy app at both a policy and organisational level. There is evidence to suggest that because of this, HCPs are beginning to implement, adopt and translate the Baby Buddy app and its features into clinical practice. This also reinforces the professional information within the app. This cyclical movement of themes are diagrammatically represented in figure 6.

Figure 6: Cyclical movement of NPT themes for Health Care Professionals



Within the NPT, Appreciative Inquiry Framework data were extracted to explore what worked well and what could be improved when using the Baby Buddy app. Interestingly, HCPs. findings concur first-time mothers' findings regarding what worked well with the Baby Buddy app (table 18):

Table 18: Using Appreciative Inquiry within the preconditioned themed analysis of HCPs data

NPT preconditions	What worked well?	What could be better?
Implementation	HCP and Best Beginnings start up meeting, showcasing the app and features	Monthly newsletter to keep HCP motivated and engaged and to introduce new professionals and refresh the BB app
Adoption	Accessibility Offering reassurance Reliable Utilising further information – knowledge	Connectivity of wifi can disrupt access
Translation	Accessing app in teaching practices and training new HCP about the app	Negotiation needed around how they create a balance between using information from the Baby Buddy app and their own resources to guide first-time mothers' decision and choice making.
Stabilisation	Reliability – professionally endorsed	HCPs may want a more flexible account when showcasing the Baby Buddy app to first-time mothers. Demo mode option would be beneficial.

CHAPTER 5: IN APP DATA

5.2: RESULTS

App usage

The overall median time spend in the app per session across 61 participants was 6.8 minutes (mean 8.3 minutes (SD 5.8 minutes) (figure 7). There was a clear difference in how frequently and how long different participants used the app, as seen on figure 8.

Figure 7: Distribution of single in-app sessions durations in minutes across all users (n = 61). (Dashed line represents median (6.8 minutes).

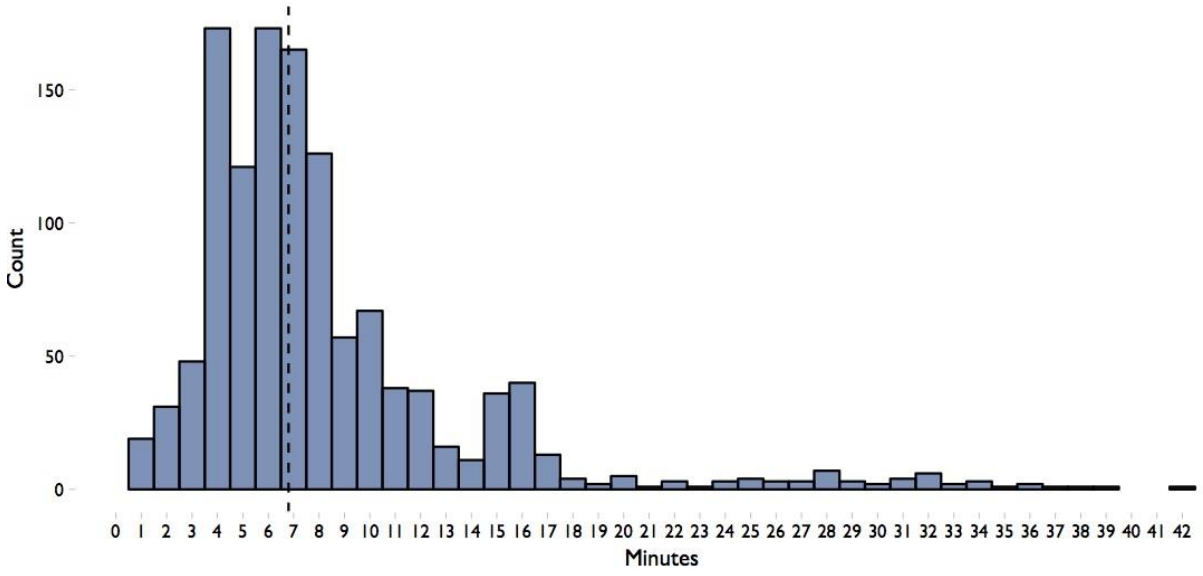
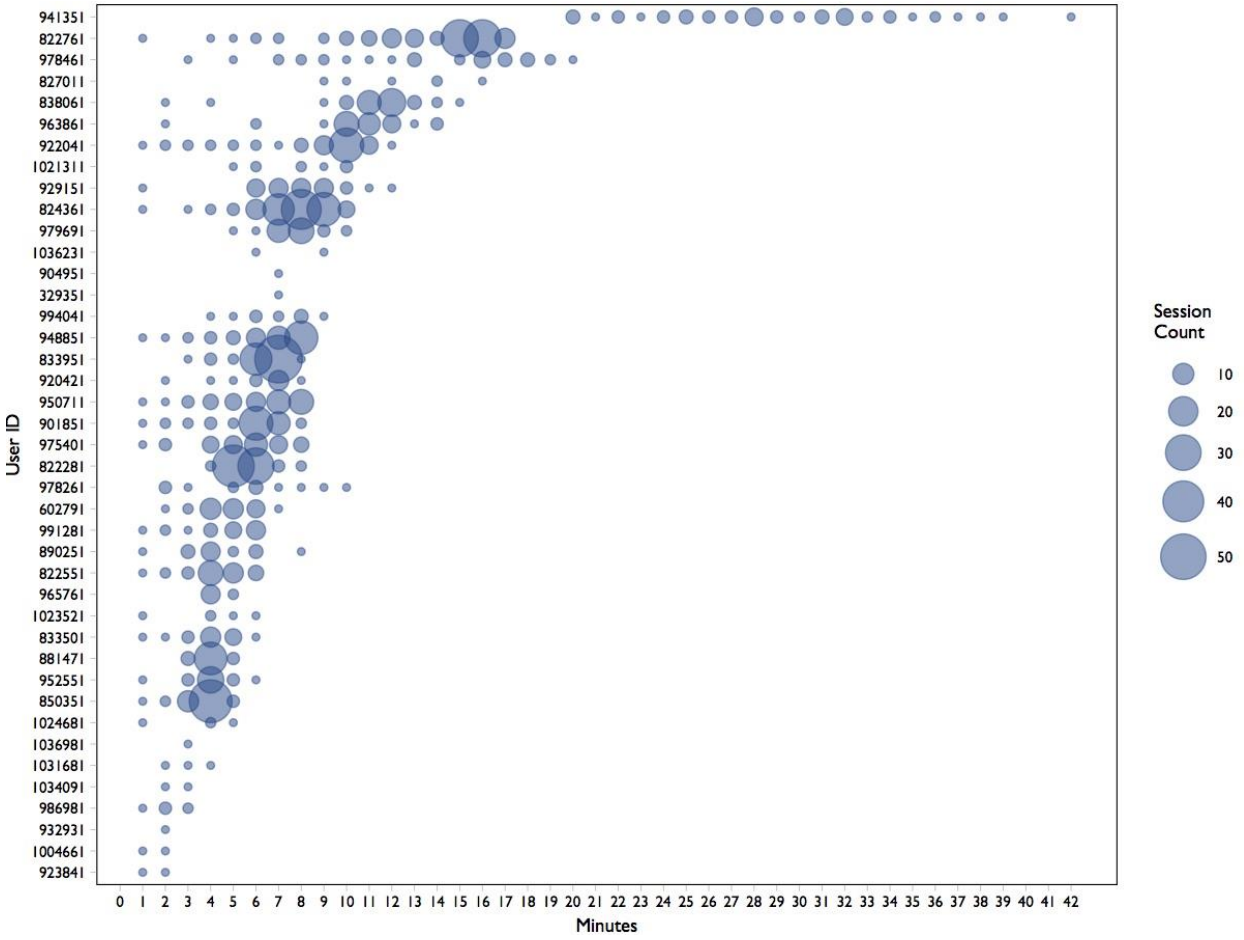


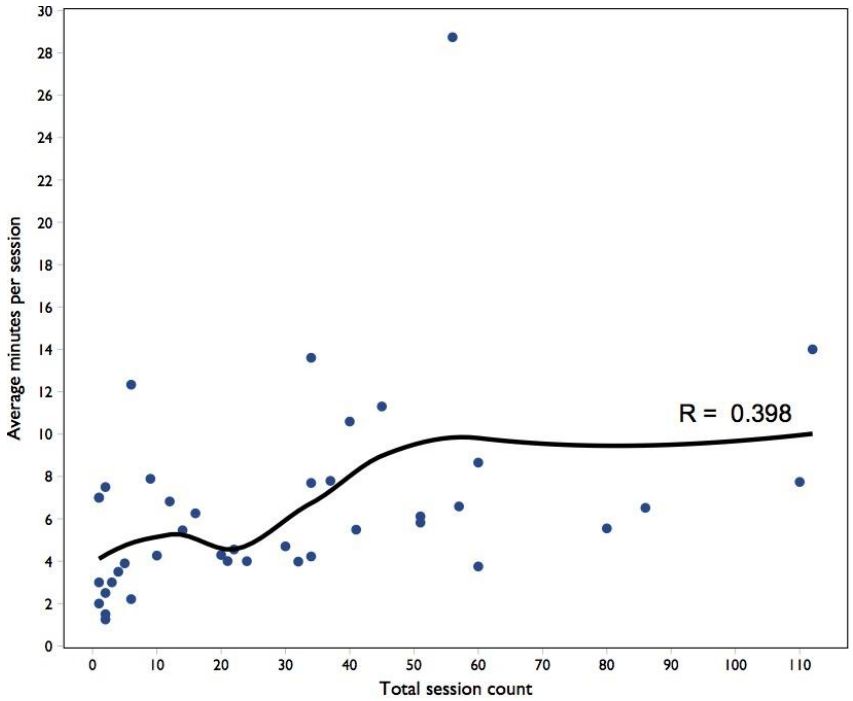
Figure 8: Distribution of single in-app session durations in minutes with circle size indicates session counts for each user (n = 41)



There were 48 participants for whom we were able to calculate the number of times the app was opened by each participant. The range for this was very wide, from 0 to 593 times, with a mean of 199.8 (SD 174.2) and median of 146.5 (LQ 52.5 – UQ 329)(appendix 7, table 8). This indicates that the distribution of data are positively skewed (bunched towards the lower end).

For the 41 participants for whom the relevant data were available, there was a positive correlation between the total number of sessions and average minutes spend using the app (Pearson's correlation coefficient *R=0.39*). This implies that users who engaged with the Baby Buddy app more frequently tended to spend more time using the app at each engagement than users who accessed the app less frequently (figure 9).

Figure 9: Correlation between total session count and average minutes per session. This displays the smooth conditional mean line and R coefficient (n=41).



App features

The top 5 most popular features used by the participants were: 1) 'Today's Information', 2) videos, 3) Bump/Baby Booth, 4) 'Ask Me' and 5), 'Remember to Ask' (table 19). The least commonly used feature were 'Bump Baby Around' and 'You can do it!' (table 19a).

Table 19 illustrates the exact distribution of frequency of features used by (a) each participant and (b) across all participants (b). 'Today's Information' were more than 10 times more frequently used feature than everything else within the app, except 'Videos' (which were still viewed around 7 times less than News).

Table 19 (a): Heatmap showing total frequency of use for specific Baby Buddy app activities by each participant (n=61). Activities were aggregated by specific core features used in the app.

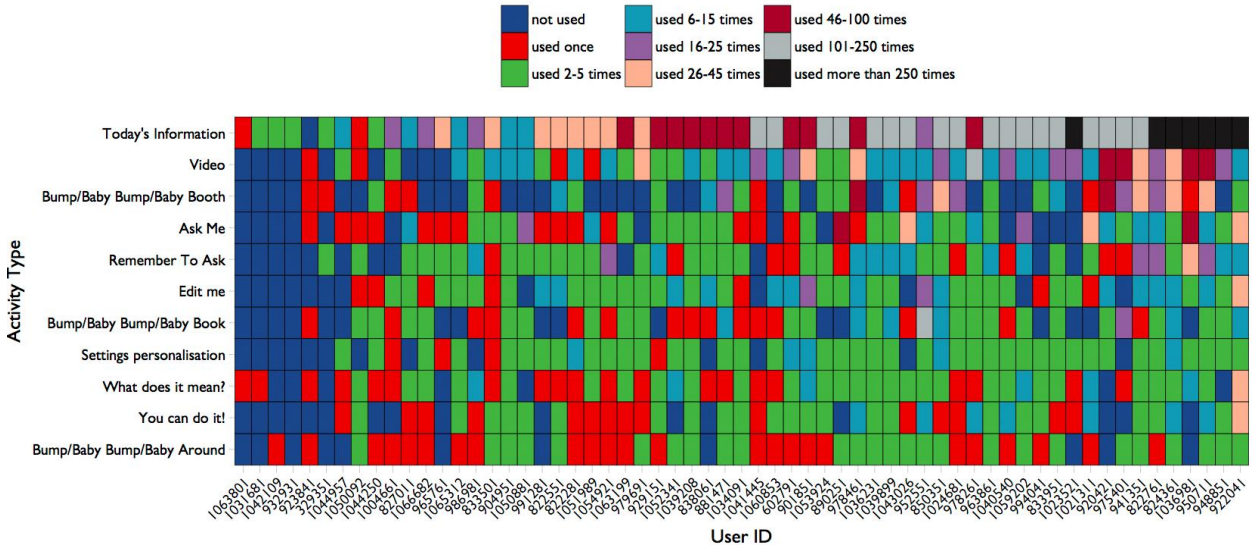
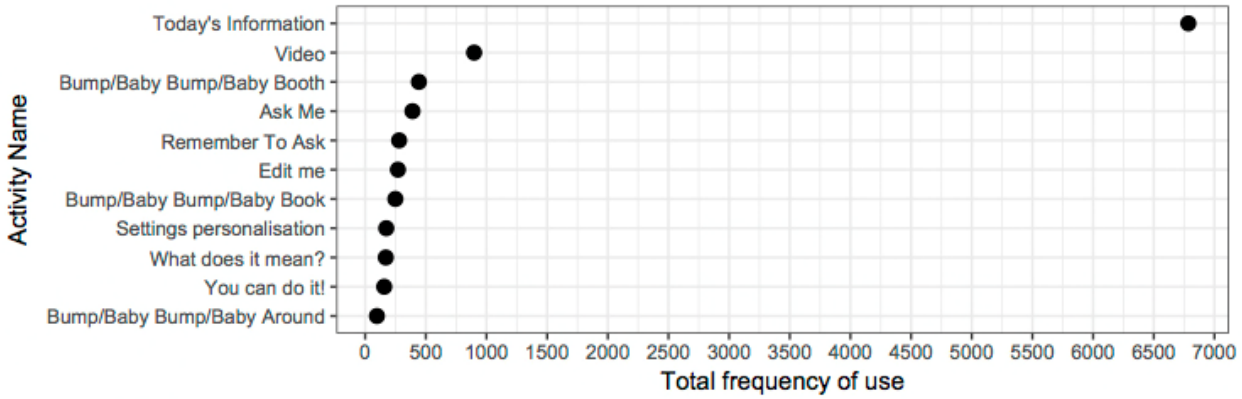


Table 19 (b) Total frequency of use for specific Baby Buddy app activities by all participants (n=61).



Time of day for app usage

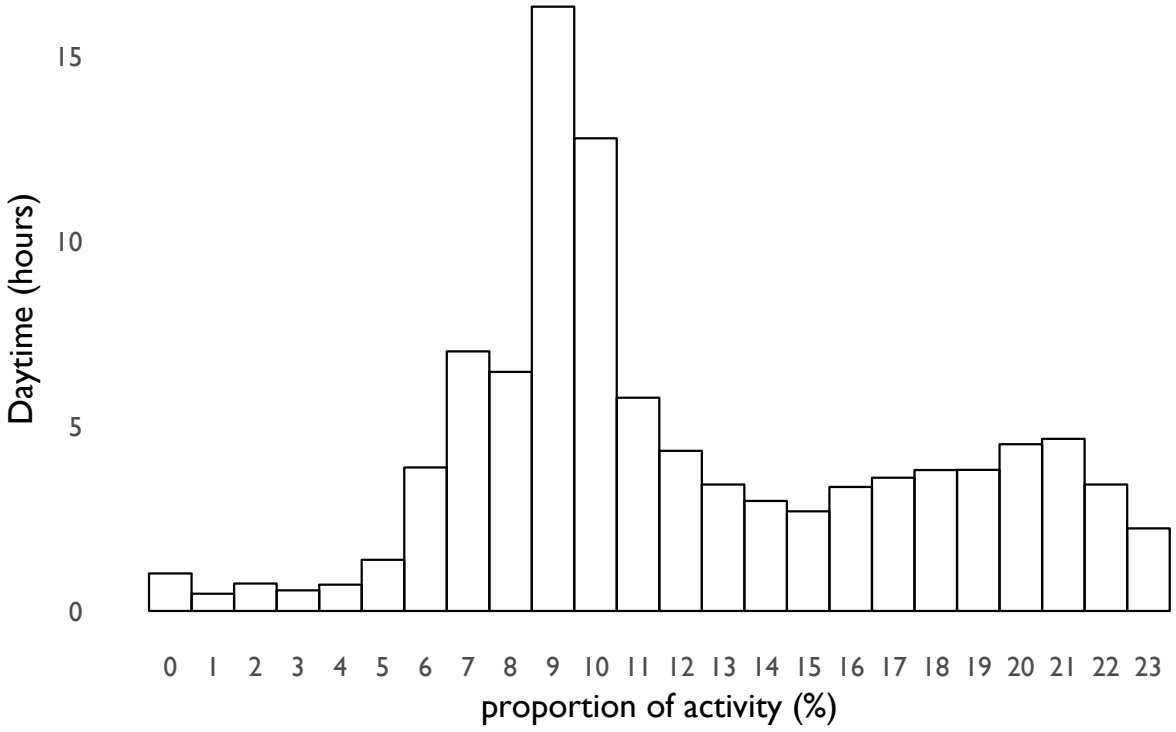
Participants were quite active in the app throughout most of the day but were most active in the morning and mid-evening, with peaks of activity between 09:00-10:00 and 20:00-21:00 (figure 10a).

To explore whether different elements of the app were used at different times of the day, a search was undertaken to look at the different search activities (i.e., question selection, keyword search, URL selection and video viewing). The participants were likely to spend time looking up questions, website urls or looking at videos primarily in the morning (06:00-11:00) but the first-time mothers focused more on specific searches in the evening (21:00)(figure 10b).

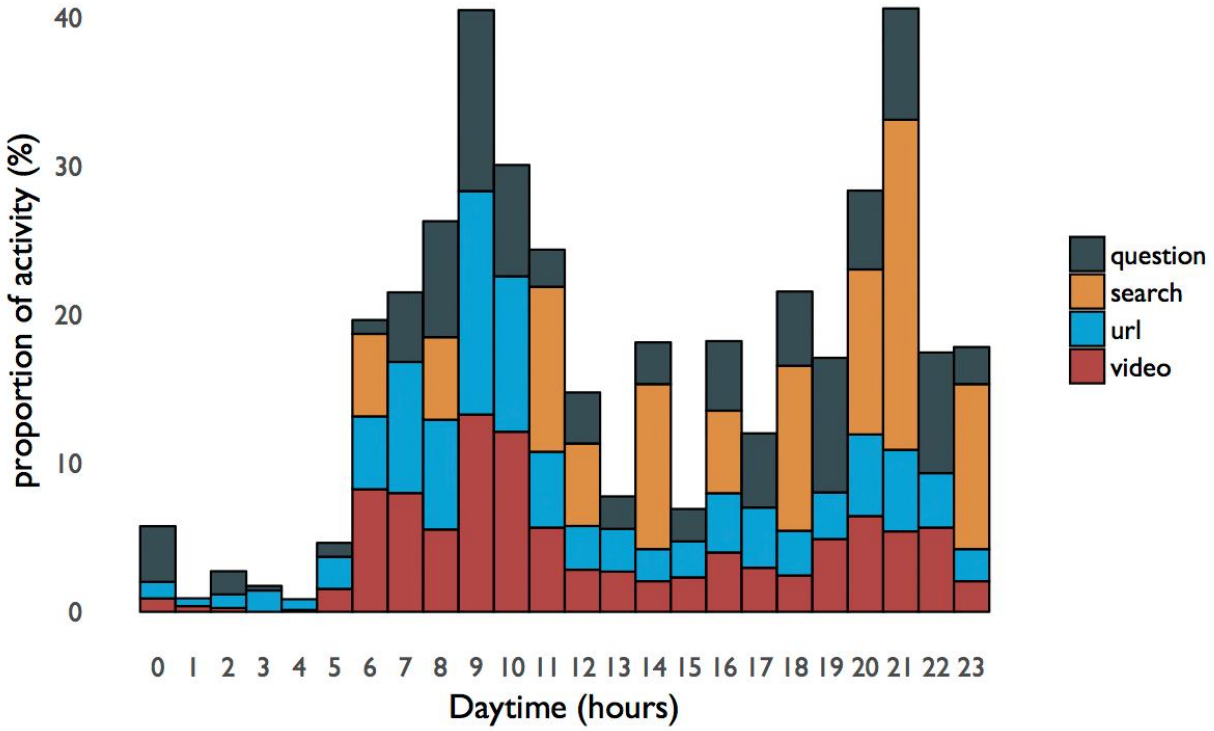
Figure 10: Proportion (%) of activity at different times of the day by:

a) total use;

b) considering only different search activities (i.e. question selection, keyword search, URL selection, and video viewing).



(a)



(b)

Searched content

Participants' Baby Buddy in-app data were analysed to determine which of the searched content was accessed and how often. The most searched words were searched between 6-14 times in a search. The words included the following: "labour", "form", "birth", "mat" (probably abbreviation for maternity), "bl", "pregnant", "ive", "developing", "concerned", "free" and "feeling". These search terms are illustrated in figure 11 and on a wordcloud in figure 12a below.

Figure 11: Most frequently used words in search and question options in the Baby Buddy app (only showing words used 2 times or more).

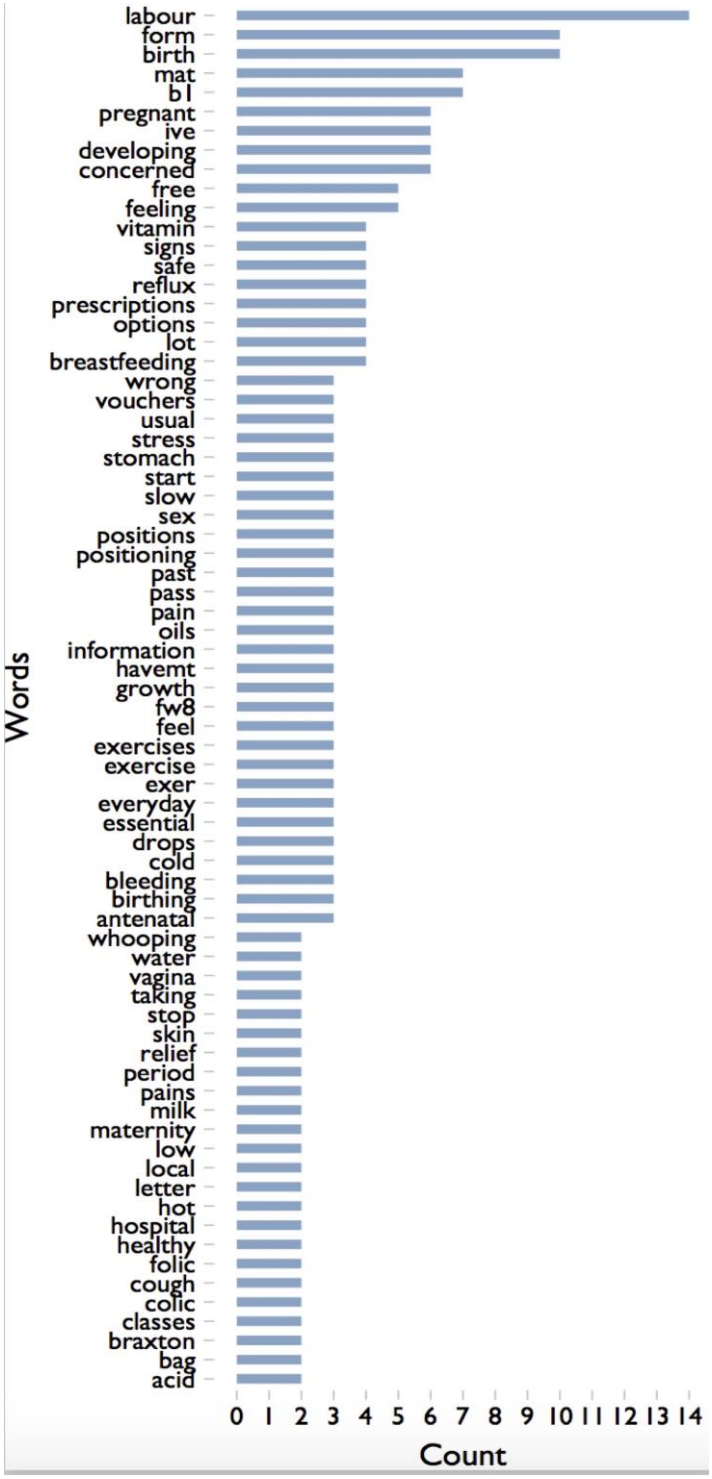


Figure 12: Wordclouds of most frequent words used in search and question options in the Baby Buddy app:

a) overall frequency without sentiment analysis

b) as classified in sentiment analysis by negative and positive category using the binary sentiment lexicon (Bing Liu et al., 2005; Bing, 2012);

c) as classified in sentiment analysis by a range of categories using NRC Word-Emotion Association Lexicon (Mohammad and Turney, 2010; 2013).

Figure 12a: overall frequency without sentiment analysis

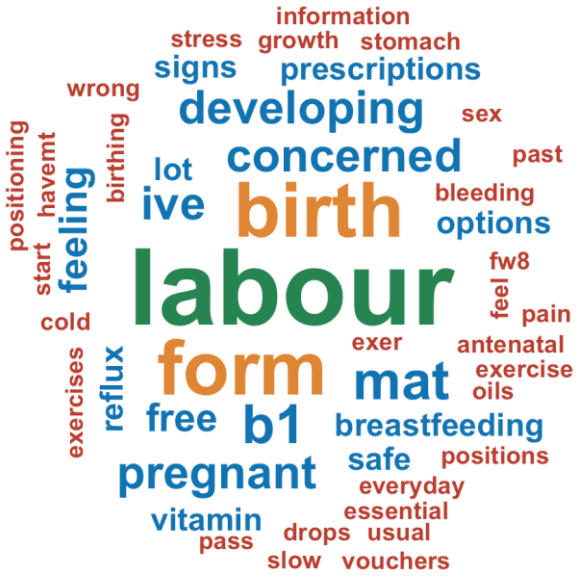
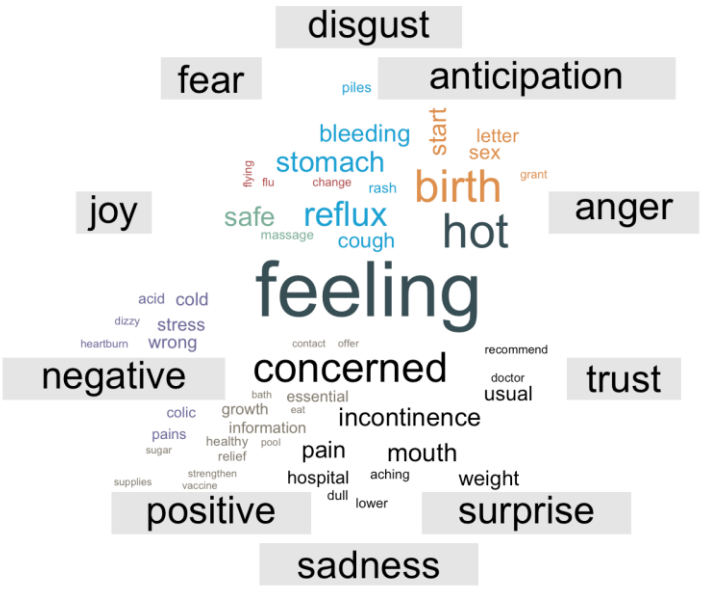


Figure 12c: sentiment analysis by a range of categories

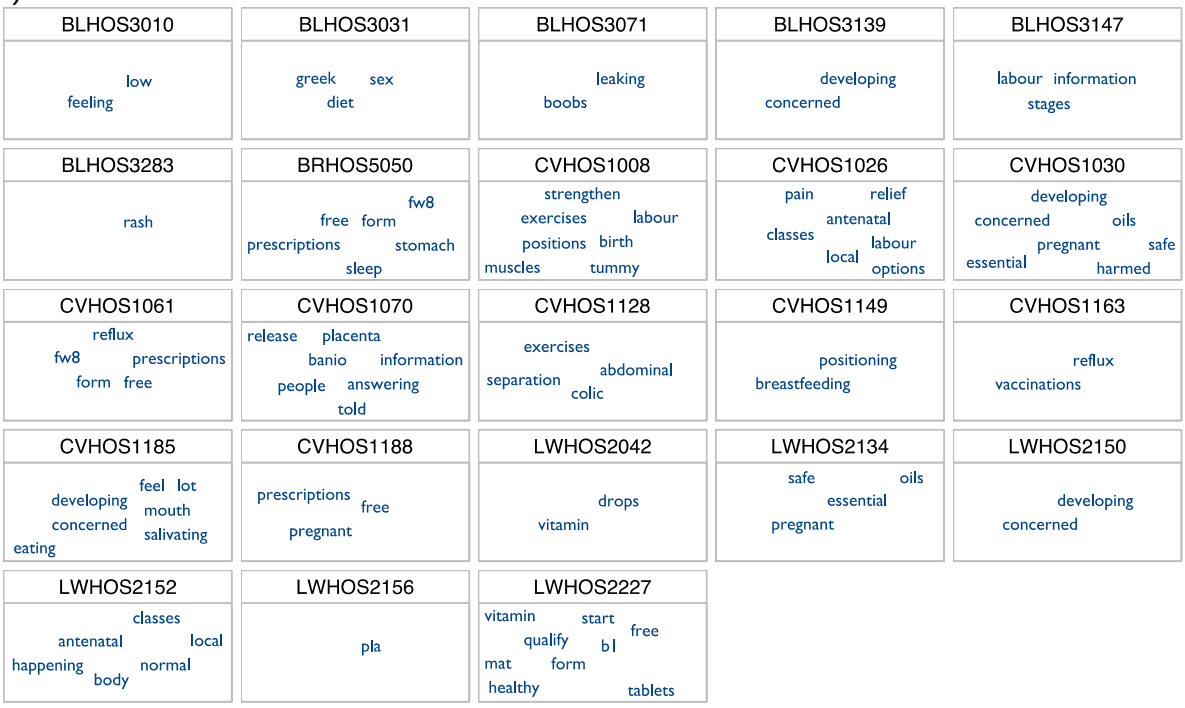


Sentiment analysis on words was used for the search and the questions. This demonstrated that there was a broad range of topics and issues that participants searched for in the app, with some negative sentiments and worries resonating strongly (figures 12b and c). This is even better illustrated by figure 13 where we split the word searches by individual participants who search the app with either low (figure 13a) or high frequency (figure 13b).

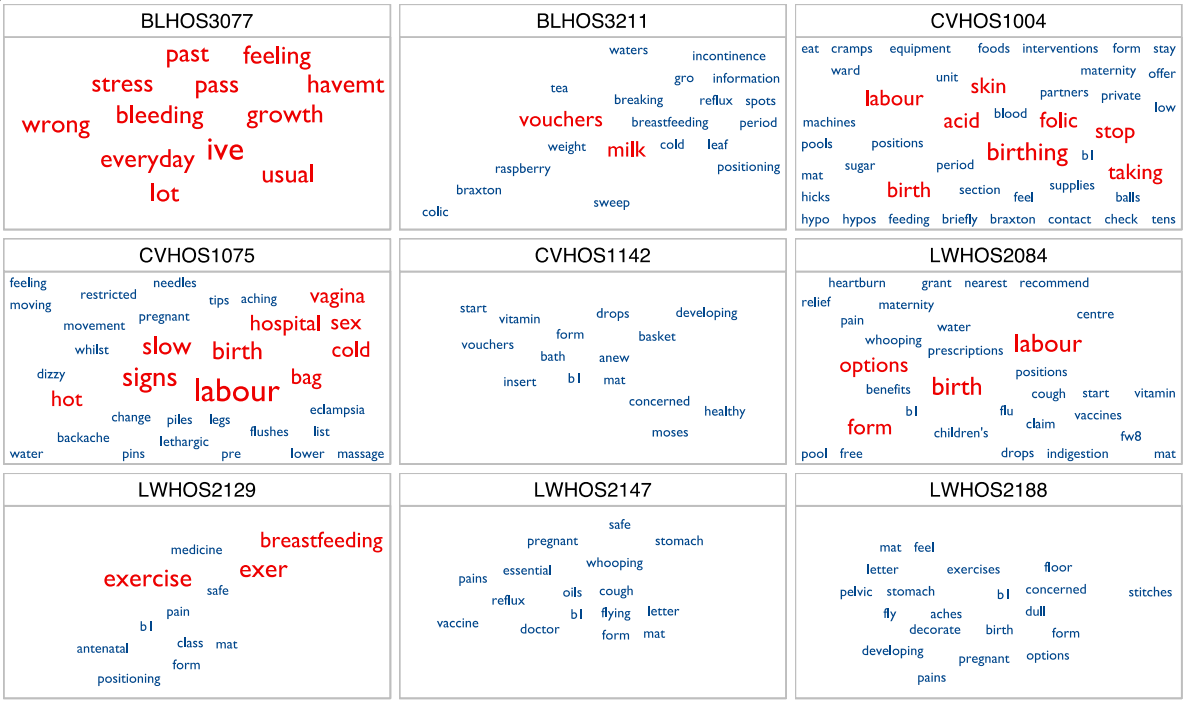
Figure 13: Wordclouds of most frequent words used in search and question options in the Baby Buddy App by specific participants who search with either:

a) lower frequency;
b) higher frequency. Red colour words indicate searches performed more than one time.

a)



b)



Additional in-app data analysis

As described in section 2.5.2, 2.5.2: Methodsan additional analysis was undertaken using Baby Buddy users' in-app data to investigate how levels of app usage affected outcomes (i.e. TOPSE and WEMWBS scores). Out of those women who consented, in-app data were obtained from 61 women, of whom 51 were included in the in-app analysis. These were participants who had provided valid outcome data at baseline (i.e., TOPSE or WEMWBS data) and who also responded at 3 months post-birth (providing valid outcome data).

The main characteristics of the Baby Buddy in-app participants (n=51), compared to those non-Baby Buddy app users included in the final sample (n=182) are summarised in table 20. The two groups were comparable in most aspects. However, in-app participants had lower social support (p=.035), which was consistent with what was found in our previous analysis (table 4 in section 2.3.7) showing that Baby Buddy users reported lower levels of social support than non-Baby Buddy users). Predictably, in-app participants also used more pregnancy apps on average than non-Baby Buddy users (p<.001).

Table 20: Characteristics of in-app participant's vs non-Baby Buddy users

	In-app participants (n=51)		**Non-Baby Buddy users in final sample** (n=182)		
	Med (LQ-UQ)	n (%)	Med (LQ-UQ)	n (%)	Difference test
Age	30 (26-33)		29 (25-33)		Z=-1.01, p=.312
IMD decile	4 (2-6)		4 (3-7)		Z=0.87, p=.386
Ethnicity - White British		32 (62.8%)		125 (70.6%)	X^2=1.15, p=.285
Education - Degree or higher		37 (72.6%)		106 (59.2%)	X^2=3.00, p=.083
Employment - In paid employment		45 (88.2%)		163 (90.1%)	X^2=0.14, p=.706
Relationship - Married or living with partner		47 (92.2%)		161 (88.5%)	X^2=0.57, p=.451
General use of technology (MTUAS score)	5 (4.7-5.3)		5.1 (4.8-5.4)		Z=0.71, p=.481
Social support (MSPSS)	6.7 (6.1-7)		6.9 (6.3-7)		Z=2.11, p=.035*
Median number of pregnancy apps used across the study time points	2 (1.5-2.3)		1.3 (1-2)		Z=-4.76, p<.001**

*p<.05; **p<.001

- All variables as reported at baseline.
- Med (LQ-UQ) – Median (Lower quartile – Upper quartile)

In consultation with the app developers, the following app elements were assessed to quantify in-app usage: 'Today's Information', 'Videos', 'Ask Me', 'Remember to Ask', 'You can Do it', 'Bump Around/Baby Around', 'Baby Book/Bump Book', 'Baby Booth/Bump Booth', and 'What Does it Mean'. 'Session count', or number of times used, was considered to be the most suitable indicator to divide app usage into high versus low. Within each of the app elements there were various possible activities; for example, for the app element 'You can do it', we took into account a), whether this app element was opened b), whether a goal was created and c), whether a goal was completed. The session counts of each app element's activities were summed and two overall aggregated scores were derived for data analysis to describe two distinct types of app use: highly engaged and less engaged (see section 2.5.2 for details).

In-app usage, using these two distinct types of app use and based on the number of uses amongst in-app participants, are summarised below (table 21). The seven-band classification was suggested by the app developers.

Table 21: In-app usage amongst in-app participants (n=51)

Level of in-app usage	**Today's Information**: 'Engaged' overall score n (%)	**Highly engaged**: overall score n (%)
Less than 5 uses	3 (5.9%)	4 (7.8%)
5-15 uses	4 (7.8%)	9 (17.7%)
16-25 uses	4 (7.8%)	9 (17.7%)
26-45 uses	7 (13.7%)	13 (25.5%)
46-100 uses	9 (17.7%)	11 (21.6%)
101-250 uses	17 (33.3%)	5 (9.8%)
251+ uses	7 (13.7%)	0 (0%)
	Median 94 (31-196)	Median 27 (13-51)

In addition, as requested by Best Beginnings, the changes in TOPSE scores from baseline to post-birth by total app usage were plotted. As the R-squared value indicates (R-squared=0.0014), there was no association between the two variables (appendix 7, figure 1). The baseline and post-birth TOPSE scores, together with total app usage and baseline characteristics (age, IMD decile and social support scale) for each of the in-app participants (n=48) are described in appendix 7, table 8. For clarification, the previously reported 51 in-app participants was based on whether valid data for the TOPSE or WEMWBS. In this case, we are

looking at only TOPSE scores, there were 3 participants who had not provided valid TOPSE data at baseline and/or 3 months post-birth.

The best fit lines of TOPSE scores across time points for the in-app sample (n=48) has been calculated. Unlike in the main sample, there was no decrease from baseline to 35 weeks (medians 304.5 (LQ 278 - UQ 324) to 304 (LQ 273 - UQ 331), respectively) but this increased slightly at three months post-birth to a median of 312.5 (LQ 296 - UQ 329). This is described in appendix 7, figure 1. Previously we reported a lack of association between Baby Buddy use and the TOPSE scale, the data here when comparing in-app participants are consistent with those findings.

Based on table 21 we created two additional categories of app user within each of the above groups. These are based on the median for that category (table 22):

1. *High versus low users in the highly engaged type of user*: high app users defined as 27 uses or more (n=27) and lower users, defined as less than 27 uses (n=24)
2. *High versus low users in the less engaged type of user*: high app users defined as 94 uses or more (n=26) and lower users, defined as less than 94 uses (n=25)

We developed separate logistic regression models to compare the outcomes (TOPSE and WEMWBS) of active and engaged high/low app users, using the same binary outcomes from previous analyses (section 2.3.7). As before, we ran two regression models, one unadjusted (model 1) and one adjusted for potential confounders (model 2). However, considering the small number of participants in the analyses we had to be selective as to how many confounding variables to include, to maximise the viability of the model. As such, we tested for any differences between high/low app users (table 22) and then selected those which were shown to be significant baseline outcome levels for TOPSE and WEMWBS.

High in-app users and low in-app users were very similar in almost every characteristic, for the two aggregated scores. The only statistically significant difference, which was marginal, was found in terms of maternal education level; high app users were more likely to hold a degree, both for highly engaged types of users (p=.049) and for the less engaged overall score (p=.032)(table 22). On the basis of this information, education was selected as a variable to adjust for in the regression analysis.

Table 22: Characteristics of high and low in-app users

	Today's Information/Engaged Overall Score (Engaged)			**Highly engaged** Overall Score (Highly engaged)		
	High users (n=26)	Low users (n=25)	Difference test	High users (n=27)	Low users (n=24)	Difference test
Age (years)	30 (27-32)	30 (26-33)	Z=0.16, p=.872	30 (27-34)	29.5 (26-31)	Z=-0.93, p=.354
IMD decile	4 (3-6)	4 (2-7)	Z=-0.10, p=.924	4 (2-5)	4 (2-8)	Z=0.86, p=.392
MTUAS score	5 (4.8-5.2)	5.1 (4.7-5.3)	Z=0.65, p=.514	5 (4.8-5.3)	5.1 (4.6-5.3)	Z=0.07, p=.947
MSPSS score	80.5 (75-84)	80 (72-84)	Z=-0.45, p=.653	81 (77-84)	78 (71-84)	Z=-1.12, p=.263
Number of pregnancy apps used across time points	2 (1.7-2)	2 (1.5-2.5)	Z=0.87, p=.386	2 (1.7-2.3)	2 (1.5-2.3)	Z=0.21, p=.832
Ethnicity n(%) - White British	16 (61.5%)	16 (64.0%)	X^2=0.03, p=.856	16 (59.3%)	16 (66.7%)	X^2=0.30, p=.585
Education n(%) - Degree or higher	22 (84.6%)	15 (60.0%)	X^2=3.88, p=.049*	23 (85.2%)	14 (58.3%)	X^2=4.6, p=.032*
Employment n(%) - In paid employment	23 (88.5%)	22 (88.0%)	X^2=0.00, p=.959	24 (88.9%)	21 (87.5%)	X^2=0.02, p=.878
Relationship n(%) - Married/living with partner	24 (92.3%)	23 (92.0%)	X^2=0.00, p=.967	25 (92.6%)	22 (91.7%)	X^2=0.02, p=.902

*p<.05

- Median (lower quartile – upper quartile) are reported for continuous variables: age, IMD decile, MTUAS score, MSPSS score and number of pregnancy apps used.
- Number (and %) are reported for all other (categorical) variables.
- Z: based on Mann-Whitney test
- All variables as measured at baseline, with the exception of number of pregnancy apps used as this is the average of pregnancy apps used at each of the data collection time points.
- IMD: Index of Multiple Deprivation (1 is highest deprivation; 10 is lowest deprivation)
- MTUAS: Media and Technology Usage Scale
- MSPSS: Multidimensional Scale of Perceived Social Support

The results of the logistic regression analysis for both self-efficacy (TOPSE) and mental wellbeing (WEMWBS) associated with the engaged type of user are described in table 23. For clarity, we also report the median value of the outcome score, for each of the two groups (under the columns 'High users' and 'Low users'). The results revealed no statistically significant associations between level of usage of the engaged type of user and TOPSE scores, and WEMWBS scores, both in the unadjusted and adjusted models. Confidence intervals were large, particularly for WEMWBS.

Table 23: Engaged type of app users: logistic regression analysis comparing TOPSE and WEMWBS between high in-app users and low app users.

	High users (n=26)	**Low users** (n=25)		OR (SE)	95% CI	p value
TOPSE overall	315 (302-330)	312 (296-329)	Model 1	0.81 (0.52)	0.23 to 2.88	.747
			Model 2	0.82 (0.56)	0.21 to 3.12	.766
WEMWBS overall	54 (48-57)	55 (52-58)	Model 1	1.67 (1.05)	0.49 to 5.69	.408
			Model 2	3.58 (2.77)	0.78 to 16.3	.099

- The values under the 'High users' and 'Low users' columns correspond to median (lower quartile – upper quartile).
- Model 1 is unadjusted; Model 2 is adjusted for education and outcome scores at baseline.
- Outcomes are binary; odds of low TOPSE, odds of low WEMWBS, based on the overall median value, as used in previous analyses.
- OR: Odds ratio. SE: Standard error
- TOPSE: Tool to measure Parenting Self-Efficacy
- WEMWBS: Warwick-Edinburgh Mental Well-being scale

The results of the analysis looking at the association between highly engaged type of app use and maternal self-efficacy and well-being (TOPSE and WEMWBS) are presented in table 24. There was no statistically significant association between usage of the active in-app element and either of the outcomes. Confidence intervals were similar to those from the engaged in-app element analysis

Table 24: <u>Highly engaged type of app users</u>: logistic regression analysis comparing TOPSE and WEMWBS between high in-app users and low app users.

	High users (n=27)	**Low users** (n=24)		OR (SE)	95% CI	p value
TOPSE overall	319 (305-336)	309 (287-318)	Model 1	0.48 (0.31)	0.13 to 1.73	.261
			Model 2	0.47 (0.33)	0.12 to 1.86	.283
WEMWBS overall	54 (48-57)	54.5 (49.5-58.5)	Model 1	1.50 (0.94)	0.44 to 5.09	.516
			Model 2	3.50 (2.78)	0.74 to 16.5	.112

- The values under the 'High users' and 'Low users' columns correspond to median (lower quartile – upper quartile).
- Model 1 is unadjusted; Model 2 is adjusted for education and outcome scores at baseline.
- Outcomes are binary; odds of TOPSE, odds of low WEMWBS, based on the overall median value, as used in previous analyses.
- OR: Odds ratio. SE: Standard error
- TOPSE: Tool to measure Parenting Self-Efficacy
- WEMWBS: Warwick-Edinburgh Mental Well-being scale

Table 25: <u>Engaged type of in-app users</u>: logistic regression analysis comparing TOPSE and WEMWBS between high in-app users and non-app users

	High users (n=26)	**Non-Baby Buddy** users in final sample (n=182)		OR (SE)	95% CI	p value
TOPSE overall	315 (302-330)	327 (305-343)	Model 1	1.00 (0.50)	0.37 to 2.68	.998
			Model 2	0.69 (0.40)	0.22 to 2.16	.519
WEMWBS overall	54 (48-57)	55 (50-61)	Model 1	1.64 (0.73)	0.68 to 3.93	.271
			Model 2	1.54 (0.78)	0.57 to 4.16	.392

- The values under the 'high users' and 'Non-Baby Buddy users…' columns correspond to median (lower quartile – upper quartile).
- Model 1 is unadjusted; Model 2 is adjusted for social support (MSPSS score at baseline), number of pregnancy apps used across time points and baseline outcome levels.
- Outcomes are binary; odds of low TOPSE, odds of low WEMWBS, based on the overall median value, as used in previous analyses.
- OR: Odds ratio. SE: Standard error
- TOPSE: Tool to measure Parenting Self-Efficacy
- WEMWBS: Warwick-Edinburgh Mental Well-being scale

It is possible that effects of using the Baby Buddy app are only evident above a certain usage threshold. To test this hypothesis, our final analysis consisted of testing the association between high app usage and outcomes, compared to non-Baby Buddy users. Results of this analysis for engaged type of app usage are presented in table 25. For the highly engaged app element, results are illustrated in table 26. The variables adjusted for in model 2 were social support and the number of pregnancy apps used (as per table 20) as well as baseline outcome levels.

Table 26: <u>Highly engaged type of-app users</u>: logistic regression analysis comparing TOPSE and WEMWBS between high in-app users and non-app users.

	High users (n=27)	**Non-Baby Buddy users** in final sample (n=182)		OR (SE)	95% CI	p value
TOPSE overall	319 (305-336)	327 (305-343)	Model 1	0.75 (0.40)	0.27 to 2.13	.595
			Model 2	0.48 (0.31)	0.14 to 1.68	.251
WEMWBS overall	54 (48-57)	55 (50-61)	Model 1	1.55 (0.69)	0.65 to 3.69	.326
			Model 2	1.40 (0.71)	0.52 to 3.76	.509

- The values under the 'high users' and 'Non-Baby Buddy users…' columns correspond to median (lower quartile – upper quartile).
- Model 1 is unadjusted; Model 2 is adjusted for social support (MSPSS score at baseline), number of pregnancy apps used across time points and baseline outcome levels.
- Outcomes are binary; odds of low TOPSE, odds of low WEMWBS, based on the overall median value, as used in previous analyses.
- OR: Odds ratio. SE: Standard error
- TOPSE: Tool to measure Parenting Self-Efficacy
- WEMWBS: Warwick-Edinburgh Mental Well-being scale

These results show that there was no statistically significant difference between high usage of either of the app elements, engaged or highly engaged type of app use, and the outcomes compared to low or non-app users. It would be helpful to recollect that the baseline scores of both TOPSE and WEMWBS were high and therefore difficult to increase very much.

Median TOPSE and WEMWBS scores were lower for the high app users (lower self-efficacy and lower wellbeing) compared to the non-users. Using a binary outcome of poor self-efficacy and poor mental health with wide variability, there was no statistical difference between the groups. However, the low numbers in these analyses makes definitive interpretation difficult; as such these additional analyses should be interpreted with caution.

CHAPTER 6: DISCUSSION

6.1 SUMMARY OF FINDINGS

A longitudinal framework using a mixed methods approach was used to explore the effect of one specific e-health mobile health app, the Baby Buddy app, on parental self-efficacy and mental wellbeing. This took part in five geographically separate sites: Bradford, Blackpool, Coventry, Leicester and Lewisham. We also aimed to understand when, why, which elements of the app were used, how mothers used the app and any benefits the app may offer them in relation to their parenting, health, relationships or communication with their child, friends and family members or health professionals.

The following section is structured according to issues that are pertinent to the outlined objectives in section 1.2.1 Study Objectives A more generalised discussion follows that includes the methodological approach used, comparison of results with previous studies and consideration of the women who use apps. It concludes with the implications of the research and conclusion.

Objectives One and Two

The effectiveness of the Baby Buddy app at 3 months post-birth on parental self-efficacy and well-being in first-time mothers who used the Baby Buddy app at any time compared to those who did not report using the app and to investigate how levels of app usage affected outcomes (objective 1) *AND* The effectiveness of the Baby Buddy app, at three months post-birth, on parental self-efficacy and well-being in first-time mothers who heard about the app from a healthcare professional compared to those who did not hear about it from a healthcare professional or did not use it (objective 2).

6.1.1. ADDRESSING OBJECTIVE ONE:

Participants completed questionnaires at baseline (early pregnancy) and at three months post-delivery. The information we collected from these questionnaires suggest that the Baby Buddy app itself had no effect in improving parenting self-efficacy or mental ill-health at three months post-birth. The data also suggest that there was no benefit to parental self-efficacy post-birth for those participants where there was a longer period between when they first downloaded the app and three months post-birth. Neither was there any difference in parenting self-efficacy or mental wellbeing for those who were high app users compared to the low app users, either in those users who were highly engaged types of users or those who were less engaged types of

users. No significant effects were found either when we compared outcomes between high users (exclusively) and non-Baby Buddy users.

6.1.2. Addressing Objective two:

Finding out about the Baby Buddy app from a healthcare professional appeared to grant no additional benefit to app users, compared to all other participants in terms of self-efficacy or mental well-being at three months post-birth. However, because the app was recommended by a healthcare professional, they reported that they felt more confident that the app was evidence-based. At both the 35 weeks gestation and three months post-birth data collection time-point, the most frequent source from which Baby Buddy app users found out about the app was a midwife, which suggests that the 'embedding' of the app by Best Beginnings may have been worthwhile (section 3.1.3). From the qualitative element, mothers reported healthcare professionals and other apps as sources of finding out about the app but they also included the information about the app in the birth pack that they were given.

Strengths, limitations and context

This study set out to explore the impact of the Baby Buddy app on parental self-efficacy and maternal well-being. Therefore, the Tool for Parenting Self-Efficacy (TOPSE; Kendall and Avril, 2009) was selected as the primary outcome; it is a validated measure and was self-completed at baseline, 35 weeks gestation and at three months post-birth. The TOPSE scores were high at baseline in both the Baby Buddy app user group (median 317, LQ 287, UQ 337) and the non-app user group (median 320, LQ 295, UQ 337) with a maximum score of 360 which left little room for improvement. It was similar for the secondary outcomes, the Warwick and Edinburgh Mental Well-Being Scale (WEMWBS; Tennant *et al*., 2007). However, there was no difference between the Baby Buddy app users and the non-Baby Buddy app users. Linear regression models could not be run due to the negatively skewed outcome data but existing guidance on this issue suggests that our conclusions may be as robust as those from full linear models (Zhao *et al.*, 2001).

The final sample included just those mothers who had complete data for the TOPSE and WEMWBS at baseline and at three months post-birth. The retention rate of 60.7% from baseline to three months post-birth attests to the difficulty of engaging with new mothers at such a challenging period of their lives. Despite some discrepancies between the initial and final samples, app users and non-users remained comparable and we adjusted for relevant confounders.

All women who met the inclusion criteria (aged 16 years or over, had no previous live child, were between 12-16 weeks and six days gestation) in the five geographical sites were invited to take part. Therefore, the participants were a self-selected group of women and we are not able to assess how representative they are of the populations of first-time mothers in those five sites. The rate of degree holders, average of 51% in the baseline sample and 58.6% in the final sample, is above the national average of 42% for the whole population (ONS, 2017). In recent years a trend has been noted towards a significant gender gap between males and females with the gender-gap in higher education participation rising from a 9.3 percentage point increase for females in 2006/07 rising to an 11.9 percentage point increase in 2015/16 (DfE 2016). Lewisham had a degree holder rate of 69.9% and London populations are known to have a higher degree rate than the rest of England. If we omitted Lewisham rates, the average for the remainder of sites would be 43% which is nearer the general population rate and so possibly less than would be expected for females in the age group for first-time mothers. It may still be true that degree holders were more likely to agree to take part in the study, as found previously (Braig *et al.*, 2016) and, specifically, more likely to be retained in the study. This is a common phenomenon in maternal health-related research (e.g., Feinberg *et al.*, 2016). Although higher educated women were overrepresented in our final sample as well as those from 'other' ethnicities, between the Baby Buddy app user group and the non-app user group, there were no differences in the proportion of degree holders and those that remained in the study. The only difference between the high Baby Buddy app users and the low app users was that the high users were more highly educated.

Randomisation was not possible because the Baby Buddy app was freely available to download by anyone. At the 35 weeks gestation data collection time point we asked participants if the Baby Buddy app was one of those they used. This may have attracted curiosity and encouraged some women to look at and use the app themselves.

This study sought to determine, through the TOPSE, women's anticipated self-efficacy as a parent. Previous work that has focussed on women's attitudes to their prediction of parenting experience from pregnancy to the postnatal period have found a varied potential for expectations to influence outcome. In the USA, antenatal optimism has been found to be protective against symptoms of postpartum depression, using a measure of maternal optimism (MMO) in women from pregnancy the postpartum period (Robakis *et al*., 2015). However, they also found that excessively high antenatal expectations increased the likelihood of having expectations failed by reality. Those with high antenatal expectations were more likely to move to more negative perceptions in the postpartum and those with pessimistic expectations move to higher perceptions postpartum. Moderate optimism was the most protective of depression

and the authors recommended healthcare workers encourage this in pregnant women (Robakis *et al*., 2015). This study also showed that most women's experiences met or exceeded their optimistic expectations. This is similar to earlier findings where optimistic women were at much less risk of developing postpartum depression symptoms at six and 12 months postpartum than those who were not optimistic (Grote and Bledsoe, 2007).

A measure of maternal attitudes (AtoMS, Attitude towards motherhood scale) was developed for use in first-time mothers (Sockol *et al*.,2014). Using this to assess the relationship between maternal attitudes and psychological symptoms from pregnant to postpartum, women with lower scores, with regard to positive attitudes to motherhood, were at risk of perinatal distress. In contrast to optimism, perinatal stress has been associated with depressive symptoms, anxiety and a low sense of parental self-efficacy (Razurel et al 2017). Social support, as well as emotional support from professionals was shown to mediate this distress (Razurel *et al*., 2017).

Baby Buddy app users had lower scores on the social support measure, the Multidimensional Scale of Perceived Social Support (Zimet *et al.*, 1988), compared to non-app users. This indicates lower levels of perceived social support and, whilst we have no evidence to explain this, it might suggest that, for those women with lower perceived peer support, they could be turning to the app for advice/guidance.

In seeing no change in both Baby Buddy app users and non-app users from the antenatal period through to three months post-birth and, in consideration of the respondents scoring towards the higher end of the TOPSE across all domains, we could infer that our cohort was generally positive about their parenting self-efficacy. It did also mean that there was little room for improvement in their scores. This seems to have resulted in a general maintenance of that positive attitude in the postpartum period, further evidenced by no change in WEMWBS scores either. One aspect to consider is the length of follow-up as we of course do not know how those scores may have changed if repeated at six or 12 months postpartum.

Another explanation for the observation of no difference in TOPSE scores compared with previous studies that have observed differences based on face-to-face interventions, is the theoretical underpinning of TOPSE. The construct of self-efficacy is based on social learning, in Bandura's (1982) work on self-efficacy that describes the sources of self-efficacy as being self-mastery, verbal persuasion, vicarious experience and stress exposure. These sources might be expected to be available in an app but given the mothers' expressed view that they liked to talk to HCPs face-to-face and to be with other parents, for example at National Childbirth Trust

classes, then it is theoretically likely that the Baby Buddy app alone does not provide the source of self-efficacy expectation that a face-to-face interaction may provide.

One of our secondary objectives was to measure outcomes at 35 weeks gestation to assess whether any reduction in the mothers' mental well-being in late pregnancy as has been found elsewhere (Bennett *et al.*, 2004; Deave *et al*., 2008a). Just 55% completed a questionnaire at this time-point and therefore we were not able to assess changes in mental well-being for the whole sample. For those who did return the 35 weeks gestation questionnaire, there were no differences in the scores for either the TOPSE or WEMWBS.

Objective 3

How the app affected the day-to-day lives of first-time mothers, specifically around their self-efficacy, parenting ability, health behaviour, interactions and communications with their friends, family and healthcare professionals.

6.1.3. Addressing Objective three:

The qualitative arm of the study obtained information from first-time mothers around their awareness and use of the Baby Buddy app in three geographical sites: Blackpool, Coventry and Lewisham. A thematic approach was taken with the first-time mothers' data. This process aimed to identify facilitators for the integration of the Baby Buddy app into routine health care. This analysis was underpinned by an Appreciative Inquiry Framework where barriers to use and what worked well within the Baby Buddy app were extracted from the data collected.

First-time mothers who participated in the qualitative arm of the study found that the Baby Buddy app worked well due to its accessibility and that the information was concise and easy to find. They liked that it followed the progress of pregnancy with appropriately-timed information and that different aspects could be accessed as and when needed. In line with the aims of the app, whilst first-time mothers enjoyed the information received from the Baby Buddy app, many still preferred in-practice support via HCPs, such as their midwife.

Strengths, limitations and context

The Blackpool site had a higher proportion of first-time mothers who had downloaded the Baby Buddy app than in the Coventry or Lewisham sites (information received from Best Beginnings, October 2015). Therefore, for the qualitative element of the study, it was anticipated that there would be a high proportion of first-time mothers who agreed to be contacted for interview from Blackpool but this was not the case; in our sample, there was a higher proportion of mothers who had downloaded the Baby Buddy app from the Coventry site. Mothers in both Blackpool

and Lewisham agreed to be interviewed but none took part in a focus group. Mothers were invited to take part in interviews and focus groups, the latter of which were held in a baby-friendly environment. Telephone interviews were also offered in case a face-to-face interview was too time-consuming. The researchers who undertook the interviews and focus groups were experienced and who were registered midwives, which enabled the women to talk openly about pregnancy and new-born care issues.

The first-time mothers often used multiple media sources to access information, including other maternity apps or web pages; there is recognition that this is a particular group who will access and use apps (Lee & Moon, 2016; Wallwiener et al., 2016). The first-time mothers used a "pick and choose" technology consumer style approach to which information was used and from which app. Examples of information sought from other apps was contraction timing, recommended shopping lists and "what to take into hospital" lists. These first-time mothers said that this increase in knowledge made them more aware of the choices they had regarding their pregnancy and gave them reassurance that they had control over the choices they made but with the support of HCPs. This study found that mothers were particularly reassured by the reliability of the sources of the videos featuring qualified midwives. These videos were taken from the Bump to Breastfeeding DVD developed by Best Beginnings and found to be informative for women (Wilkins *et al*., 2009). As mentioned above, in line with the aim of the app - to be used in addition to support from HCPs - women enjoyed the information received from the Baby Buddy app but they preferred in-practice support from HCPs, such as their midwife. The value of support or backing from HCPs has been found previously and is an important aspect to take into account when providing information to first-time mothers (Deave *et al.,* 2008b). The importance of the HCPs' perspective could be that they were first-time mothers and, whilst they did find the Baby Buddy app reliable, they wanted to seek face-to-face advice from a healthcare professional to support their decision-making.

These first-time mothers also gained reassurance from other first-time mothers that the information they were receiving through the Baby Buddy app was trustworthy and correct. This ultimately gave them the confidence to ask more detailed questions from their HCPs, knowing that they could always refer to the Baby Buddy app if necessary. The satisfaction gained from personal contact as opposed to exchanges in a digital platform has previously been highlighted (Sacco and Ismail, 2014; Tratnik *et al.*, 2017). This type of use of the app was also reflected in the HCPs' findings: they would often refer women to the Baby Buddy app to find further information or to watch videos which they could then discuss together. This suggests that, for certain aspects of the Baby Buddy app, that HCPs were embedding it into their healthcare delivery, a key feature in the overall purpose of the app

(https://www.bestbeginnings.org.uk/vision). The Baby Buddy app appeared to act as an overall communication tool between first-time mothers and HCPs, which created a cyclical movement of accessibility, knowledge, reliability, reassurance and confidence to communicate decision-making and raise their awareness of choices. This cyclical process indicates why the Baby Buddy app was used effectively by first-time mothers. They particularly liked the personalised daily updates of the progress of their pregnancy in the Bump area and child development in the Baby area of the app and this was reflected in the findings from the in-app data. This finding is important and highlights that first-time mothers were aware of the Baby Buddy app and were beginning to use it as part of their daily lives to increase their knowledge on specific topic areas of interest around pregnancy and birth. This is a very positive finding.

What appeared to be a barrier to using the Baby Buddy app was that some mothers made a conscious decision not to engage in some of the more 'nerve wracking' topics of information, such as labour or post-birth care. This might be particularly relevant for women if they had had a negative birth experience. Access to peer support via social groups might have increased the likelihood of interacting in these topics. This tendency to pre-empt emotional responses to the content and elements that mothers may consider upsetting is an area that may benefit from more in-depth investigation through research and could be further supported by healthcare professional direction and reassurance. First-time mothers whose first language was not English also struggled with some of the Baby Buddy app content. If the option to change languages was made available then it would give other cultures and ethnic minorities a chance to fully engage with the Baby Buddy app, increasing its usage not only regionally, but nationally.

Influence on health behaviour: breastfeeding

Although breastfeeding was not a standalone theme within the qualitative findings, it did appear to be a repeating topic that emerged from both the maternal and HCPs' data across all themes. These mothers reported that midwives and breastfeeding support workers had directed them to the content on breastfeeding in the Baby Buddy app, the mothers liked the visual content and practical advice. Most of the first-time mothers had decided to breastfeed themselves or had discussed it with their midwife but, from the qualitative findings, it appears that the Baby Buddy app was not the primary influence on their decision-making process.

A post-hoc analysis[2] was undertaken of the questionnaire data and there was some evidence that Baby Buddy app users were more likely to breastfeed than non-Baby Buddy app users,

[2] A post-hoc analysis involves undertaking analyses that were not pre-planned and were conducted as 'additional' analyses, trying to find patterns that were not primary objectives of the study.

even after controlling for relevant confounding factors. This pattern was observed consistently for both any and exclusive breastfeeding and across the one month and three months post-birth time-points. Baby Buddy app users were three times more likely to report any breastfeeding at one month post-birth and almost twice as likely to report exclusive breastfeeding at three months post-birth compared to non-Baby Buddy app users. These results need to be treated with caution. As in all non-randomised evaluations, the findings could be due to inherent differences in the samples (residual confounding), in this case those participants who used the app compared to those who didn't. Wide confidence intervals in these results points to variability in the data. These findings are interesting and encouraging, from a public health perspective, considering that efforts to increase breastfeeding often prove unsuccessful or require more resource-intense strategies such as the involvement of healthcare professionals or educational programmes (Guise *et al.*, 2003; Cartwright *et al.*, 2017). In addition, Baby Buddy app users were more likely to be younger and from a lower socio-economic group; both factors are known to reduce the likelihood of breastfeeding.

When the qualitative data were explored further, aspects that might have contributed to this include the following:

- breastfeeding is an 'activity' and mothers felt they could learn from the video content and remind themselves about what healthcare professionals had told them
- the content was evidence-based/professionally endorsed
- healthcare professionals felt the breastfeeding content was helpful, they therefore used it in their encounters with women and was central to healthcare professionals recommending the app to mothers
- first-time mothers reported that midwives and breastfeeding support workers were directing them to the content on breastfeeding and therefore trusted it, thus enhancing their interaction.

The aim of using Appreciative Inquiry (utilised in the qualitative study) was to explore what worked well, to search for an opportunity to replicate that success. With this in mind, a further exploration of the potential mechanism for success around breastfeeding and the influence of the app is explored in section 6.2.5 of this discussion.

Objective 4

Health professionals' awareness of the Baby Buddy app and barriers and facilitators to integration of the app into routine health care.

6.1.4. ADDRESSING OBJECTIVE FOUR:

The qualitative arm of the study also obtained information from healthcare professionals (HCPs) about their awareness and use of the Baby Buddy app in their service delivery; again in three geographical sites: Blackpool, Coventry and Lewisham. A normalisation process analysis was used for the HCPs' data. This process aimed to identify facilitators for the integration of the Baby Buddy app into routine health care. This analysis was underpinned by an Appreciative Inquiry Framework where barriers to use and what worked well within the Baby Buddy app were extracted from the data collected.

The data from the HCPs suggest that the four preconditions of implementation, adoption, translation and stabilisation were being used by them in relation to the Baby Buddy app. As a result, the HCPs are actively integrating the Baby Buddy app into clinical practice with other healthcare professionals and first-time mothers.

Strengths, limitations and context

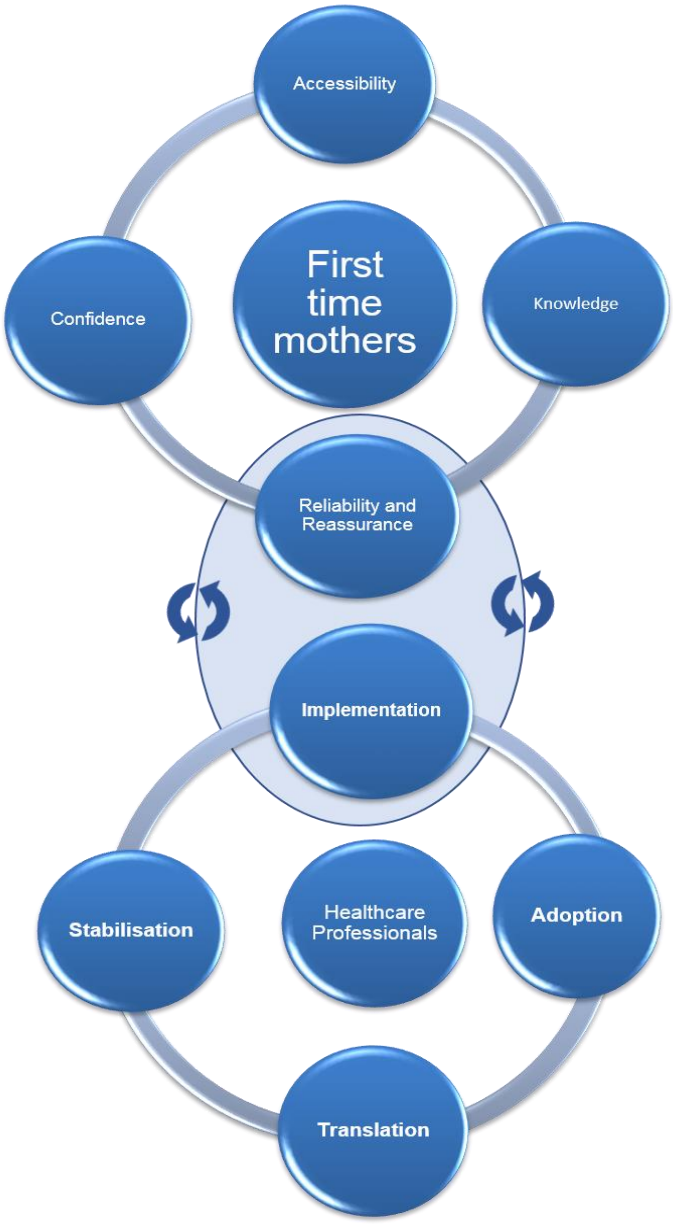
Healthcare professionals appear to have integrated the Baby Buddy app into their healthcare practice. The findings suggest that the four preconditions of Normalisation Process Theory Framework: implementation, adoption, translation and stabilisation were used by HCPs for incorporating the Baby Buddy app into their service delivery. HCPs need to feel confident, motivated and engaged with the features of the Baby Buddy app to maintain their use of the app in their day-to-day work. The main feature that encouraged HCPs to use and refer their patients to the Baby Buddy app, particularly around breastfeeding and postnatal care, was that it was professionally endorsed. The HCPs appeared to be using the Baby Buddy app as an adjunct to their work, implying that the advice and information they offered women at antenatal appointments was backed up by the information on the app. HCPs felt that this helped first-time mothers to feel reassured about the care and support they were receiving. This was also reflected in the first-time mothers' data, demonstrating a unifying link between these two groups' views of the Baby Buddy app. This is an important finding, it demonstrates an overall link between the two cyclical movements of the data from the HCPs and first-time mothers' data (figure 14).

The figure below (figure 14) is a visual representation that illustrates how the two cyclical movements come together when the Baby Buddy app is used within practice. The two key

elements in integrating the use of the app in the care of first-time mothers come from the theme, 'reliability and reassurance'. Both HCPs and first-time mothers felt that the Baby Buddy app worked well because the information stored on the app was reliable and this meant that HCPs were more likely to implement it within their own clinical practice and to adopt its' features. This, in turn, reassured the first-time mothers and supported HCPs in their practice; the momentum of the Baby Buddy app in engaging first-time mothers and practitioners in their decision-making and care was maintained.

A key example of what worked well within this model was use of the breastfeeding videos. As mentioned above, the breastfeeding videos appeared popular with HCPs who viewed them as a useful visual tool in explaining positioning when feeding and attachment. They then highlighted the breastfeeding content to women who again expressed a preference for this element of the app (see section 4.1.1: What Worked Well). The use of the videos by healthcare professionals in encounters with women led to the successful uptake of this element in app users, even though many of the films had been added after the embedding had taken place in some of the sites. Other elements of the app that were less used or reported seemed to be those features that both women and professionals were less aware of, such as the *Bump Around* or the *Bump Book* features. Another finding suggests women were asking for the app to continue in the postnatal period. As the '*Baby Buddy'* area of the App does feature post-natal information it may be that some women or professionals are not clear for how long content continues or how to manage this transition.

Figure 14: Key areas of interconnectivity, between themes of 'Reassurance and Reliability' and 'Implementation' of the Baby Buddy app, between first-time mothers and HCPs which, in turn, drives Baby Buddy app use in clinical practice.



Data collection from the HCPs proved difficult in the Blackpool site and none were interviewed or participated in a focus group. Staff from Lewisham were offered interviews or focus group participation. Staff took part in a focus group as this was easier for managers to facilitate within staffing demands on the service than for interviews.

The BaBBLeS study itself became part of the embedding cycle as we reminded or introduced HCPs to different sections of the app during the focus groups and interviews. It was not unusual for healthcare professionals to comment around the interview that they felt reminded and encouraged to use the Baby Buddy app more frequently in practice.

Objective 5

Uptake, patterns of usage and detailed analytics of key factors within the app.

6.1.5. Addressing Objective five:

There was a clear difference in the amount of time participants spent accessing specific elements of the app and there were particular times of day that when certain elements were accessed. The participants who were regular Baby Buddy app users appeared to spend more time on the app each time they accessed it than the less regular users. There were a variety of words that women used in the search and options section of the app but these were not reflected in those that were used in the qualitative interviews and focus groups.

Strengths, limitations and context

Consent for the in-app data was requested at the 35 weeks gestation data collection point and there were just 91 women (30.7% of the final sample) who agreed for their in-app data to be made available. However, there was only one difference, more highly educated, between the participants who gave permission for their in-app data to be accessed compared to those who didn't. We were able to compare outcomes for the high versus low app users groups but, due to the relatively small numbers involved, the confidence intervals were wide. We were also able to look at both highly engaged users, who had to specifically search for information or videos, or set up reminders, and less engaged users. These were participants who, when looking at 'Today's Information' just viewed it and didn't follow links; they were less goal oriented. This was a new method of analysing the in-app data which denotes the highly engaged user compared to the less engaged user.

Those participants for whom we have in-app data were a self-selected sample. The data collected were just from the women themselves but no data were collected from their partners or their families who may have been able to provide additional perspectives on the mothers' health and well-being.

In respect of the in-app data, there were irregularities in the participant numbers and information between both files provided by the funder. This resulted in a different number of participants being analysed for various stages of the exploratory analysis. Overall, we were able to analyse just 41 participants from the "user property" file and 61 participants from "user events" file. Those irregularities were difficult to untangle due to different file structure for both data sets. In relation to the small sample size, this is a major concern for the following reasons. A larger sample would enable us to run unsupervised machine learning algorithms to cluster participants automatically into specific usage groups and create a "typology of users". This could be considered for future use. Time stamps were of limited value due to the lack of an ending time stamp for events (only start was available). It was, therefore, impossible to establish how much time participants spent on specific in-app activities. Some data were encoded in the internal Best Beginnings' system so it was not possible to incorporate these data, meaningfully, into the analysis (e.g., what specific videos or URL links participants viewed).

In comparison to the national and local data, the overall Baby Buddy app usage in the five evaluation sites was higher than that of the national average where less than half of app users used the app 100 or more times (56% versus 46%, respectively) (appendix 10, personal communication, Best Beginnings, March 2018). Using this definition of 'users' in our sample, there were 47% who used the app in a less engaged way and just 10% who used a highly engaged format of interaction with the app; this is slightly less than all the app users in the five evaluation sites.

In respect of how embedded the Baby Buddy app was in the evaluation sites in comparison to other NHS sites in England: from the national in-app data, by February 2018, the five evaluation sites used in this evaluation held positions from sixth to sixty-seventh most embedded areas in the country (appendix 10, personal communication, Best Beginnings, March 2018). The national in-app data found that the proportion of women who had downloaded the Baby Buddy app in all five evaluation sites (9.1%-29.5%) was above the national average of nine percent and none of them were in the top five embedded sites. Blackpool was the most embedded of the five, in sixth position with Bradford the least, at sixty-seventh. Whilst Coventry hadn't been through the formal embedding process it had used the Baby Buddy app within its delivery of midwifery services. With Blackpool and Bradford as high and low embedded sites, the other three evaluation sites represented the full range of NHS sites in England (Coventry, 17th; Leicester, 45th; Lewisham, 61st). In our final sample of participants, 38.5% of them reported to have downloaded the Baby Buddy app, which is more than the proportion of women in the fifth embedded site (37.8%), albeit a self-selected sample, as mentioned above.

6.2. METHODOLOGICAL APPROACH

6.2.1. STRENGTHS, LIMITATIONS AND CONTEXT

We used a mixed methods approach that included survey data, interviews and focus groups, with both women and HCPs, to gain their perspectives as well as in-app data for those women who gave us consent to access their data. We are one of the first to use a large prospective cohort design to evaluate a pregnancy-related app. We collected information on a number of potential confounding factors and assessed potential baseline differences between Baby Buddy app users and non-Baby Buddy app users and high as well as low app users. We used validated tools and the results were consistent across the primary and secondary outcomes, which contributed to the robustness of our conclusions. The sample size was sufficient for a powered analysis comparing Baby Buddy app use and non-use and we adjusted for important confounders including any significant baseline differences between app users and non-users. This suggests that our findings are attributable to a genuine lack of effect of the Baby Buddy app on two specific outcomes, the Tool of Parenting Self-Efficacy (Kendall and Bloomfield, 2005) and the Warwick and Edinburgh Mental Well-Being Scale (Tennant *et al*., 2007).

Participants were recruited in five sites across England which reflected the ethnic and socio-economic diversity of those areas. In the final sample, the average age of women upon enrolment into the study was 29 years old which is close to the average age of first-time mothers nationally (28.6 years)(ONS, 2016). An average IMD decile of 4, which corresponds to the 40% most deprived areas in the country, is likely to be related to our recruitment sites, some of which are in areas of great socio-economic deprivation and two of which were Better Start Sites, which themselves were chosen as areas of need with poor child health outcomes. One third of participants identified themselves as other than White British. This is above the national average of 19.5% (ONS, 2012) and likely to be due to the inclusion of Lewisham and Bradford in our study, which are two places known for their large non-White British communities.

Baseline data were collected between 12-16 weeks pregnancy and, whilst some of the women reported using the Baby Buddy app at that point, the numbers were few (n=51, 14.3%). This suggests that, by the time the baseline data were collected, few of the participants would have accessed the Baby Buddy app or been influenced by it.

Appreciative Inquiry was a useful research methodology to use in the qualitative arm. It has theoretical and philosophical underpinnings in action research and organisational change (Cooperrider and Whitney, 1999). It lends itself well to a pragmatic discovery of information; it

focuses on the positive stance of what is useful before moving to what could be improved. The Normalisation Process Theory (NPT) Framework (May *et al.,* 2009) was used to analyse the HCP data. This approach proposes four preconditions for the success or failure of implementation of, and hence integration, of e-health interventions into routine healthcare practice: Implementation, Adoption, Translation and Stabilization (May *et al.,* 2003).

This study was based on any maternal report of any use of the Baby Buddy app. There were in-app data from a sub-sample of women, which demonstrated how often they opened particular elements of the app but there were no data were available to indicate length of time using the app. For example, it was not possible to assess whether, when the app was opened once or twice, it was used for a particular length of time or whether it was just for a few seconds. Likewise, for those women who opened up the app and some of its elements several times, we cannot know the length of time that was spent on each of these elements. This follows the principle of 'intention to treat'[3] in randomised controlled trials but is quite a high bar to set. We applied this principle because it is also consistent with the way that the app is made publicly available and currently used. To explore further the potential effect of the app on the outcomes, with the self-selected group of women for whom we had in-app data, we compared those who were high app users compared to those who did not use the app for both a highly engaged use of the app and a less engaged use of the app. No differences in outcomes were found between high and non-app users in either group.

6.2.2: COMPARISON WITH PREVIOUS LITERATURE

There are many e-health mobile apps available online. Good examples are those listed on the NHS Choices website (https://apps.beta.nhs.uk/), designed to help with a wide range of conditions as diverse as diabetes, COPD or mental health. However, there is still a general lack of evidence to assess the effectiveness and acceptability of these apps (Marley and Farooq, 2015; McMillan *et al.*, 2016). Mobile technology has been cited as an influential information source for pregnant women (Tripp *et al*., 2014) and there is a widespread use of pregnancy and parenthood-related apps amongst antenatal and postnatal women (Lee and Moon, 2016; Lupton and Pedersen, 2016). These have the potential to affect interactions with HCPs as well as facilitate new forms of communications and networking opportunities (Rodger et al., 2013). Whilst policy documents have encouraged the use of websites and apps with the Baby Buddy app cited as one example (NHS, 2016), the need for a stronger evidence-base is necessary to

[3] Intention to treat analysis means all patients who were recruited and were placed in a particular group (app user and non-app user) are included in the analysis and are analysed in those groups no matter whether they stopped using the app or not (thus replicating what happens in the 'real world').

recommend their use has been highlighted (Derbyshire and Dancey, 2013). This study is amongst the first to address this gap.

The internet was the main source of information for the first-time mothers in the study, followed by asking friends and their midwife; the importance of these sources has been highlighted in previous research (Lagan *et al.*, 2010; Grimes *et al.*, 2014). Baby Buddy app users and non-users were comparable in how they looked for information about pregnancy and parenthood. For both groups, apps were the fourth most frequent source of information about pregnancy and parenthood, mentioned by 60.2% of Baby Buddy app users and by 44.1% of non-Baby Buddy users. This reiterates their popularity and therefore the importance of ascertaining any impact of apps on maternal outcomes, specifically the Baby Buddy app. Although smartphone apps can be useful in providing mental health services (Donker *et al.*, 2013; Marley and Farooq, 2015), it is often argued that communication technologies cannot replace face-to-face interactions (Åkesson *et al.*, 2007; Gonzales, 2014). The Baby Buddy app aims to inform, support and increase access to health information by the embedding process, thus being used in addition to normal healthcare delivery.

Baby Buddy app users reported lower levels of perceived social support than non-app users at baseline, evident from the scores of the subscale 'friends'. We found Baby Buddy app users also tended to use pregnancy and parenthood apps more than non-Baby Buddy users. One might conceive that women who perceived support from friends as being less available, were more likely to seek interaction with a phone app, especially one such as the Baby Buddy app which is interactive and embedded into current service delivery.

The Baby Buddy app does not have social engagement within its features and this may have been a factor in the first-time mothers saying that, during the latter half of pregnancy, antenatal classes were more engaging. The classes gave them the opportunity to speak to other first-time mothers about their decisions and worries as well as with HCPs. There is one app that might be seen to provide an alternative to classes (Mush App); it offers this social interaction element by helping mothers find like-minded mothers in their local area, an alternative method of doing this. If this is as important to women as they say, this could be seen to be a key threat to sustained use of the Baby Buddy app in the early motherhood period. Parents felt the post-birth information on the Baby Buddy app was good but it did not continue to offer valuable information for long enough after their child's birth. Other apps were therefore also downloaded and used more frequently post-birth.

The first-time mothers in our study scored quite low on the childbirth experience scale which corresponds to a more negative childbirth experience, below that reported in previous studies (Walker *et al.*, 2015; Soriano-Vidal *et al.*, 2016). This may be a reflection of the severe cuts that have been experienced in recent years and resulted in a shortage of midwives and delays in natal care (Royal College of Midwives, 2018). If they had had a negative experience they might be less likely to look at certain aspects of the Baby Buddy app, such as post-birth care.

6.2.3. WHAT WORKS FOR MOTHERS, WHAT DOESN'T WORK SO WELL?

First-time mothers reported finding the information on the Baby Buddy app accessible, easy to use and the different elements could be looked at as and when they needed it. This suggests that the mothers were using the app to increase their knowledge around pregnancy and early parenthood just as they would other aspects of their daily lives. However, both the qualitative and the in-app data suggest that, whilst there were some elements of the app that were well used there were also those that were hardly accessed. The first-time mothers wanted short, sharp messages, for example pop-ups with links if they want more information or short films of two-three minutes. Longer films were unlikely to be watched all the way through.

The top five most popular features appeared to be 'Today's Information', videos, Bump/Baby Booth, 'Ask Me' and 'Remember to Ask'). Those that were least accessed by the women for whom we had in-app data were 'Bump Baby Around' and 'You can do it!'. This might be that the mothers didn't know about these elements and better signposting, or map of what content was available on the app, might have helped. The healthcare professionals seemed to be in a similar situation and were aware of only certain elements of the content. The Baby Buddy app contains a comprehensive reservoir of knowledge and information with several elements for the user to engage with. There is a possibility that the app is trying to do too much and that the 'pick and choose' attitude highlighted by the data, tells us something new about how women access information. If they go into an app with more than, for example, two clicks, they are more likely to use another where the information is immediately available. There are a number of ways forward: simplify and focus; consider reach to target specific populations; investigate the potential for optimising the impact of the informational function by exploring proactive practitioner-assisted use rather than the current 'signposting' that healthcare professionals report.

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6.2.4: WOMEN WHO USE APPS

There is little known about those who use pregnancy apps. Previous research found that the women who use apps are likely to be younger, more likely to be first-time mothers, less healthy (Wallwiener *et al*., 2016) and be more likely to be influenced by the information on the app than those who did not use apps. One inclusion criteria for our study was that they should be first-time mothers (no previous live baby), the median age was 28 years old, which is not young but does reflect the over-representation of this age group (25-29 year-olds), compared to ONS data, in both the national and wider population of women who have downloaded the app in the five evaluation sites. There was no suggestion from any of the data collected that they were not healthy, especially their mental health. Prior to the 35 weeks gestation data collection point, the participants had been told that the research was about the use of new technologies and if the use of social media or apps might affect how they felt about themselves and their baby. It is likely that they would not have taken part if they were not interested in social media or apps and therefore we have a group of women who may be more likely to enjoy using apps and feel comfortable accessing information from them than others of similar ages and situations. We do not know what makes them different to those that aren't interested and/or don't use apps except that half of the baseline sample in his study were degree holders, which is higher than the national average.

6.2.5: BREAST FEEDING

Lessons learned from the 'successes of breastfeeding content use

A main feature to emerge from the HCPs' findings was that participants liked the fact the Baby Buddy app was professionally endorsed, compared to other pregnancy apps and search engines. This was also reflected in first-time mothers' data which demonstrates a unifying link between HCPs' and first-time mothers' views of the Baby Buddy app. HCPs suggested that, because of this, they felt more likely to refer their patients to the information provided within the app, particularly around breastfeeding and postnatal care. It suggests that HCPs were using the app in adjunct to information they were giving within practice. HCPs often implied that, in doing this, the information they received from the app backed up the knowledge that they shared at appointments. They felt that this led to first-time mothers feeling reassured in the care and support they were receiving. This is an important finding as it shows an overall link between the two cyclical movements from HCPs' and first-time mothers' data, as shown in figure 16.

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A key example of what worked well within this model was the use of the breastfeeding videos. These seemed popular with HCPs who viewed them as a useful visual tool in explaining positioning and attachment. They then highlighted the breastfeeding content to women who again expressed a preference for this element of the app. The use of the videos by healthcare professionals in encounters with women led to the successful uptake of this element in app users.

The context in which mothers talked about their use of the breastfeeding content was around visual and practical tips that supported knowledge of latching and positioning. The post-hoc analysis from the questionnaire data found that there was more breastfeeding for app-user mothers than the non-app users, which might be linked to the popularity of the breastfeeding films. This aspect of breastfeeding as an 'activity' where knowledge and skill is required seemed to support a sense of opportunity to learn from the video content and refresh what healthcare professionals had discussed in person, as indicated in the quotes below:

> *'Yes because it spoke about breast feeding and how it works best and the videos on how to clean your baby and things like that so yes, I think what I liked about the app as a new mum was you just had a security blanket in a way'*

> *'Yes, I'm breastfeeding, it shows me how to body stance for breastfeeding, so it's my home and shows me how to take your baby, but in the hospital, we had to, explain me, you know, do it like this, no'*

> *'I thought it was really good…. The information about feeding, particularly about breast feeding, anything that I wasn't too sure about I knew I could go on that app to look for it...and the list of key words I found quite useful as well to look at'*

> *'(talking about breast feeding and latching) Yes, people can tell you how to do it, but actually seeing on the video it being done was much clearer'*

> *'Gosh there's loads, I think I learned that you can restart your milk supply, and different ways of feeding her so, I struggled a little bit at first because she was taking too much too quickly, but I read that if I leant back a little bit it would slow the flow'*

'…and then the videos as well, which when the baby was first born I was told to look at it for like breastfeeding bits and stuff, by my midwife and the breastfeeding team…that was useful'

Healthcare professionals' adoption of breastfeeding content

When reviewing the data from healthcare professionals' interviews and focus groups regarding breastfeeding, some reported that they felt the breastfeeding content was helpful and that women could freely explore this content through the Baby Buddy app. The quotes below described their opinions of the breastfeeding content:

'feedback that we've had they really find the breastfeeding sections helpful, but that's as much as I know...just good breastfeeding support and information'

'I think overall its good, although it was designed for young mums, there's lots of the mum find it's just targeted at them, the videos the breastfeeding part of It, postnatal I think is the best part compared to the antenatal….'

'they like the videos as well, and they like the what does this mean, the look up tool, they often don't want to ask, don't want people to judge them, I wouldn't always know either'

When talking about their use of the Baby Buddy app in encounters with women, breastfeeding was often mentioned as an example of how it was being used and seemed to be a key area around their recommendation to mothers to use the app.

'when I have done a normal community visit and I've spoken about breast feeding and I've signposted to the BB app, and they look a little bit of a blank expression, and then we get them to download it it and they know it can be utilised up to that 6 month age'

'so it's really about helping them to understand the fundamentals of lactation, and feeding their baby, I think a lot of the other health information, general health information, I've given from my own knowledge, umm, I wouldn't have used the app for that, but that's only because I'm using the app for the purposes of breastfeeding'

'…..and particularly because the app is all evidence-based, they might show you some random app because it looked free and they'd seen it, then I would tend to signpost them to that app, and get them to utilise it for the postnatal period…. postnatally breastfeeding definitely, antenatally umm, more health and wellbeing'

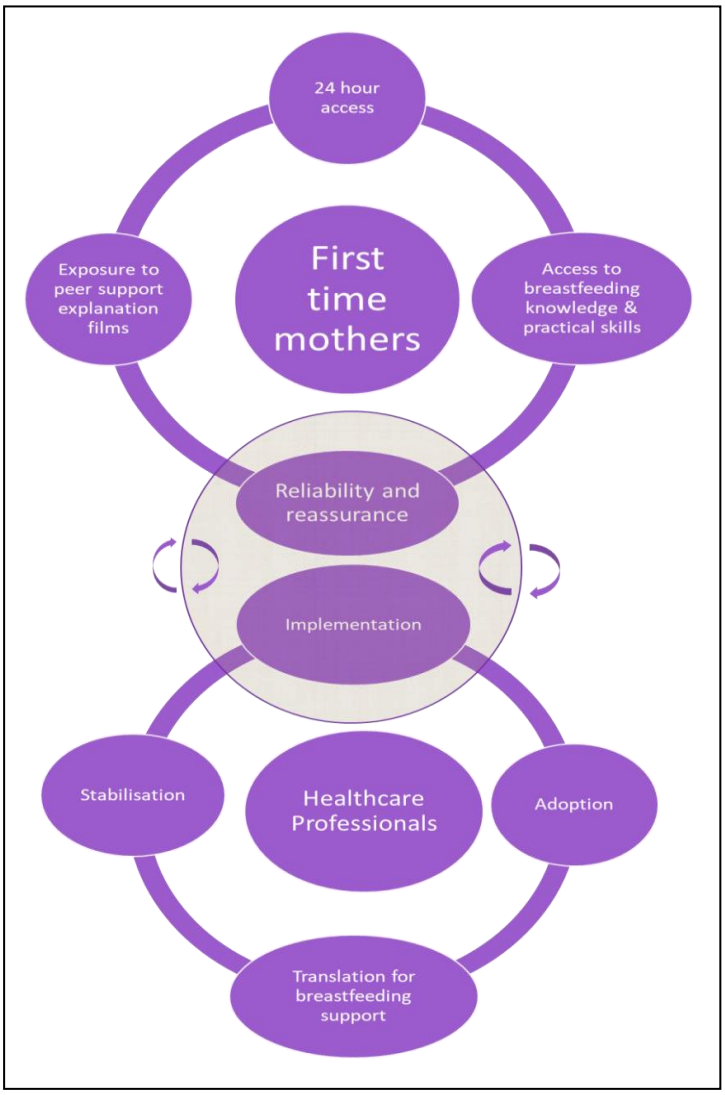
'….Yes, and common breast-feeding problems, and for those who want to bottle feed safely making up feeds, bathing, changing nappies, and they are particularly helpful for those who don't speak English because they can watch and learn'

As framed in the discussion section above, there seemed to be a key opportunity for interaction with the app when women were signposted to content through healthcare professionals. This seemed to be particularly happening around breastfeeding. Women seemed to appreciate the skills-based learning that the app offered around breastfeeding; this was accessible and could be explored at their own inclination. Healthcare professionals seemed to acknowledge that this content had the potential to support women and so it became a key area around where the app was recommended to women. This has been illustrated in the figure below (figure 15) in an example-specific adaptation of the diagram featured above (figure 5 in section 4.1.1) which depicts the key areas of interaction between healthcare professionals and women in using the app.

Further exploration of the data around breastfeeding has given us insight as to the potential mechanisms for the breastfeeding rate increase that was found in the quantitative data, the relationships women and HCPs have around breastfeeding content as well as the popularity of the breastfeeding films. These data are presented in congruence with the underpinning methodological approach of Appreciative Inquiry. By focusing on what has emerged to have worked well in the practical application of the app in the 'real world' of the users and HCPs, lessons can be learned to capture the opportunity to improve the interaction in other areas of wellbeing information and support.

Given the current debates around the particularly low breastfeeding rates in the UK and the significant benefits for babies, women and public health that breastfeeding and human milk provide (Vitora et el, 2016), then this aspect of the Baby Buddy app deserves further analysis and consideration as a potential approach to promoting and enabling women to breastfeed.

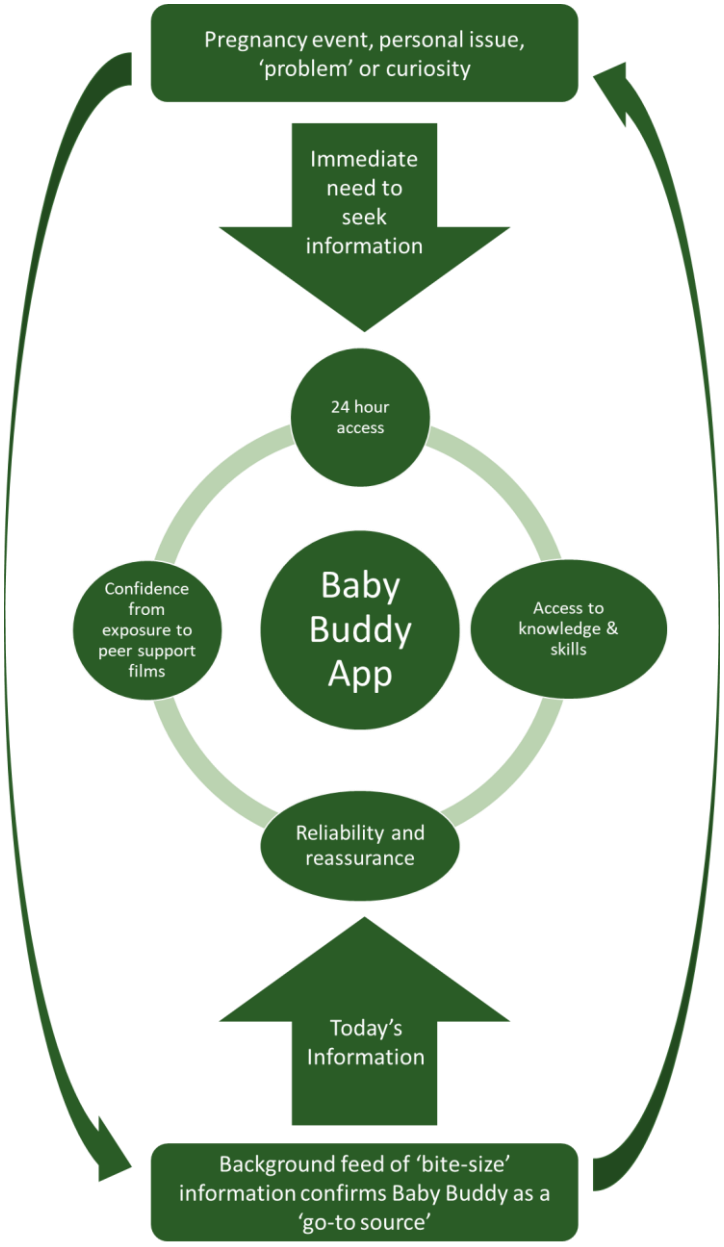
Figure 15: The key area of interactivity between HCP and app users activity around breastfeeding content which supported HCP implementation and reliability and reassurance of this content to app users.



Accessibility is a key element to successful app use, demonstrated in the data provided by the first-time mothers in our study. Users appreciated the instant availability of information. The daily interaction of the 'Today's Information' content allows users to become familiar with the style of information provided through the app. The personalisation of this information aligns the information with a sense of individualised support which might provide an underpinning sense of reliability and reassurance. As with the breastfeeding scenario, when a need arises and further support or information is required, the app can be instantly 'mined' for this information. Instant access to reliable and reassuring information which imparts knowledge, skills or, through the peer-voiced films, a sense of shared experience, at a time of need, could have a significant impact on the user. This seems to be a strength of the app in its' practical usage. Our insight from the qualitative data seems to suggest that the impact for the individual user may not arise from regular and frequent 'browsing' of the extensive information in the app but more to do with their being able to access specific information at a time of acute need.

The figure below (figure 16) draws on the healthcare professionals' and app users' interaction model derived from the qualitative data. This diagram represents how the background impact of the 'Today's Information' content supports a sense of reliability and reassurance in the app user. When an acute need arises in the user (examples being: an identified pregnancy complication, curiosity around a topic, verification of information, breastfeeding issue, emotional issue etc) the 24hr accessibility enables support to be sought instantly through the app. This is when app content has the potential to have the most positive impact on the user. Within this model, the app has the potential to have a positive impact on any individual user at any time, in the moments when the need for key reliable information arises, regardless of the amount of previous regular use. This is a unique benefit of a health intervention app: information instantly available in response to individualised need and represents a new understanding of how health apps are used by their audience. The unique benefit of a health intervention app may offer insight into how the Baby Buddy app specifically supports users in pregnancy and early parenthood and how its content and style facilitate this use may be of interest to other health app developers. This includes the additional elements of maternity service embedding, HCP engagement and implementation, further supporting the reliability and reassurance of endorsed content in the app. The model can also be applied to the manner in which HCPs use the app: a background awareness of the app and its content and prompted to initiate or recommend use where they feel the app can support the woman beyond the time afforded in care contact points, when an acute support need arises. Maintaining app awareness, as well as confidence in content reliability in HCPs, is also key to ensuring the app is the 'go to' tool in such circumstances.

Figure 16: The Baby Buddy app supports its users in pregnancy and early parenthood.



A combination of the background impact of the regular information updates, paired with instant accessibility of information in the event of an acute and personal information need in the user offers potential for a positive impact and helpful support.

6.4: CONCLUSION

This multi-site study took place in the context of a burgeoning array of apps designed to support women during their pregnancies and the first-time mothers in this study accessed a variety of different ones. Our study is one of the few studies to date that has investigated how the use of one particular app, the Baby Buddy app, affects the well-being of women in the antenatal and early postnatal period and we have highlighted a range of issues and challenges in doing this. Whilst there was no evidence that the Baby Buddy app itself impacted on parental self-efficacy or maternal mental wellbeing at the three months post-birth outcome, the first-time mothers in the study found the app accessible and that the information was concise. The Baby Buddy app users had lower scores on the social support scale which might suggest that the app was attractive to less well-supported mothers. Both mothers and healthcare professionals valued the fact that it was professionally endorsed which then motivated the healthcare professionals to use it in their everyday practice and the women to trust its' contents. Therefore, the Baby Buddy app has gone some way in helping to 'Make Every Contact Count' for both the first-time mothers and the healthcare professionals in the study.

This topic is highly relevant if we consider the role increasingly played by technologies in supporting the delivery of healthcare services, antenatal or otherwise. New technologies have great potential for enhancing traditional healthcare services and empowering members of the public to take more control over their healthcare. To evaluate the impact of these technologies, the method of collecting app usage data and the ability to combine these with the app analytics data needs to be carefully considered.

CHAPTER 7: RECOMMENDATIONS

7.1: RECOMMENDATIONS FOR PRACTICE

The findings described above highlight that healthcare professionals act as key gatekeepers and facilitators to the Baby Buddy app being used. Our recommendations therefore begin with those targeted at engaging healthcare professionals further.

7.1.1: RECOMMENDATIONS TO ENGAGE HEALTHCARE PROFESSIONALS:

- Reminder messages to professional users on a regular basis to keep the Baby Buddy app in their thoughts. These should be in a bite-size manner and vary in content to showcase the different elements of the app as well as any new content. User feedback from mothers as the users would be a good incentive to promote app use
- The availability of a 'Demo mode' version of the Baby Buddy app that healthcare professionals can use to demonstrate to others without having to do a full set-up and registration or having to demonstrate on their personal devices
- Further support for healthcare professionals regarding the transition from 'Bump World' to 'Baby World'
- Further support for healthcare professionals regarding adding content to the 'Bump Around' feature to highlight local services or events.

7.1.2: RECOMMENDATIONS THAT RELATE TO FIRST-TIME MOTHER APP USERS

- The encouragement and facilitation of support through social groups or contacts with other mothers. In particular, to emphasise the 'Bump Around' element and the rating and feedback about the groups featured
- Prompts or a map to encourage users to explore the different features of the Baby Buddy app
- Highlighted the transition from the 'Bump area' to the 'Baby area'
- Explore how the use of the social function of the Baby Buddy app can be enhanced to improve social support, particularly in relation to time spent with friends and other people. This could include a group discussion or networking feature to keep first-time mothers engaged throughout the latter stages of pregnancy and for support in early motherhood

- Link to other features such as ‘Google maps’ to help identify locations for meeting other parents e.g., NCT, Children’s Centres
- Shorter videos, showing the main messages and in such a way that will engage mothers
- An option to change languages to enable other cultures and ethnic minorities to engage fully with the Baby Buddy app. This would increase its usage not only regionally but nationally and internationally.

7.2: RECOMMENDATIONS FOR RESEARCH

- Investigate whether the Baby Buddy app may be effective at promoting breastfeeding. We recommend that this be explored in future research using a randomised controlled trial (RCT) with clear *a priori* hypotheses. One option could be to compare the effects of a breastfeeding promotion programme, such as the Baby Friendly Initiative (UNICEF, 2018), alone and in combination with the use of the Baby Buddy app
- Use the findings from this study e.g., around enhanced social support features to enhance the Baby Buddy app and evaluate the impact of this second generation app
- Explore what aspects of technology use can facilitate social networks, e.g., different forms of stimulation (visual or auditory), amount of text presented
- Examine the effect of a healthcare professional specifically introducing and demonstrating certain features of the Baby Buddy app to first-time women in pregnancy
- Test the combined effect of the qualitative model of implementation by healthcare professionals and reassurance by mothers to understand the mechanisms that could enhance app use and outcomes (i.e., need to develop the logic model further to improve effectiveness)
- Identify a set of parental or maternal outcomes that women would expect to be impacted on by the Baby Buddy app. This could include women’s perceived and actual app usage and its impact on the outcomes they identify.

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APPENDICES

APPENDIX 1: Patient information booklet

APPENDIX 2: Informed consent form

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APPENDIX 5: Statistical analysis plan

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BaBBLeS

BUMPS AND BABIES LONGITUDINAL STUDY

INVITATION TO PARTICIPATE

&

INFORMATION ABOUT THE STUDY

Dear Mother-to-be

On behalf of researchers from the Universities of the West of England (Bristol), Coventry, Newcastle, Hertfordshire, Kent, Bath and The Kings Health Partners, ***we would like to invite you to take part in a research study.***

The researchers are hoping to discover if using new technologies, such as social media and apps, during pregnancy and early parenthood affect how you feel about yourself and your new baby. The research is also interested in finding out how using the new technologies might affect the conversations that you have with your health professionals, family and friends as you become a parent for the first time.

The research study called 'BaBBLeS' will be open to new mothers in Coventry, Bradford, Lewisham (London), Blackpool and Leicester who would like to take part.

We know that there are many different types of new technologies that you might use. By asking mothers like yourself to take part, we hope to discover if they are useful for you and the health professionals who care for you during pregnancy and the early months of parenthood.

This leaflet gives you some information about the study and what will be involved if you decide to take part.

If anything is not clear to you, or if you would like more information, please feel free to ask **Trudy Goodenough or Toity Deave**. Their contact details are given at the end of this leaflet.

Before you make your decision, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information and discuss it with your family and friends if you wish.

Thank you for your time.

Dr Toity Deave

Chief Investigator, BaBBLeS Research Team

INFORMATION ABOUT THE STUDY

What is the purpose of the study?

Many women are now using 'new technologies' including apps, websites, and social media sites for information and support. Some women may use these new technologies a lot of the time, while others may only refer to them for particular events in their lives such as having their first baby.

Our study aims to find out how useful these new technologies are for all women who are having their first baby, both during pregnancy and in the first few months after the baby is born.

We would like to find out if using these new technologies changes women's knowledge and confidence about their pregnancy, birth and motherhood while they are expecting their first baby and during the first few months after their baby's birth. These technologies may also alter the conversations that they have with family, friends and health professionals. For example, with their midwife or health visitor.

The study is being paid for by the Big Lottery and is being carried out by researchers from the Universities of the West of England, Coventry, Newcastle, Hertfordshire, Kent, Bath and Kings Health Partners who are working with maternity services in Coventry, Bradford, Lewisham (London), Blackpool and Leicester.

We are inviting all women to take part in our study who are expecting their first baby, and who are between 12-16 weeks pregnant living in one of the five study areas of Coventry, Bradford, Lewisham (London), Blackpool and Leicester.

Why have I been asked to take part?

We are working with maternity services in Coventry, Bradford, Lewisham (London), Blackpool and Leicester.

This **Information** has been given or sent to you by your local maternity service as from their records, they understand that you are expecting your first baby, you are between 12-16 weeks pregnant and live in their area.

We do not have any personal information about you until you send your questionnaire, contact form and consent form back to us.

Do I have to take part?

We would really like you to take part, but it is up to you to decide. You can change your mind at any time and if you no longer want to take part, at any stage, you can contact us to let us know. You don't have to give a reason.

The care that you receive from your midwife or health visitor will not change whether you decide to take part or not.

What will happen if I take part?

There are 4 parts to this study:

1. You will be asked to fill in **two questionnaires while you are pregnant**. One now and one when you are about 35 weeks pregnant*. You can do this **online in one of 3 ways**: by TEXT; by email or by using the link on the Questionnaire. OR you can ask for the **paper version** from your midwife today or by contacting the study team.

   The information for how to contact the team and get the online links for your phone, tablet or computer are on page 7 of this leaflet.

Each questionnaire should take no longer than 15-20 minutes of your time to complete.

**Please note that if you have given birth to your baby before 34 weeks of pregnancy, you should not receive a second pregnancy questionnaire.*

2. You will be sent **one more questionnaire** to fill in (either online or on paper) **6 months after your baby is born**. This final questionnaire should also take about 15-20 minutes to complete.

3. We will send you a £5 gift voucher when we receive your first and final completed questionnaires. You may choose to enter a Prize Draw to win one of 10, £10 vouchers when we receive your completed second pregnancy questionnaire.

4. We would also like to talk to some women in person to find out more details about how they use apps, websites and social media sites during pregnancy and early months after their baby is born. We will do this by arranging some individual telephone interviews and organising small group (focus group) discussions with other first time mums in your area after your baby is born.

   If you would be interested in the phone interview or group meeting, please complete the 'telephone interview or focus group section' on the Contact details in the Questionnaire, and a researcher will contact you.

If you have any questions about the Questionnaire, Consent or the Contact information or would like help with any of this please ring **Trudy Goodenough or Toity Deave** who will be pleased to help. Our contact details are on the back page of this leaflet

What are the possible benefits of taking part?

You will be helping the research team, and health professionals understand more about how women, like yourself, use new technologies for information and support during pregnancy and in the early months after your baby is born. Taking part in this study may also help to improve how the new technologies provide this kind of information in the future.

Are there any disadvantages or risks of taking part in the research?

Not really, we just need a little of your time to complete the questionnaire. If you decide to take part in the telephone interview or in a focus group this will take some more of your time, but we will make arrangements to suit you, and we will pay your travel costs for coming to the focus group.

What if there is a problem?

If you have any questions or concerns about the study you can talk to us. Our names and phone numbers are given at the end of this information booklet.

If you do not want to talk to us, or there is still a problem, you can contact an independent source of advice: Dr Julie Mytton Associate Professor in Child Health; University of the West of England Julie.Mytton@uwe.ac.uk, 0117 3314085 or your local Patient Advisory and Liaison Service (PALS).

Will my taking part be kept confidential?

Yes, all information you give will us be handled in confidence. Your name will not be on the Questionnaires that you complete and the Questionnaire will be stored separately from your Contact details and Consent.

If you take part in the telephone interview or focus group, when we write about the study we may want to use some of what you have said but this will be anonymised. We plan to digitally record the interviews and focus groups but your name will not be used and the recordings will be destroyed once the interviews or focus groups have been transcribed.

In accordance with the terms and conditions of the 1998 Data Protection Act, we will keep all of the information from the study securely at the University of the West of England for 7 years after we have finished.

We will make sure that any information that could identify you is destroyed as soon as we no longer need to contact you.

What will happen if I don't want to carry on with the study?

Taking part in this study is up to you and you are free to withdraw at any time, without giving any reason. Just let us know by phone, text, email or letter. Our contact details are at the end of this information leaflet.

There is one exception to this. Because all of the information that you give us in the questionnaire is kept anonymously, once we have started looking at the answers you give us, we will not be able to remove your information.

What will happen to the results of the study?

We will publish a report for the Big Lottery and talk about the study at research meetings. We will also send you a study summary, if you would like one.

Who is organising and funding this research?

This research is being led by the University of the West of England, Bristol working with research teams from Kings Health Partners and the Universities of Coventry, Newcastle, Kent, Bath and Hertfordshire. It is funded with money from the Big Lottery.

Who has reviewed this study?

All research is looked at by an independent group of people, called a Research Ethics Committee, to protect your safety, rights, wellbeing and dignity.

This study has been reviewed and given a favourable opinion by

West Midlands - South Birmingham Research Ethics Committee

Reference number: 16/WM/0029

What to do next….

How can I take part in BaBBLeS?

Read the Information sheet and if you would like to take part

CHOOSE how you would like to complete the questionnaire

Go online

http://

http://tinyurl.com/babbles1

or

TEXT

BaBBLeS1 to 07817 875309
To receive the on-line link to your phone

or

Email us at

Babblesteam@uwe.ac.uk

or

Ask your **midwife** or ring **BaBBLeS** 0117 3314085 for a **paper copy**

to send back to us

Enter your unique **BaBBLeS ID** to begin

That's the 9 digit code on the front of this information booklet

Complete and send us your questionnaire

Don't forget to sign up for your gift voucher!

Any Questions?

Please ask us!

Email: Babblesteam@uwe.ac.uk
Text: 07817 875309
Phone: 0117 3314085

Thank you

Contacts for further information

If you have any questions about the research please contact or leave a message for:

Dr Trudy Goodenough, (Researcher)

University of the West of England

babblesteam@uwe.ac.uk

Landline: 0117 3314085 (with answerphone):

Work Mobile: 07817 875309

Dr Toity Deave (Associate Professor)

BaBBLeS Chief Investigator

University of the West of England

babblesteam@uwe.ac.uk

Landline: 0117 3314085 (with answerphone):

Work Mobile: 07817 875309

Thank you for taking the time to read this leaflet

APPENDIX 2: INFORMED CONSENT FORM

BaBBLeS

Mothers' Consent Form
Questionnaires

REC REF: _____

Name of Researcher _____

Participant UIC _____

Please put your **initials** in each box

1.	I have read the Information Sheet version 3.0, dated 08 March 2016, about this research study. I have had the opportunity to ask questions, and I am happy with the answers that I have been given.	
2.	I understand that taking part in this research is voluntary and that I am free to stop at any time, without giving a reason.	
3.	I understand that the information I give in the questionnaires, now while I'm pregnant and after my baby is born, is part of the collection of information for the research study.	
4.	I understand that once the study is complete, my information will be kept securely at the University of the West of England for 7 years in line with the 1998 Data Protection Act, and then destroyed.	
5.	I understand that relevant sections of my and/or my baby's medical notes and data collected during the study, may be looked at by individuals from the research team, regulatory authorities or from the NHS Trust, where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
6.	I understand that my personal details will be kept confidential	
7.	I agree to take part in this study	

_____	_____	_____	
Name of Participant	**Date**	**Signature**	
_____	_____	_____	
Name of Researcher	**Date**	**Signature**	

2 copies: 1 for participant, 1 for study records,

Coventry University · King's Health Partners · UWE University of the West of England · University of Hertfordshire UH · Newcastle University

□□□□□□□□□□

First questionnaire for BaBBLeS study

Optionally, this questionnaire can be completed online via the link:

https://www.tinyurl.com/babbles1

When prompted, please enter your unique code shown on the top right corner of this page and follow the instructions given.

We would be really grateful if you could complete this questionnaire about you as a future parent, your use of technology, your support networks, confidence and well-being.

- Others have found that it takes about 15 minutes to complete.
- If you make a mistake, just cross out the wrong answer and give a new answer.
- Everything you tell us will be treated as confidential.
- Please return the questionnaire in the envelope provided. You can choose to receive a £5 voucher when you send back the completed questionnaire.
- If you would like help to complete the questionnaire please contact:

  Toity Deave or Trudy Goodenough
  Tel: 0117 3314085
  Email: babblesteam@uwe.ac.uk

Your answers are really important to us. They will help us understand the needs of mothers like you and help develop better ways to support them.

We will contact you again nearer to the birth of your baby with a shorter questionnaire.

Section 1 – About your pregnancy

1. When is your baby due? D D M M Y Y Y Y

Please write in day (DD), month (MM) and year (YYYY)

2. How do you think you will feed your baby: *Please tick one box only for each row*

	Breast feed only	Formula milk only	Both breast feed and formula milk	Not sure
a. in the first week	☐	☐	☐	☐
b. by the end of the first month	☐	☐	☐	☐
c. by the end of three months	☐	☐	☐	☐
d. at six months	☐	☐	☐	☐

Section 2: Your use of technology and how you look for information

Please tick one box only on each row, YES or NO	YES	NO
3. Do you use a mobile phone? ……..…….	☐	☐
4. Do you use a tablet (e.g. iPad/ Android)? ……..	☐	☐
5. Do you access the internet on your mobile phone or on your tablet?	☐	☐

6. Do you access the internet at home? ……..... ☐ ☐

7. *The next question is about your use of mobile phones, tablets, laptops or any other device. Please indicate how often you do each of the following activities, by ticking one box for each row.*[1]

	Never/ Not applicable	Less than once a week	Once a week	Several times a week	Once a day	Several times a day
a. Send and receive text messages on a mobile phone or tablet	☐	☐	☐	☐	☐	☐
b. Make and receive calls on a mobile phone or tablet	☐	☐	☐	☐	☐	☐
c. Browse the web on a mobile phone or tablet	☐	☐	☐	☐	☐	☐
d. Use apps (for any purpose) on a mobile phone or tablet	☐	☐	☐	☐	☐	☐
e. Search the internet for news on any device	☐	☐	☐	☐	☐	☐
f. Search the internet for information on any device	☐	☐	☐	☐	☐	☐
g. Check your Facebook page or other social networks on any device	☐	☐	☐	☐	☐	☐
h. Post photos on Facebook or other social networks	☐	☐	☐	☐	☐	☐
i. Comment on postings, status updates, photos, etc. on Facebook or other social networks.	☐	☐	☐	☐	☐	☐

8. Did you or do you use any app specifically about pregnancy (on a phone, tablet or computer)? *Please tick one box only, YES or NO*

Yes ☐ *Please name*:

a) ……..

b) ……..

c) ……..

No ☐

If you have answered No, please go to question 10

9. How did you hear about the pregnancy app(s) you are using or used? *Please tick all that apply*

- a. Midwife………………………..……………………………………..…………… ☐
- b. Health Visitor……………... ☐
- c. GP…………………..…………………………………………..……………….. ☐
- d. Other health professional(s)... ☐

Please say which one(s): ________________________________

- e. Partner………………………………………………………………………….……….. ☐
- f. Friends, other mothers-to-be or new mothers……...................................... ☐
- g. Posters at GP surgery, clinic or hospital………….................................... ☐
- h. Through other apps that I have used before…………..……………….…........ ☐

Please say which one(s): ________________________________

- i. Internet search………..….……… ☐
- j. Books or magazines……………………………………………….................... ☐
- k. Other. *Please specify*: ___________________________________ ☐

10. Where do you look or who do you ask for information about pregnancy and parenthood? *Please tick all that apply*

- a. Midwife………………………………………………………………………….…... ☐
- b. Health Visitor………………………………………………………………….. ☐
- c. GP……………………………………………………………………………........... ☐
- d. Other health professional(s)………………………………………………........... ☐

Please say which one(s): ________________________________

- e. Partner………………………………………………………………………………. ☐
- f. Friends, other mothers-to-be or new mothers………………………………..…. ☐

g. Posters at GP surgery, clinic or hospital……...… ☐

h. Apps…… ☐

i. Internet search…….…. ☐

j. Books or magazines……..... ☐

k. Other. *Please specify*: _____ ☐

Section 3 – About how you might feel when your baby is born

11*. We would like to know how you are feeling now, while you are pregnant, about becoming a mother. We understand that it might be difficult for you to imagine how you will interact with you baby, but we would be grateful if you can complete each of the questions as best as you can.*

We would also like to know about the support you receive from other people, and how you feel emotionally.

- The following section is about emotion and affection -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

1. I will be able to show affection towards my baby……..……. ☐
2. I will be able to recognise when my baby is happy or sad……..... ☐
3. I am confident my baby will be able to come to me if he/she is unhappy……..……. ☐
4. When my baby is sad I will understand why……..…… ☐
5. I will have a good relationship with my baby……..……..... ☐
6. I will find it hard to cuddle my baby……..... ☐

- The following section is about play and enjoyment -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

7. I will be able to have fun with my baby……..... ☐
8. I will be able to enjoy each stage of my baby's development……..... ☐
9. I will be able to have nice days with my baby……..……..…….. ☐
10. I will be able to plan activities that my baby will enjoy…….……..…… ☐
11. Playing with my baby will come easily to me……..... ☐
12. I will be able to help my baby reach their full potential……..…… ☐

- *The following section is about empathy and understanding* -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

13. I will be able to explain things patiently to my baby…… ☐
14. I will be able to get my baby to listen to me……..…….…….. ☐
15. I will be able to comfort my baby……..…….……..... ☐
16. I will be able to listen to my baby……...…….…… ☐
17. I will be able to put myself in my baby's shoes…….…… ☐
18. I will understand my baby's needs……..……... ☐

- *The following section is about pressures* -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

19. It will be difficult to cope with other people's expectations of me as a parent……..... ☐
20. I will not be able to assert myself when other people will tell me what to do with my baby……..…. ☐
21. Listening to other people's advice will make it hard for me to decide what to do……..…. ☐
22. I will be able to say 'no' to other people if I don't agree with them……..….. ☐
23. I will be able to ignore pressure from other people to do things their way…….. ☐
24. I will not feel a need to compare myself to other parents…… ☐

- *The following section is about self-acceptance* -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

25. I know I will be a good enough parent……. ☐
26. I will manage the pressures of parenting as well as other parents do……. ☐
27. I will not do that well as a parent……..……. ☐
28. As a parent I will be able to take most things in my stride……. ☐
29. I will be able to be strong for my baby……..……. ☐
30. My baby will feel safe around me……..……. ☐

- *The following section is about learning and knowledge* -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

31. I will be able to recognise developmental changes in my baby…….……... ☐
32. I will be able to share ideas with other parents……..... ☐
33. I will be able to learn and use new ways of dealing with my baby…… ☐
34. I will be able to make the changes needed to improve my baby's behaviour……. ☐
35. I will be able to overcome most problems with a bit of advice……..... ☐
36. Knowing that other people have similar difficulties with their babies will make it easier for me…… ☐

12. *About the support you receive from other people - We are interested in how you feel about the following statements[3]. Read each statement carefully. Indicate how you feel about each statement by* ***ticking one box only for each row****.*

	Very Strongly Agree	Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree	Very Strongly Disagree
a. There is a special person who is around when I am in need.	☐	☐	☐	☐	☐	☐	☐
b. There is a special person with whom I can share my joys and sorrows.	☐	☐	☐	☐	☐	☐	☐
c. My family really tries to help me.	☐	☐	☐	☐	☐	☐	☐
d. I get the emotional help and support I need from my family.	☐	☐	☐	☐	☐	☐	☐
e. I have a special person who is a real source of comfort to me.	☐	☐	☐	☐	☐	☐	☐
f. My friends really try to help me.	☐	☐	☐	☐	☐	☐	☐
g. I can count on my friends when things go wrong.	☐	☐	☐	☐	☐	☐	☐
h. I can talk about my problems with my family.	☐	☐	☐	☐	☐	☐	☐
i. I have friends with whom I can share my joys and sorrows.	☐	☐	☐	☐	☐	☐	☐

j. There is a special person in my life who cares about my feelings.	☐	☐	☐	☐	☐	☐	☐
k. My family is willing to help me make decisions.	☐	☐	☐	☐	☐	☐	☐
l. I can talk about my problems with my friends.	☐	☐	☐	☐	☐	☐	☐

13. *About how you feel emotionally - Below are some statements about feelings and thoughts.*[4] *Please **circle the number** that best describes your experience of each of the statements over the **last 2 weeks.***

	None of the time	Rarely	Some of the time	Often	All of the time
a. I've been feeling optimistic about the future	1	2	3	4	5
b. I've been feeling useful	1	2	3	4	5
c. I've been feeling relaxed	1	2	3	4	5
d. I've been feeling interested in other people	1	2	3	4	5
e. I've had energy to spare	1	2	3	4	5
f. I've been dealing with problems well	1	2	3	4	5
g. I've been thinking clearly	1	2	3	4	5
h. I've been feeling good about myself	1	2	3	4	5
i. I've been feeling close to other people	1	2	3	4	5
j. I've been feeling confident	1	2	3	4	5
k. I've been able to make up my own mind about things	1	2	3	4	5
l. I've been feeling loved	1	2	3	4	5

m. I've been interested in new things	1	2	3	4	5
n. I've been feeling cheerful	1	2	3	4	5

Section 4 – About your background

14. What is your date of birth? D D M M Y Y Y Y

Please write in day (DD), month (MM) and year (YYYY)

15. What is your ethnic group? *Please tick one box only*

White:

a. British ☐ b. Irish ☐ c. Other White European ☐

d. Other ☐ *Please specify:* …….

Asian or Asian British:

e. Pakistani ☐ f. Bangladeshi ☐ g. Indian ☐ h. Chinese ☐

i. Other ☐ *Please specify:* …….

Black or Black British:

j. Caribbean ☐ k. African ☐

l. Other ☐ *Please specify:* ……..

Mixed background:

m. White & Black Caribbean ☐ n. White & Black African ☐

o. White & Asian ☐

p. Other ☐ *Please specify:* ……..

q. Any other ethnic group ☐ *Please specify:* …….

r. I do not wish to say ☐

16. What is the highest level of education that you reached? *Please tick one box only*

a. Left school before completing GCSEs…… ☐
b. GCSEs…….... ☐
c. A Levels/Scottish Highers or International Baccalaureate……. ☐
d. Apprenticeship…….. ☐
e. Professional qualifications…… ☐
f. First Degree……..... ☐
g. Higher degree or above…….. ☐

17. What best describes your current status? *Please tick one box only*

a. Married or living with your partner…….. ☐
b. Single…… ☐
c. Have a partner but not living together.... ☐
d. Other……..... ☐ *Please specify*: _____

18. What best describes your current employment? *Please tick one box only*

a. In paid Full time employment…… ☐
b. In paid Part time employment…… ☐
c. Self-employed or freelance…… ☐
d. Studying or in training…….. ☐
e. On Maternity Leave or Sick Leave from full time employment….. ☐
f. On Maternity Leave or Sick Leave from part-time employment… ☐
g. Not in paid employment…….... ☐

19. Date when you finished completing this questionnaire: D D M M Y Y Y Y
Please write in day (DD), month (MM) and year (YYYY)

20. Please feel free to leave any comments in the box below relating to any of your answers to this questionnaire or suggestions for improvement:

.....
.....
.....
.....
.....

21. What are the first three or four digits of your postcode? ☐ ☐ ☐ ☐

Thank you very much for filling in this questionnaire.

Please check that you have answered all the questions.

Please send this back to us in the **envelope provided** together with the **consent form** completed and signed by you, and the completed **contact details form**. Don't forget to tick the box if you would like to receive a £5 voucher!

Our address: BABBLeS,
University of the West of England, Bristol
Centre for Child & Adolescent Health
Oakfield House, Oakfield Grove
Clifton
Bristol BS8 2BN

This project is a collaboration between:

University of the West of England

Sources of questions (superscripts):

1. *Adapted from the Media and Technology Usage and Attitudes Scale, Rosen et al. 2013*
2. *Adapted from the TOPSE, a tool to measure Parenting Self-Efficacy, Kendall S. & Bloomfield L. 2005, available on www.topse.org.uk*
3. *Zimet et al. (1988), The multidimensional scale of perceived social support (MCSDS).*
4. *Warwick-Edinburgh Mental Well-being Scale (WEMWBS), NHS Health Scotland, University of Warwick and University of Edinburgh, 2006*

☐☐☐☐☐☐☐☐☐

Third Questionnaire for BaBBLeS project

Welcome back! This is the third and last questionnaire for the BaBBLeS study.

Optionally, this questionnaire can be completed online via the link ***https://tinyurl.com/babbles5***

When prompted, please enter your unique code (available on the top right corner of this page) and follow the instructions given.

This questionnaire is about you as a parent, your use of technology, your experience of giving birth, your support networks, confidence and well-being. If you are happy to complete this paper questionnaire, please go to the next page.

If you feel that you should not complete this questionnaire, please tick this box ☐ and post the blank questionnaire back to us in the envelope provided.

- Others have found that it takes about 15 minutes to complete.
- If you make a mistake, just cross out the wrong answer and give a new answer.
- Everything you tell us will be treated as confidential.
- Please return the questionnaire in the envelope provided. You will receive a £5 voucher when you send back the completed questionnaire.
- If you would like help to complete the questionnaire please contact:

  Toity Deave or Trudy Goodenough
  Tel: 0117 3314085
  Email: babblesteam@uwe.ac.uk

Your answers are really important to us. They will help us understand the needs of mothers like you and help develop better ways to support them.

Section 1 – About your baby

1. How many weeks pregnant were you when you gave birth? ☐☐

Please write number of weeks in the boxes

2. How did you feed your baby: *Please tick one box only for each row*

	Breast feed only	Formula milk only	Both breast feed and formula milk	Not sure
a. during the first week	☐	☐	☐	☐
b. up to end of the first month	☐	☐	☐	☐
c. currently	☐	☐	☐	☐

Section 2: Your use of technology and how you look for information

3. Did you use any apps specifically about pregnancy, or do use apps specifically about being a parent (on a phone, tablet or computer)? *Please tick one box only, YES or NO*

Yes ☐ *Please name*: No ☐

a) ……..

b) ……..

c) ……..

d) ……..

If you have answered No, please go to question 5

4. Is the Baby Buddy app one of the apps you listed on Question 3? YES ☐

Please tick one box only, YES or NO NO ☐

If your answer is YES, go to question 4.1

If your answer is NO, go to question 5

4.1 When did you download the Baby Buddy app?

Please try to remember as best as you can; write in month (MM) and year (YYYY)

M	M	Y	Y	Y	Y

4.1.1 Are you still using the Baby Buddy app?

Please tick one box only, YES or NO

YES ☐

NO ☐

If your answer is YES, go to question 4.2

If your answer is NO, go to question 4.1.2

4.1.2 When did you stop using the Baby Buddy app?

Please try to remember as best as you can; write in month (MM) and year (YYYY)

M	M	Y	Y	Y	Y

4.2 How did you hear about the Baby Buddy app? *Please tick all that apply*

a. Midwife…… ☐

b. Health Visitor……..... ☐

c. GP…… ☐

d. Other health professional(s)..... ☐

Please say which health professional(s): _____

e. Family or partner…… ☐

f. Friends, other mothers-to-be or new mothers……..... ☐

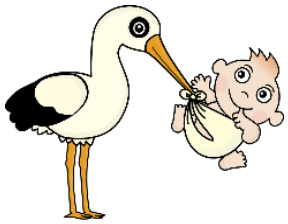
g. Posters at GP surgery, clinic or hospital……..... ☐

h. Through other apps I have used before……..... ☐

i. Internet search……..……. ☐

j. Books or magazines……..... ☐

k. Other. *Please specify*: _____ ☐



5. Where do you look or who do you ask for information about being a parent? *Please tick all that apply*

a. Midwife…….……... ☐

b. Health Visitor…….. ☐

c. GP……..... ☐

d. Other health professional(s)……..... ☐

Please say which health professional(s): _____

e. Family or partner...…… ☐

f. Friends, other mothers-to-be or new mothers……..… ☐

g. Posters at GP surgery, clinic or hospital……..… ☐

h. Apps…… ☐

i. Internet search…….. ☐

j. Books or magazines……..... ☐

k. Other. *Please specify*: _____ ☐

Section 3 – About your experience of giving birth

6. INSERT INSTRUCTIONS FROM CEQ[1] – CHECK EXACT WORDING AND ITEM ORDER – WAITING TO RECEIVE THE CEQ FROM THE AUTHOR
*items g, h and s to be assessed with visual analogue scales (VAS) (original scale needed to know how)

	Totally agree (1)	Mostly Agree (2)	Mostly Disagree (3)	Totally Disagree (4)
a. Labour and birth went as I had expected	☐	☐	☐	☐
b. I felt strong during labour and birth	☐	☐	☐	☐
c. I felt capable during labour and birth	☐	☐	☐	☐
d. I was tired during labour and birth	☐	☐	☐	☐
e. I felt happy during labour and birth	☐	☐	☐	☐
f. I felt that I handled the situation well	☐	☐	☐	☐
g. As a whole, how painful did you feel childbirth was?*				

	Totally agree (1)	Mostly Agree (2)	Mostly Disagree (3)	Totally Disagree (4)
h. As a whole, how much control did you feel you had during childbirth?*				
i. My midwife devoted enough time to me	☐	☐	☐	☐
j. My midwife devoted enough time to my partner	☐	☐	☐	☐
k. My midwife kept me informed about what was happening during labour and birth	☐	☐	☐	☐
l. My midwife understood my needs	☐	☐	☐	☐
m. I felt very well cared for by my midwife	☐	☐	☐	☐
n. I felt scared during labour and birth	☐	☐	☐	☐
o. I have many positive memories from childbirth	☐	☐	☐	☐
p. I have many negative memories from childbirth	☐	☐	☐	☐

q. Some of my memories from childbirth make me feel depressed ☐ ☐ ☐ ☐

r. My impression of the team's medical skills made me feel secure ☐ ☐ ☐ ☐

s. As a whole, how secure did you feel during childbirth?*

t. I felt I could have a say whether I could be up and about or lie down ☐ ☐ ☐ ☐

u. I felt I could have a say in deciding my birthing position ☐ ☐ ☐ ☐

v. I felt I could have a say in the choice of pain relief ☐ ☐ ☐ ☐

Section 4 – About how you feel as a new mother

7. *We would like to know how you are feeling now as a new mother, about the support you receive from other people, and how you feel emotionally.*

- The following section is about emotion and affection -

Using the scale below[2], **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

1. I am able to show affection towards my baby ……..……. ☐

2. I can recognise when my baby is happy or sad……..... ☐

3. I am confident my baby can come to me if they're unhappy……..……. ☐

4. When my baby is sad I understand why……..……..…… ☐

5. I have a good relationship with my baby……..…….....

6. I find it hard to cuddle my baby…….....

- *The following section is about play and enjoyment -*

Using the scale below, **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

7. I am able to have fun with my baby……..…..

8. I am able to enjoy each stage of my baby's development…….....

9. I am able to have nice days with my baby……..……..……..

10. I can plan activities that my baby will enjoy…….……..……

11. Playing with my baby comes easily to me…….…….....

12. I am able to help my baby reach their full potential……..…….……..……

- *The following section is about empathy and understanding -*

Using the scale below, **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

13. I am able to explain things patiently to my baby…….…….

14. I can get my baby to listen to me……..……..……..

15. I am able to comfort my baby……..…….....

16. I am able to listen to my baby……..……

17. I am able to put myself in my baby's shoes…….……

18. I understand my baby's needs……..……..……...

- *The following section is about pressures* -

Using the scale below, **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

19. It is difficult to cope with other people's expectations of me as a parent……..…....

20. I am not able to assert myself when other people tell me what to do with my baby……..…..….

21. Listening to other people's advice makes it hard for me to decide what to do …….……...….

22. I can say 'no' to other people if I don't agree with them…….....…..

23. I can ignore pressure from other people to do things their way ……..

24. I do not feel a need to compare myself to other parents……

- *The following section is about self-acceptance* -

Using the scale below, **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

25. I know I am a good enough parent……..……

26. I manage the pressures of parenting as well as other parents do……..…….…….

27. I am not doing that well as a parent.……..…….

28. As a parent I can take most things in my stride……

29. I can be strong for my baby……..…….……

30. My baby feels safe around me……..……..…….…

- *The following section is about learning and knowledge* -

Using the scale below, **please enter in the boxes how much you agree with each statement**. The scale ranges from 0 (completely disagree) to 10 (completely agree). You may use any number between 0 and 10. Please answer all statements.

0 1 2 3 4 5 6 7 8 9 10

Completely disagree Moderately agree Completely agree

31. I am able to recognise developmental changes in my baby……..……... ☐

32. I can share ideas with other parents……..... ☐

33. I am able to learn and use new ways of dealing with my baby……..… ☐

34. I am able to make the changes needed to improve my baby's behaviour……. ☐

35. I can overcome most problems with a bit of advice……..... ☐

36. Knowing that other people have similar difficulties with their babies makes it easier for me……....… ☐

8. *About the support you receive from other people - we are interested in how you feel about the following statements[3]. Read each statement carefully. Indicate how you feel about each statement by ticking one box only for each row.*

	Very Strongly Agree	Strongly Agree	Mildly Agree	Neutral	Mildly Disagree	Strongly Disagree	Very Strongly Disagree
a. There is a special person who is around when I am in need.	☐	☐	☐	☐	☐	☐	☐
b. There is a special person with whom I can share my joys and sorrows.	☐	☐	☐	☐	☐	☐	☐
c. My family really tries to help me.	☐	☐	☐	☐	☐	☐	☐

d. I get the emotional help and support I need from my family.	☐	☐	☐	☐	☐	☐	☐
e. I have a special person who is a real source of comfort to me.	☐	☐	☐	☐	☐	☐	☐
f. My friends really try to help me.	☐	☐	☐	☐	☐	☐	☐
g. I can count on my friends when things go wrong.	☐	☐	☐	☐	☐	☐	☐
h. I can talk about my problems with my family.	☐	☐	☐	☐	☐	☐	☐
i. I have friends with whom I can share my joys and sorrows.	☐	☐	☐	☐	☐	☐	☐
j. There is a special person in my life who cares about my feelings.	☐	☐	☐	☐	☐	☐	☐
k. My family is willing to help me make decisions.	☐	☐	☐	☐	☐	☐	☐
l. I can talk about my problems with my friends.	☐	☐	☐	☐	☐	☐	☐

9. *About how you feel emotionally - below are some statements about feelings and thoughts[4.] Please* ***circle*** *the number that best describes your experience of each of the statements over the* ***last 2 weeks.***

	None of the time	Rarely	Some of the time	Often	All of the time
a. I've been feeling optimistic about the future	1	2	3	4	5
b. I've been feeling useful	1	2	3	4	5
c. I've been feeling relaxed	1	2	3	4	5
d. I've been feeling interested in other people	1	2	3	4	5
e. I've had energy to spare	1	2	3	4	5
f. I've been dealing with problems well	1	2	3	4	5
g. I've been thinking clearly	1	2	3	4	5
h. I've been feeling good about myself	1	2	3	4	5
i. I've been feeling close to other people	1	2	3	4	5
j. I've been feeling confident	1	2	3	4	5
k. I've been able to make up my own mind about things	1	2	3	4	5
l. I've been feeling loved	1	2	3	4	5
m. I've been interested in new things	1	2	3	4	5
n. I've been feeling cheerful	1	2	3	4	5

Section 4 – About your background

10. What is your date of birth? D D M M Y Y Y Y

Please write in day (DD), month (MM) and year (YYYY)

11. What best describes your current status? *Please tick one box only*

Married or living with your partner……. ☐

Single…… ☐

Have a partner but not living together... ☐

Other……..... ☐ *Please specify*: _____

12. What best describes your current employment? *Please tick one box only*

On Maternity Leave (or Sick Leave) from full time employment.... ☐

On Maternity Leave (or Sick Leave) from part-time employment... ☐

In paid Full time employment…… ☐

In paid Part time employment…….. ☐

Self-employed or freelance…….. ☐

Studying or in training……... ☐

Not in paid employment……... ☐

13. What are the first three or four digits of your postcode? ☐ ☐ ☐ ☐

14. Date when you finished completing this questionnaire: D D M M Y Y Y Y

Please write in day (DD), month (MM) and year (YYYY)

15. Please feel free to leave any comments in the box below relating to any of your answers to this questionnaire or suggestions for improvement:

…… …… …… …… ……

Please check that you have answered all the questions.

Tick this box ☐ if you would like us to send you a £5 voucher when we receive your completed questionnaire.

16. Whether you have opted to receive a voucher or not, please tick one of the following boxes to indicate if there have been any changes to your contact details since the last BaBBLeS questionnaire.

My contact details are the same since the last BaBBLeS questionnaire ☐

My contact details have changed ☐

- If your contact details have changed, please let us know what changed:

Home address: …… ……Postcode: …… Phone number: …… Email address: ……

Please send this back to us in the **envelope provided**.

If you have requested to receive the results of the study, you will hear from us soon.

Thank you for your participation in the BaBBLeS study.

Our address: BaBBLeS

University of the West of England, Bristol

Centre for Child & Adolescent Health

Oakfield House, Oakfield Grove

Clifton

Bristol BS8 2BN

This project is a collaboration between:

University of the West of England, Bristol

Coventry University

Newcastle University

University of Kent

University of Hertfordshire

University of Bath

Health Partners – Pioneering better health for all

Sources of questions (superscripts):

1. *Walker et al (2015), Childbirth Experience Questionnaire (CEQ), adapted from Dencker et al 2010.*
2. *Adapted from the TOPSE, a Tool to measure Parenting Self-Efficacy, Kendall S. & Bloomfield L. 2005, available on www.topse.org.uk*
3. *Zimet et al. (1988), The Multidimensional Scale of Perceived Social Support (MSPSS).*
4. *Warwick-Edinburgh Mental Well-being Scale (WEMWBS), NHS Health Scotland, University of Warwick and University of Edinburgh, 2006*

Statistical plan for the BaBBLeS study

Statistical plan developed by: Samuel Ginja, Raghu Lingam

Full BaBBLeS team: Toity Deave (PI), Trudy Goodenough, Maggie Heeley, Samuel Ginja, Raghu Lingam, Jane Coad, Elizabeth Bailey, Samantha Nightingale, Sally Kendall, Jane Smiddy, Crispin Day, Adam Joinson, Lukasz Piwek

Contents

1. Aim

The aim of the BaBBLeS study is to assess the impact of the Baby Buddy app on maternal self-efficacy and mental wellbeing at 3 months post-delivery.

2. Objectives

2.1 Primary objective

a. To assess if mothers who downloaded the Baby Buddy (BB) app have significantly higher levels of self-efficacy (measured with the TOPSE total score) at 3 months post-delivery, than mothers who did not download the app.

2.2 Secondary objectives

b. To assess if mothers who downloaded the app have significantly higher scores on each of the six self-efficacy domains (measured with the six TOPSE subscale scores) at 3 months post-delivery, than mothers who did not download the app.

c. To assess if mothers who downloaded the app have significantly higher scores for mental wellbeing (measured with the WEMWBS total score) 3 months post-delivery, than mothers who did not download the app.

d. To assess if mothers who downloaded the app and heard about it from a health professional have significantly higher self-efficacy (measured using the TOPSE total score) at 3 months post-delivery, than mothers who downloaded the app but did not hear about it from a health professional, and than those who did not download it.

c. To assess if mothers who downloaded the app and heard about it from a health professional have significantly higher mental wellbeing scores (measured using the WEMWBS total score) at 3 months post-delivery, than mothers who downloaded the app but did not hear about it from a health professional, and than those who did not download it.

3. Design

Prospective cohort study. Randomisation was not possible as the app was freely available for download.

4. Timeline

Data will be collected at three time points: 12-16 weeks gestation (baseline), at 35 weeks gestation and at 3 months post-delivery using maternal self-completion questionnaires. Baseline data collection will be carried out at recruitment.

5. Inclusion criteria

Participants eligible for this study will be pregnant women aged 16 or above, with no previous live child, recruited at 12 to 16 (+6 days) weeks' gestation in any of the following five study sites: Coventry, Lewisham, Blackpool, Leicester and Bradford.

Excluded participants will be those who are younger than 16 years old, who already have one child or more, were at a gestational stage of less than 12 weeks or after 17 weeks at recruitment, and those unable to provide informed consent.

6. Exposure variables

6.1 Primary exposure variable

App download status (dichotomous) – outcomes will be compared between i) mothers who downloaded the BB app and ii) mothers who did not download it. Download can be at any time point: baseline, 35 weeks or 3 months post-delivery. This variable will be self-reported.

6.2 Secondary exposure variable

Instruction status (categorical) – outcomes will be compared between i) mothers who downloaded the BB app and were shown how to use it by a health professional, ii) mothers who downloaded the app but were not shown how to use it by a health professional, and iii) mothers who did not download it. This variable will also be self-reported and can be at any of the three data collection time points.

7. Outcome variables

7.1 Primary outcome variable

The primary outcome is maternal self-efficacy as measured by the TOPSE (Kendall and Bloomfield, 2005) at 3 months post-delivery. The primary outcome is the total TOPSE score only and this will be self-reported.

The TOPSE is a scale composed of 36 items to which participants attribute scores of 0 (completely disagree) to 10 (completely agree). Items 6, 19, 20, 21 and 27 are reverse-scored. The scale comprises six domains, each with six items. The six domains of the TOPSE are: emotion and affection, play and enjoyment, empathy and understanding, pressures, self-acceptance, and learning and knowledge. Seven scores will be used in the analyses: each domain score, i.e. total (sum) of the six item scores in each domain, min 0 – max 60; and the total TOPSE score, i.e. total (sum) of all the 36 item scores, min 0 – max 360. Higher scores mean higher levels of maternal self-efficacy.

7.2. Secondary outcome variables

The secondary outcomes assessed in this study are:

a) Scores of each of the six TOPSE subscales at 3 months post-delivery

b) Mental wellbeing at 3 months post-delivery

Mental health will be assessed with the Warwick-Edinburgh Mental Wellbeing Scale (WEMWBS). Each of the 14 statement responses in the WEMWBS are scored from 1 to 5, from ‘none of the time’ to ‘all of the time’. A total score is calculated by summing the 14 individual statement scores (min 14 - max 70). A higher score means a higher level of mental wellbeing.

Secondary outcomes will also be self-reported.

8. Potential confounding variables

Potential confounding variables in this study will include maternal age, ethnic group, education, relationship status, employment status, socioeconomic deprivation based on IMD decile (to be confirmed), recruitment site, social support, propensity to use technology, baseline levels of self-efficacy (for analyses where self-efficacy is the outcome), baseline levels of mental wellbeing (for analyses where mental wellbeing is the outcome), and duration of app use.

Ethnic background, education, relationship status, employment status, recruitment site and IMD decile will be categorical variables. All other potential confounders will be continuous variables. Social support will be measured with the Multidimensional Scale of Perceived Social Support (MSPSS) (Zimet *et al.*, 1988), and propensity to use technology will be assessed with an adapted version of the Media and Technology Usage and Attitudes Scale (MTUAS) (Rosen *et al.*, 2013).

9. Analysis

A plan of analysis for the BaBBLeS study is provided in Table 1.

Table 1 – Plan of analysis in BaBBLes

	Exposure	Outcome	Analysis
Primary analysis	i) downloaded the app ii) did not download the app	Self-efficacy (total TOPSE score) at 3 months post-delivery	Linear regression analysis
	i) downloaded the app ii) did not download the app	Self-efficacy (TOPSE) subscale scores at 3 months post-delivery: 1) Emotion and affection 2) Play and enjoyment 3) Empathy and understanding 4) Pressures 5) Self-acceptance 6) Learning and knowledge	Linear regression analysis (one for each subscale)
Secondary analyses	i) downloaded the app ii) did not download the app	Mental wellbeing (WEMWBS total score) at 3 months post-delivery	Linear regression analysis
	i) downloaded app and heard about it from HP ii) downloaded the app but did not hear about it from HP iii) did not download the app	Self-efficacy (total TOPSE score) at 3 months post-delivery	Linear regression analysis
	i) downloaded the app and heard about it from HP ii) downloaded the app but did not hear about it from HP iii) did not download the app	Mental wellbeing (total WEMWBS score) at 3 months post-delivery	Linear regression analysis

HP=health professional

For each of the regression analysis, the following three models will be developed:

Model 1 – association between exposure and outcome, unadjusted

Model 2 - association between exposure and outcome, adjusted for potential confounders (maternal age, ethnic group, education, relationship status, employment, recruitment site, IMD score (to be confirmed), social support, propensity to use technology, baseline levels of the outcome, and duration of app use)

Model 3 - association between exposure and outcome, adjusted for potential confounders (maternal age, ethnic group, education, relationship status, employment, recruitment site, IMD score (to be confirmed), social

support, propensity to use technology, baseline levels of the outcome, and duration of app use) and for levels of outcome at 35 weeks gestation

All the analysis for the final report will consist of linear regression models. For publication, we will explore multivariate linear regression techniques for the analysis of the TOPSE subscales.

Model 3 will allow us to assess how outcome scores at 35 weeks gestation affect outcome scores at 3 months post-delivery.

Baseline data indicated that error terms of outcome variables are normally distributed. This suggests the suitability of linear regression models. Data normality will be assessed again at endline.

10. Baseline variables

Baseline characteristics will be presented in tables by download/no download group. Categorical variables will be summarized by frequencies and percentages. Percentages will be calculated using the number of participants for whom data are available as the denominator. Denominators will be systematically reported (e.g, nn/NN and %). Continuous variables will be summarised using standard measures of central tendency and dispersion, either mean or SD or median and interquartile range as appropriate.

A full list of baseline variables will be provided as an appendix. For publications and reports, a shorter list of those variables will be presented.

11. Sample size

A sample size calculation suggested that 559 participants are needed to detect a 7 point difference in TOPSE total scores between download and no download groups, which corresponds to half a standard deviation. This calculation assumes a 30% lost-to-follow up and a 12.5% app usage rate. It is estimated that there will be 1892 eligible women across all study sites in a three-month period based on current birth figures. The total of 559 includes 76 mothers who downloaded the app and 483 who did not download the app, which corresponds to a ratio of approximately 1 to 7.

If the number of recruited participants at baseline is below 559, we will consider powering our analysis at 80%. Assuming the same 12.5% app download rate and a 30% lost to follow up, we would need to recruit 412 participants at baseline.

12. General analysis principles

The general principles of analysis are:

- Only those participants who provided data at baseline and at follow up will be included in the primary analyses.

- All tests will be two-sided and the nominal level of alpha will be 5% ($p<.05$).

- Analyses will be conducted in Stata 14.

- Statistical analyses will be adjusted for potential confounders, unless indicated otherwise.

- Summaries of continuous variables that are normally distributed will be presented as means and SDs (or medians and inter-quartiles for skewed data), whereas categorical variables will be presented as frequencies and percentages.

- The possibility of using imputation procedures to deal with missing data will be considered depending on the amount of missing data.

13. Study reporting

Report of the study will follow existing guidelines for the report of cohort studies (STROBE checklist) (Von Elm *et al.*, 2007). A two-column participant flowchart will compare download vs no download participants throughout the study. This will report the number of women who met study inclusion criteria in each group, any excluded participants with reasons for exclusion, and number of participants who provided valid data for the primary analysis at baseline, 35 weeks gestation and at 3 months post-delivery.

14. References

Kendall, S. and Bloomfield, L. (2005) 'Developing and validating a tool to measure parenting self-efficacy', *Journal of advanced nursing*, 51(2), pp. 174-181.

Rosen, L.D., Whaling, K., Carrier, L.M., Cheever, N.A. and Rokkum, J. (2013) 'The media and technology usage and attitudes scale: An empirical investigation', *Computers in human behavior*, 29(6), pp. 2501-2511.

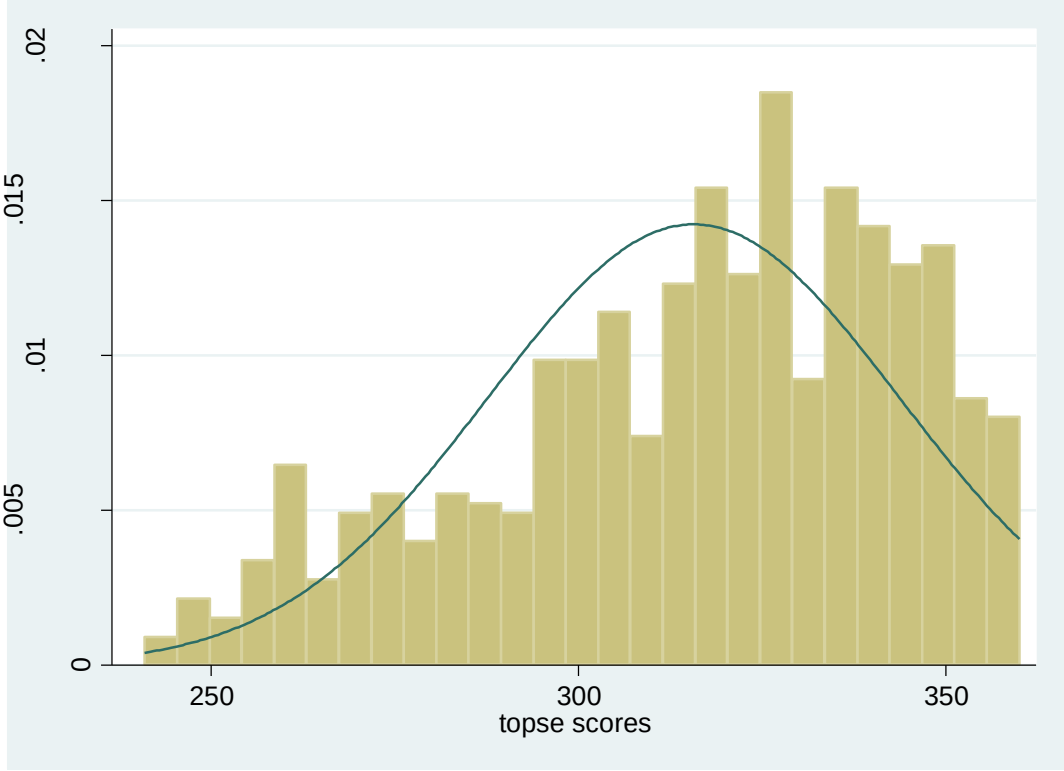
Von Elm, E., Altman, D.G., Egger, M., Pocock, S.J., Gøtzsche, P.C., Vandenbroucke, J.P. and Strobe, I. (2007) 'The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies', *Preventive medicine*, 45(4), pp. 247-251.

Zimet, G.D., Dahlem, N.W., Zimet, S.G. and Farley, G.K. (1988) 'The multidimensional scale of perceived social support', *Journal of personality assessment*, 52(1), pp. 30-41.

APPENDIX 6: TOPSE DATA DISTRIBUTION

Figure 1 shows that the TOPSE data were negatively skewed towards the upper end of the scale. Two common residual analysis procedures – the standardized normal probability plot and the analysis of TOPSE quantiles against quantiles of normal distribution – suggested that residuals were not far from a normal distribution. However, a normality test (Shapiro-Wilk) of the above mentioned standard residuals suggested a non-normal distribution ($p<.05$). That is why we had used logistic regression analysis in this report, which does not require particular normality assumptions to be met.

Appendix 6, figure 1: TOPSE data distribution



APPENDIX 7: ADDITIONAL STATISTICAL ANALYSES DESCRIPTIONS

Appendix 7, table 1. Baseline characteristics of the three samples: baseline, 35 weeks gestation, 3 months post-birth

	Baseline (12-16 weeks' gestation) (N=488)		35 weeks gestation (n=256)		3 months post-birth (n=294)		Differences between baseline and 3 months post-birth
Variable	n (%)	Med (LQ-UQ)	n (%)	Med (LQ-UQ)	n (%)	Med (LQ-UQ)	
Age		28 (24-32)		29.5 (25-33)		29 (26-33)	z=-2.06, p=.040*
By group:							
16 – 24 years	129 (27.3%)		46 (18.4%)		58 (20.1%)		
25 – 34 years	284 (60.0%)		168 (67.2%)		192 (66.4%)		
35 years or above	60 (12.7%)		36 (14.4%)		39 (13.5%)		
IMD decile		4 (2-6)		4 (2-6)		4 (3-6)	z=-1.29, p=.197
By group:							
1 to 3 (most deprived)	201 (42.5%)		102 (40.5%)		116 (39.9%)		
4 to 6	173 (36.6%)		89 (35.3%)		106 (36.4%)		
7 to 10 (least deprived)	99 (20.9%)		61 (24.2%)		69 (23.7%)		
Ethnicity							
- White British	305 (64.8%)		169 (67.6%)		192 (66.7%)		$X^2(1)=0.26$, p=.607
- Other	166 (35.2%)		81 (32.4%)		96 (33.3%)		
Highest education							
- Degree or higher	235 (49.0%)		103 (40.9%)		171 (58.6%)		$X^2(1)=3.64$, p=.056
- No degree	245 (51.0%)		149 (59.1%)		121 (41.4%)		
Employment							
- In paid employment	412 (86.4%)		226 (90.0%)		260 (89.0%)		
- Not in paid employment	65 (13.6%)		25 (10.0%)		32 (11.0%)		$X^2(1)=1.35$, p=.244
Relationship							
- Married or living with partner	408 (83.8%)		227 (89.0%)		263 (89.2%)		$X^2(1)=4.62$, p=.032*
- Not married or not living with partner	79 (16.2%)		28 (11.0%)		32 (10.9%)		

*p<.05. Z: based on Mann-Whitney test; X^2: based on chi-squared test.
- Med: Median; LQ-UQ: Lower quartile – Upper quartile.
- Ethnicity: At baseline, 'Other' includes White Irish (n=5), White Other European (n=59), White Other (n=12), Asian or Asian British Pakistani (n=28), Asian or Asian British Bangladeshi (n=4), Asian or Asian British Indian (n=20), Asian or Asian British Chinese (n=5), Asian or Asian British Other (n=8), Black or Black British Caribbean (n=7), Black or Black British African (n=12), Mixed (n=3), Any Other (n=3). No one replied 'I do not wish to say'; 17 participants (out of 488) did not to answer this question.
- IMD: Index of Multiple Deprivation, based on postcode; from decile 1 (most deprived) to decile 10 (least deprived).
- N missing per variable at baseline (N=488): age (n=15), IMD decile (n=15), ethnicity (n=17), highest education (n=1), employment (n=11) and relationship status (n=1). N missing per variable at 35-40 weeks gestation (N=256): age (n=6), IMD decile (n=4), ethnicity (n=6), highest education (n=4), employment (n=5) and relationship status (n=1). N missing per variable at 3 months post-birth (N=294): age (n=7), IMD decile (n=5), ethnicity (n=8), highest education (n=4), employment (n=4) and relationship status (n=1).

Appendix 7, table 2: Baseline breastfeeding, social support, technology use and outcome scores of 3 samples

	Baseline (12-16 weeks' gestation) (N=488)		35 weeks gestation (n=256)		3 months post-birth (n=294)		
Variable	n (%)	Med (LQ-UQ)	n (%)	Med (LQ-UQ)	n (%)	Med (LQ-UQ)	Differences between baseline and 3 months post-birth
Breastfeeding, intended/actual:							
- 1 week post-birth	382 (79.9%)		216 (86.1%)		250 (85.6%)		$X^2(1)=4.00$, p=.045*
- 1 month post-birth	353 (74.9%)		197 (79.5%)		227 (78.8%)		$X^2(1)=1.49$, p=.223
- 3 months post-birth	306 (65.4%)		168 (68.3%)		195 (67.9%)		$X^2(1)=0.52$, p=.470
Social support (MSPSS), subscales:							
- Significant other		28 (28-28)		28 (27-28)		28 (28-28)	
- Family		28 (25-28)		28 (25-28)		28 (25-28)	
- Friends		27 (24-28)		26 (24-28)		27 (24-28)	
- Overall		81 (74-84)		81 (74-84)		82 (76-84)	Z=-0.92, p=.356
Technology use (MTUAS), overall		5.1 (4.8-5.4)		5.1 (4.7-5.3)		5.1 (4.8-5.4)	Z=0.49, p=.626
Uses pregnancy/parenthood app(s)	355 (73.1%)		186 (72.9%)		218 (73.9%)		$X^2(1)=0.07$, p=.794
Uses or has used Baby Buddy app	51 (14.3%)		34 (18.2%)		33 (15.1%)		$X^2(1)=0.07$, p=.796
Self-efficacy (TOPSE), overall		319 (295-340)		314.5 (288-333)		318 (293-337)	Z=1.15, p=.250
Mental well-being (WEMWBS), overall		54 (48-60)		54 (48-59)		54 (48-60)	Z=-0.38, p=.701

*p<.05; **p<.001; Z: based on Mann-Whitney test; X^2: based on chi-squared test.
- Med: Median; LQ-UQ: Lower quartile – Upper quartile.
- Breastfeeding includes breastfeeding only, as well as breastfeeding in combination with formula milk. At baseline and at 35 weeks gestation, it refers to the intention of breastfeeding; at 3 months post-birth, it is the actual behaviour of breastfeeding. As intention and behaviour are not really comparable, no difference tests were performed.
- All variables, except MTUAS, are as reported by participants at each of the time points; MTUAS was only collected at baseline, so it is the baseline value of those participants who responded at each time point.
- MTUAS: Media and Technology Usage and Attitudes Scale. Score range is 1-6; higher scores = higher technology use.
- MSPSS: Multidimensional Scale of Perceived Social Support. Sum score range is 12-84; sum score range for the three subscales is 4-28. Higher scores = higher perceived social support. Subscale data are reported due to the scale being the only one which differed significantly between baseline and 3 months post-birth.
- TOPSE: Tool to Measure Parenting Self-Efficacy; Overall score range is 0-360. Items 6, 19, 20, 21, 27 were reverse scored. Higher scores = higher self-efficacy. An adapted antenatal version of the TOPSE was used at baseline and 35-40 weeks; the (already existing) postnatal TOPSE was used at follow up.
- WEMWBS: Warwick-Edinburgh Mental Well-being Scale. Overall score range 14-70. Higher scores = higher well-being.
- N missing per variable at baseline (N=488): breastfeeding at 1 week post-birth (n=10), breastfeeding at 1 month post-birth (n=17), breastfeeding at 3 months post-birth (n=20), MSPSS Overall (n=5), MTUAS overall (n=1), use of pregnancy app(s) (n=2), use of Baby Buddy app (n=0), TOPSE overall (n=37), and WEMWBS overall (n=10). N missing per variable at 35-40 weeks gestation (n=256): breastfeeding at 1 week post-birth (n=9), breastfeeding at 1 month post-birth (n=13), breastfeeding at 3 months post-birth (n=12), MSPSS Overall (n=5), MTUAS overall (n=3), use of pregnancy app(s) (n=7), use of BABY BUDDY app (n=0), TOPSE overall (n=16), and WEMWBS overall (n=5). N missing per variable at 3 months post-birth (n=294): breastfeeding at 1 week post-birth (n=4), breastfeeding at 1 month post-birth (n=5), breastfeeding at 3 months post-birth (n=3), MSPSS Overall (n=1), MTUAS overall (n=1), use of pregnancy app(s) (n=0), use of Baby Buddy app (n=0), TOPSE overall (n=14), and WEMWBS overall (n=2).

Appendix 7, table 3: Odds ratio of low TOPSE associated with Baby Buddy app use

		Baby Buddy app use		
	n	OR (SE)	95% CI	p value
Model 1	282	1.17 (0.33)	0.68 to 2.03	.564
Model 2	263	1.12 (0.37)	0.59 to 2.13	.730
Model 3	189	0.89 (0.36)	0.41 to 1.95	.777
OR: Odds ratio; SE: Standard error Model 1 – Baby Buddy use (at any time) and TOPSE overall sum score at 3 months, unadjusted. Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), baseline TOPSE overall sum score. Model 3 – Same as model 2, adjusted for TOPSE overall sum score at 35 weeks gestation.				

Appendix 7, table 4: Odds ratio of low WEMWBS associated with Baby Buddy app use

		Baby Buddy app use		
	n	OR (SE)	95% CI	p value
Model 1	294	1.10 (0.30)	0.64 to 1.89	.719
Model 2	283	1.02 (0.32)	0.55 to 1.89	.943
Model 3	206	1.23 (0.49)	0.56 to 2.67	.606
OR: Odds ratio; SE: Standard error Model 1 – Baby Buddy use (at any time) and TOPSE overall sum score at 3 months, unadjusted. Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), baseline WEMWBS overall sum score. Model 3 – Same as model 2, adjusted for WEMWBS overall sum score at 35 weeks gestation.				

Appendix 7, table 5: Odds of low TOPSE scores associated with Baby Buddy app use, per TOPSE

			Baby Buddy app use		
		n	OR (SE)	95% CI	p value
TOPSE emotion & affection	Model 1	290	1.58 (0.41)	0.95 to 2.62	.080
	Model 2	275	1.57 (0.48)	0.87 to 2.87	.136
	Model 3	200	1.67 (0.59)	0.84 to 3.35	.147
TOPSE play & enjoyment	Model 1	296	1.80 (0.47)	1.07 to 3.02	.025*
	Model 2	283	1.65 (0.49)	0.92 to 2.97	.092
	Model 3	204	1.58 (0.54)	0.81 to 3.08	.183
TOPSE empathy & understanding	Model 1	292	1.62 (0.43)	0.96 to 2.73	.070
	Model 2	280	1.38 (0.42)	0.76 to 2.52	.289
	Model 3	202	1.06 (0.38)	0.52 to 2.14	.881
TOPSE pressures	Model 1	289	1.14 (0.31)	0.66 to 1.96	.635
	Model 2	277	1.32 (0.43)	0.70 to 2.49	.395
	Model 3	201	1.06 (0.41)	0.50 to 2.28	.874
TOPSE self-acceptance	Model 1	291	0.90 (0.24)	0.53 to 1.53	.697
	Model 2	278	0.83 (0.26)	0.46 to 1.52	.547
	Model 3	203	0.87 (0.32)	0.43 to 1.78	.707
TOPSE learning & knowledge	Model 1	294	1.80 (0.49)	1.06 to 3.05	.031*
	Model 2	285	1.45 (0.44)	0.80 to 2.64	.226
	Model 3	207	1.30 (0.47)	0.65 to 2.62	.459

OR: Odds ratio; SE: Standard error
Model 1 – Baby Buddy app use and TOPSE subscale sum score at 3 months, unadjusted.
Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline TOPSE subscale sum score.
Model 3 – Same as model 2, adjusted for TOPSE subscale sum score at 35 weeks gestation.

Appendix 7, table 6: Odds ratio of low TOPSE associated with instructed Baby Buddy app use

		Instructed use of the Baby Buddy app		
	n	OR (SE)	95% CI	P value
Model 1	282	1.16 (0.33)	0.66 to 2.04	.596
Model 2	263	1.16 (0.39)	0.60 to 2.23	.666
Model 3	189	0.89 (0.36)	0.40 to 1.98	.782

OR: Odds ratio; SE: Standard error
Model 1 – Instructed use of the Baby Buddy by a health professional and TOPSE overall sum score at 3 months, unadjusted.
Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline TOPSE overall sum score.
Model 3 – Same as model 2, adjusted for TOPSE overall sum score at 35 weeks gestation.

Appendix 7, table 7: Odds ratio of low WEMWBS associated with instructed Baby Buddy app use

		Instructed use of the Baby Buddy app		
	n	OR (SE)	95% CI	P value
Model 1	294	1.03 (0.29)	0.59 to 1.79	.924
Model 2	283	1.00 (0.32)	0.53 to 1.87	.990
Model 3	206	1.18 (0.48)	0.54 to 2.62	.676

OR: Odds ratio; SE: Standard error

Model 1 – Instructed use of the Baby Buddy by a health professional and WEMWBS overall sum score at 3 months, unadjusted.

Model 2 – Same as model 1, adjusted for IMD decile, technology use (baseline MTUAS total mean score), use of pregnancy/parenthood apps (any), social support (baseline MSPSS overall sum score), and baseline WEMWBS overall sum score.

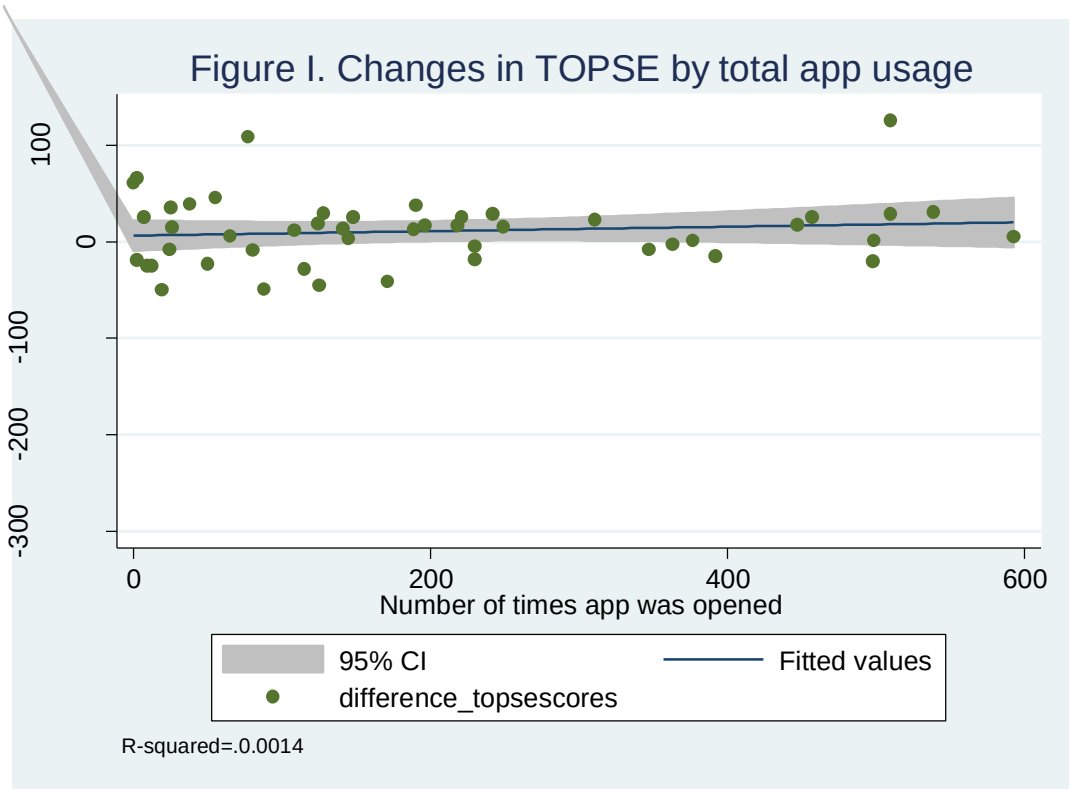
Model 3 – Same as model 2, adjusted for WEMWBS overall sum score at 35 weeks gestation.

Appendix 7, table 8: Changes in TOPSE scores, total app usage and baseline characteristics (age, IMD decile and social support) of in app participants

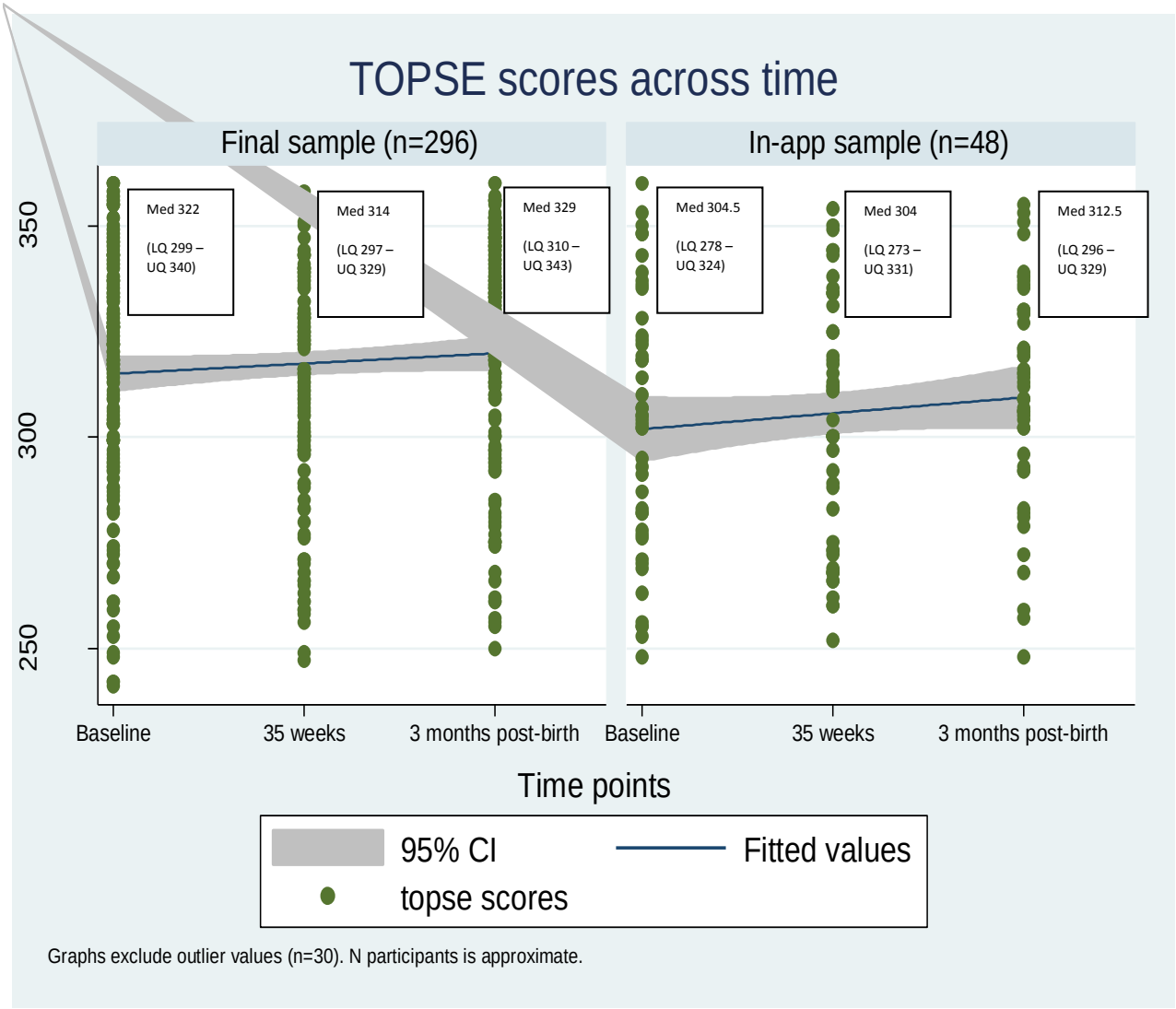
In-app participant number	Number of times app was opened	TOPSE score at baseline	TOPSE score at post-birth	Change in TOPSE	Age at baseline	IMD decile at baseline	MSPSS score at baseline (social support)
1.	0	248	309	+61	29	8	75
2.	2	263	329	+66	37	6	12
3.	2	291	272	-19	24	8	84
4.	7	287	313	+26	25	7	84
5.	9	282	257	-25	30	10	80
6.	12	360	335	-25	23	1	68
7.	19	318	268	-50	26	3	77
8.	24	304	296	-8	29	10	72
9.	25	278	314	+36	46	4	72
10.	26	323	338	+15	28	9	84
11.	38	270	309	+39	34	8	84
12.	50	335	312	-23	25	1	84
13.	55	269	315	+46	30	4	81
14.	65	253	259	+6	31	5	80
15.	77	220	329	+109	26	1	64
16.	80	348	339	-9	34	3	81
17.	88	353	304	-49	30	2	84
18.	108	295	307	+12	31	1	84
19.	115	310	282	-28	27	3	79
20.	124	283	302	+19	32	6	64
21.	125	337	292	-45	29	9	84
22.	128	307	337	+30	23	1	69
23.	141	302	316	+14	19	5	77
24.	145	318	321	+3	32	7	83
25.	148	255	281	+26	30	3	72
26.	171	324	283	-41	30	3	84
27.	189	302	315	+13	29	8	75
28.	190	255	293	+38	27	4	80
29.	196	336	353	+17	33	5	84
30.	218	319	336	+17	30	4	82
31.	221	293	319	+26	39	2	70
32.	230	343	338	-5	32	4	80
33.	230	348	330	-18	30	7	84
34.	242	277	306	+29	35	2	82
35.	249	339	355	+16	27	3	84
36.	311	328	351	+23	21	1	84
37.	347	256	248	-8	34	8	77
38.	363	282	279	-3	31	4	70
39.	377	305	306	+1	39	6	74
40.	392	307	292	-15	35	5	83
41.	447	303	321	+18	33	2	80
42.	457	322	348	+26	36	1	84
43.	498	350	330	-20	25	5	81
44.	499	305	306	+1	31	2	84
45.	510	194	320	+126	29	3	73
46.	510	276	305	+29	45	6	73
47.	539	271	302	+31	28	3	82
48.	593	314	319	+5	23	2	81
Mean (SD)	199.8 (174.2)	299.1 (35.7)	310.2 (25.6)	11.1 (35.2)	30.3 (5.4)	4.5 (2.7)	77.3 (11.2)
Median (LQ-UQ)	146.5 (52.5 – 329)	303.5 (276.5 – 323.5)	312.5 (294.5 – 329.5)	13.5 (-12 – 27.5)	30 (27 – 33)	4 (2 – 6.5)	80.5 (73.5 – 84)

- Number of times app was opened is order from smallest to largest number
- Higher TOPSE scores mean higher self-efficacy. Lower IMD deciles mean higher deprivation. Higher MSPS scores mean higher social support
-SD: standard deviation; LQ – lower quartile; UQ – upper quartile

Appendix 7, figure 1: Changes in TOPSE by total app usage



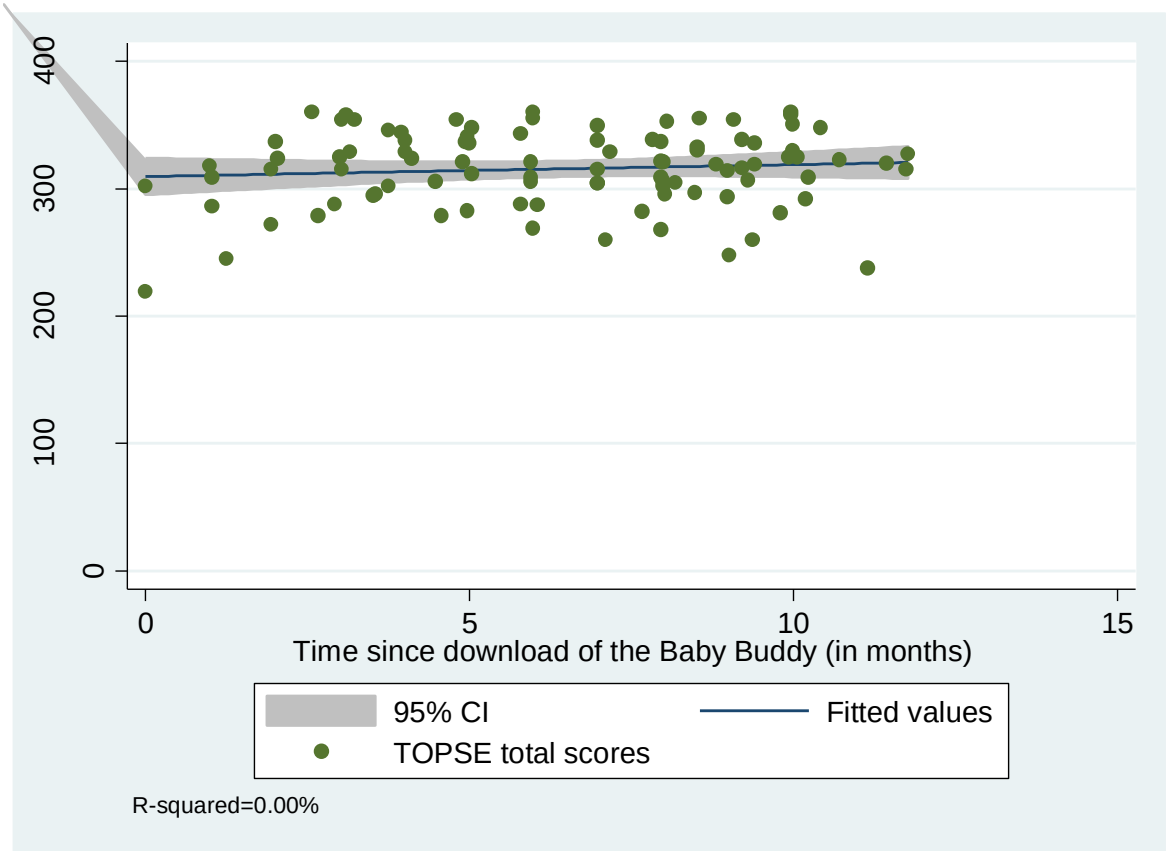
Appendix 7, figure 2: best fit of TOPSE scores across time, by final sample and in-app participants.



Graphs exclude outlier values (n=30). N participants is approximate.

APPENDIX 8: REGRESSION ANALYSIS: ASSOCIATION BETWEEN TIME SINCE BABY BUDDY APP DOWNLOAD AND OUTCOMES

Appendix 8 figure 1: TOPSE scores by time since Baby Buddy app download



APPENDIX 9: INTERVIEW AND FOCUS GROUP SCHEDULES

FLEXIBLE INTERVIEW TOOL for Mothers – Main Study

Please note – we will only use this as flexible interview tool allowing discussion to take place.

Mothers will have been contacted prior to the interview and the interview time and contact number will have been agreed.

Researcher Prompt Sheet

1. ***What did you think of the App and its features in general?***

Prompts:

What worked well?

What could be improved?

2. ***What has been your experience of using the App to find things out?***

Prompts:

- Can you tell me about something you learned from the App that you didn't know before?
- Can you think of a time you may have used the App to check information was right, or to remind yourself of some information?
- What do you think you would have done if you did not have, or know about the App?
- Was the information in the App was easy to find?
- Was the information in the App was easy to understand?
- Do you remember a time when you wanted information and you couldn't find it in the App
- Did you use other Apps?

3. ***Did the App support the choices you made about your care in pregnancy and birth?***

Prompts:

- Did you use the App to prepare for labour?
    - Did you use the App to help you make choices around birth, birth plan, pain relief etc?
- Did you use the App to find out about how to feed the baby
    - Did the information in the App help you decide if you wanted to breastfeed or bottle feed?
- Have you used the App to find out about how to best care for your baby?
- Did you attend any antenatal classes?

- How was the information you received in your class different from the information on the App?

4. ***How did others around you interact with the App?***

Prompts:

- Did information in the App remind you, or prompt you to ask your midwife for more information on a particular topic?
- Did your midwife refer to the App in your appointments?
  - The App in general
  - Or specific content
- Did you share information from the App with partner/family/friends?
  - Did your partner/friends/family download the App for their own use?

FLEXIBLE INTERVIEW TOOL for Health Professionals – Main Study

Please note – we will only use this as flexible interview tool allowing discussion to take place.

Health professionals will have been contacted prior to the interview and the interview time and contact number will have been agreed.

Researcher Prompt Sheet

1. ***What did you think of the App and its features in general?***

Prompts:

What worked well?

What could be improved?

2. ***What has been your experience of the app embedding process in your area?***

Prompts:

- What do you understand about the way the app was embedded in your are
- To what extent were you aware of the embedding and how were you involved?

What worked well?

What could have been improved?

3. ***What has been your experience of using the App in providing public health/lifestyle information?***

Prompts:

- can you think of a time you sign-posted a woman or partner to health/lifestyle information in the app
- can you think of a time a woman initiated a discussion about health/lifestyle information following use of the app?
- to what extent do you feel the app can support your professional public health role?
- to what extent does the app support how you communicate health and lifestyle information?
- What other ways do you support this part of your role - other apps/websites/written information? How does this app compare to other resources that you use?

4. What has been your experience of using the app to support choice about care and parenting?

Prompts:

- can you think of a time that you sign-posted women and their partners to information on care choices and parenting (for example: birth planning, pain relief choices, feeding choices, baby care)
- can you think of a time that women initiated a discussion regarding choices for care and parenting based on information in the app?
- to what extent do you feel the app can support you in care planning with women and partners
- to what extent does the app support how you communicate choices for care and parenting advice?
- What other ways do you support this part of your role - other apps/websites/written information? How does this app compare to other resources that you use?

5. How has the app influenced your encounters with women and partners?

Prompts:

- to what extent has the app influenced the way that you communicate with women and partners?
- to what extent has the app influenced the professional relationship you have with women and partners?
- to what extent have you been aware that women have been using the app between appointments?
- what features of the app do you think women access the most?
- do you think there are some women who may be more likely to use or to benefit from the app?

APPENDIX 9: INFORMATION RECEIVED FROM BEST BEGINNINGS WHO REQUESTED THAT THIS SECTION IS INCLUDED.

(The research team has not had input to any of the text, graphs or diagrams in this appendix.)

THE BABY BUDDY APP AND ITS DEVELOPMENT AND DEPLOYMENT

The thinking behind Baby Buddy

Baby Buddy is a free and advert free, multi-award winning parenting app which was created by the national charity Best Beginnings thanks to funding from the Big Lottery Fund and the Guys and St Thomas' Charity. Baby Buddy was developed to deliver to the core of Best Beginnings mission to give every child the best start and reduce inequalities. The app delivers to Best Beginnings three guiding principles that underpin all the charity does: evidence, collaboration and innovation.

Figure 1

Baby Buddy was developed to be a free national intervention to inform and empower parents of all backgrounds and to ensure that the app was particularly relevant and engaging for parents whose children are at increased risk of poor outcomes including young parents and parents from BME groups. This "proportionate universalism" approach was informed by the Marmot Review.

The development of Baby Buddy

As with Best Beginnings' previous national resources, a multi-stage iterative process of co-creation with parents and professionals, informed by behaviour change theory, underpinned the development of Baby Buddy. This multi-year process is highlighted in Figure 1 above. The Figure also shows the first areas in the UK were the charity worked with local professionals and parents to embed (integrate) Baby Buddy into local care-pathways.

During the development of the thinking behind Baby Buddy in 2011 the Department of Health published their "Preparation for Pregnancy Birth and Beyond Report". The report highlighted the need for preparation for parenthood classes to support parents in their emotional and physical transition to parenthood, to support bonding and attunement and to help maximise child development.

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Alison Baum OBE, Best Beginnings' Founder and CEO, was a Stakeholder on the Department of Health working group and was aware how long the development, testing and scaling of new parenting classes would be. With this in mind, and taking a population level and innovative approach, the idea of Baby Buddy took shape - an app that would directly inform and empower parents that would be designed to support the relationship between parents and professionals and be integrated into local care-pathways. So, from the beginning, Baby Buddy was created an "as well as" not an "instead of" intervention to be used directly by parents and also to augment and enhance standard care and the work of other charities.

In December 2013, following the development of a prototype and the creation of a 65 page specification, funding from the Big Lottery Fund enabled Best Beginnings to take their concept from idea into reality. Following different tendering processes, the charity commissioned an app developer to create Baby Buddy, commissioned over 100 new films to go into the app and commission an academic evaluation of Baby Buddy (this evaluation). Best Beginnings continued to work with the expert panel the charity had established in 2011 for the project and this panel became the Baby Buddy Editorial Board. Following years of co-creation with formal involvement from the Department of Health and a number of professional bodies, Baby Buddy was launched in November 2014 at the Royal College of Obstetricians and Gynaecologists. Details of the endorsing organisations of Baby Buddy follow below in Figure 2.

Figure 2

An overview of Baby Buddy

Baby Buddy provides personalised daily information covering all aspects of the transition to parenthood in the tone of a friend. The central idea of this daily information is to provide a "drip drip drip" effect of knowledge transfer and empowerment. In addition to this, Baby Buddy has a host of interactive features including goal setting. At the time of launch Baby Buddy had around 200 films in it, including 39 short films edited from the charity's previously created "From Bump to Breastfeeding" DVD. Following an academic evaluation completed by Bournemouth University showing the impact of the DVD, in 2009 the DVD became included in the Department of Health/NHS England/UNICEF BFI/Start4Life care-pathway. Over 2 million copies of the DVD were distributed to pregnant women from their midwife but in 2010 central funding for this distribution of DVDs stopped. From launch, Baby Buddy provided a way to freely get these evidence-based and effective films to women across the UK.

Baby Buddy mentions the mother and baby by name and also the partner/dad if the mother has one and chooses to input it. Also, the in-app breastfeeding messages can be turned off by the user if, for whatever reason they are no longer breastfeeding. Since launch, Baby Buddy has covered the period from conception until the child is six months old. Funding dependent, the plan is (and has been since 2011) to create bespoke content and functionality for

(The research team has not had input to any of the text, graphs or diagrams in this appendix.)

fathers and partners, to support the couple relationship and to support both parents (whether or not they are together) until their child is three.

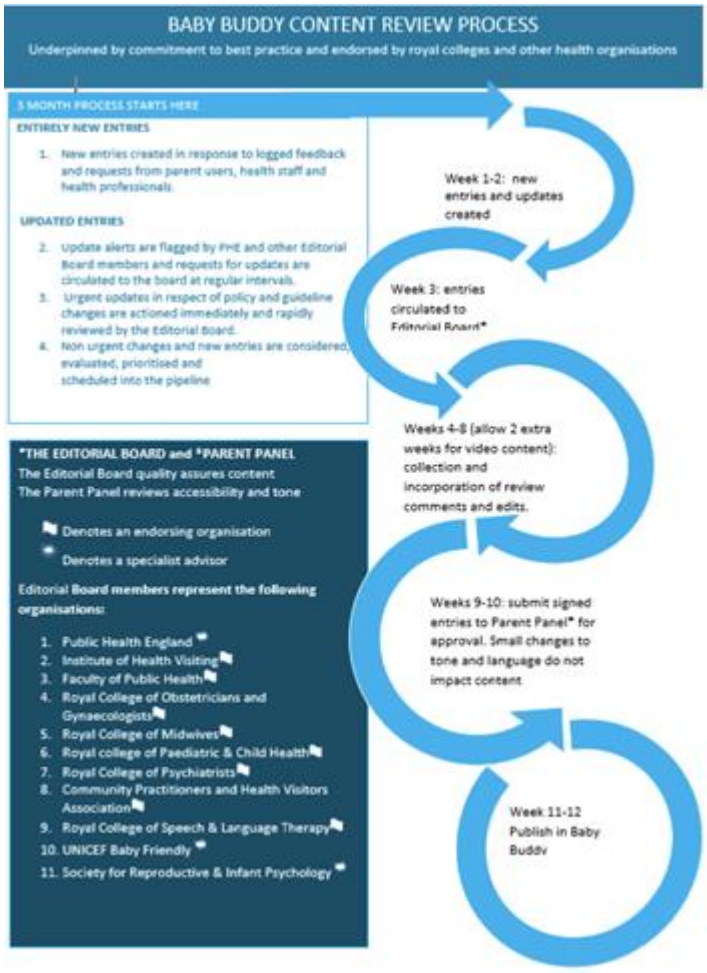
Baby Buddy is featured in Better Births, supports the Maternity Transformation Programme and supports key public health and early years priorities including maternal and infant mental health, breastfeeding, smoking cessation and language development.

As shown in Figure 3 below, since its launch Baby Buddy has won a number of prestigious awards.

Figure 3

Developing a mobile app was an important strategy for Best Beginnings. Mobile software applications (Apps) are a central technology in digital health and risk communication (Thomas and Lupton 2015). Thomas and Lupton (2015) go on to discuss that Apps directed at pregnancy constitute a major genre, and that there are hundreds of Apps available that focus on pregnancy, and many of them are very popular. Thus, Boulos et al (2011) suggest that there is huge potential for mobile communication to transform healthcare. Furthermore, Robinson and Jones (2014) propose that midwives find that apps may empower and inform women so that they take more responsibility for their health, but that the quality of information offered is often dubious and they should be used only to supplement professional advice.

(The research team has not had input to any of the text, graphs or diagrams in this appendix.)



Best Beginnings approach to work with royal colleges and professional bodies and to ensure the veracity of all its resources dates back to the founding days of the charity. In 2008 Baby Buddy launched their first national resources, the From Bump to Breastfeeding DVD which was co-created with parents, professional bodies, statutory bodies and other charities. All new film and written content created prior and subsequent to the launch of Baby Buddy has been and is approved by the Editorial Board prior to being uploaded into Baby Buddy. The protocol for updating content into Baby Buddy is captured in Figure 4 below.

Figure 4

Quality assurance of the content of Baby Buddy is one way Best Beginnings works to ensure that the app can directly inform and empower parents and also augment and enhance service delivery,

Integrating Baby Buddy into local care-pathways

In addition, and as with the charity's previous resources, Baby Buddy has been designed to be integrated into local maternity and early years pathways and to support self-care and community networks.

Over the last several years Best Beginnings has developed, tried and tested and refined their "embedding" process (see stage 2 of the chart to the left) whereby the charity works in co-creation with local parents and professionals to support Baby Buddy to become "Business as usual" in that locality.

Figure 5 below shows the data driven iterative approach to creating national resources and embedding them locally. To-date Best Beginnings has secured funding to embed Baby Buddy into 27 areas of the country.

(The research team has not had input to any of the text, graphs or diagrams in this appendix.)

Figure 5

The analytics system that sits behind Baby Buddy

Best Beginnings has invested as much time and money on Baby Buddy's back-end analytics system as the charity has on the app's front-end functionality. A sophisticated analytics tool behind Baby Buddy that integrates with the data visualisation software Tableau, allows the charity to track uptake and usage by locality, age, gender, ethnicity, language, education, employment and training. It also allows the charity to identify which videos Baby Buddy users are watching, what questions they're asking and which features they are using, as an anonymised data set. This rich data along with pop-up in-app questionnaires capturing feedback from pregnant women and new mothers has informed developments of Baby Buddy and the embedding programme prior to the findings from this and the other academic evaluations completing data collection and analysis.

Figure 6a below shows the total cumulative Baby Buddy app registrations from 1st August 2014 to 30th April 2018, by evaluation site in figure 6b and per 100 birth cohort in figure 6c. The starting and ending points of the BaBBLeS research study is marked on the graph. A steady increase in all downloads can be seen from 2014-2018. During the period of data collection within the evaluation sites the national number of downloads more than doubled from 63,120 to 163,452.

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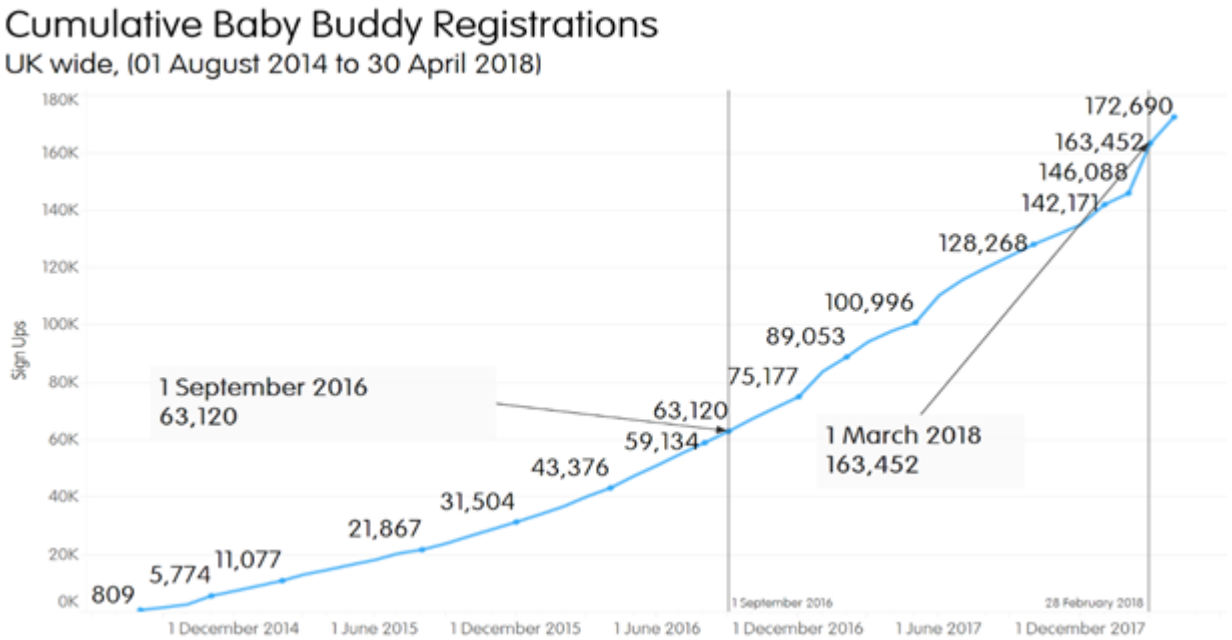

Figure 6a

Figure 6b

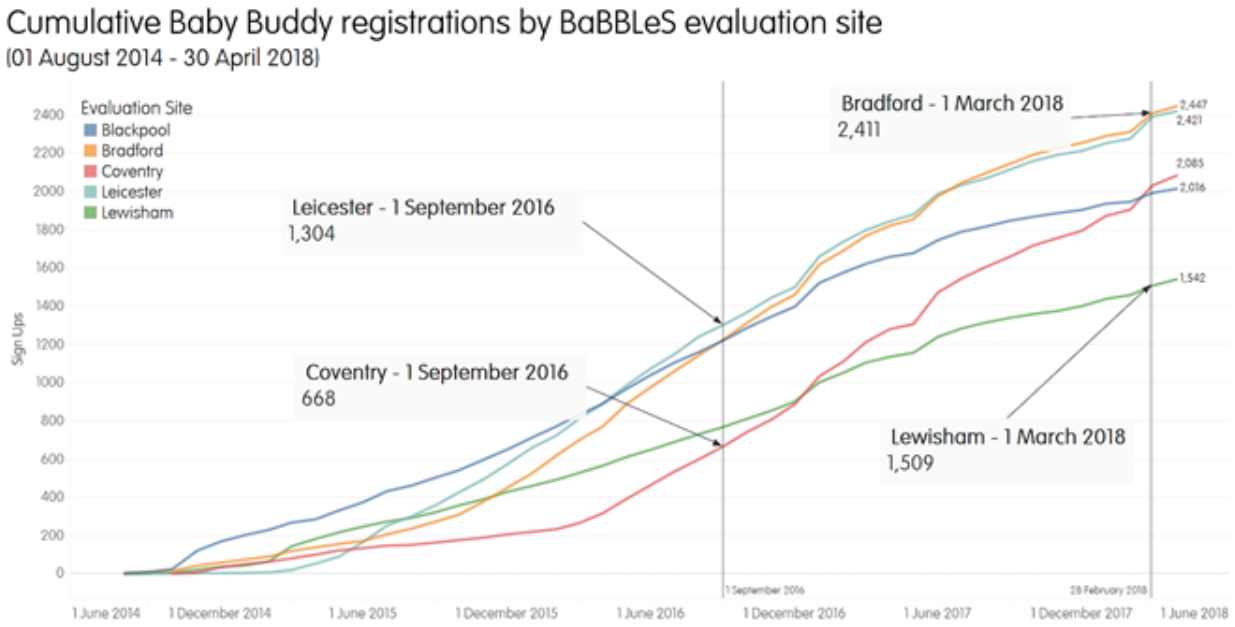

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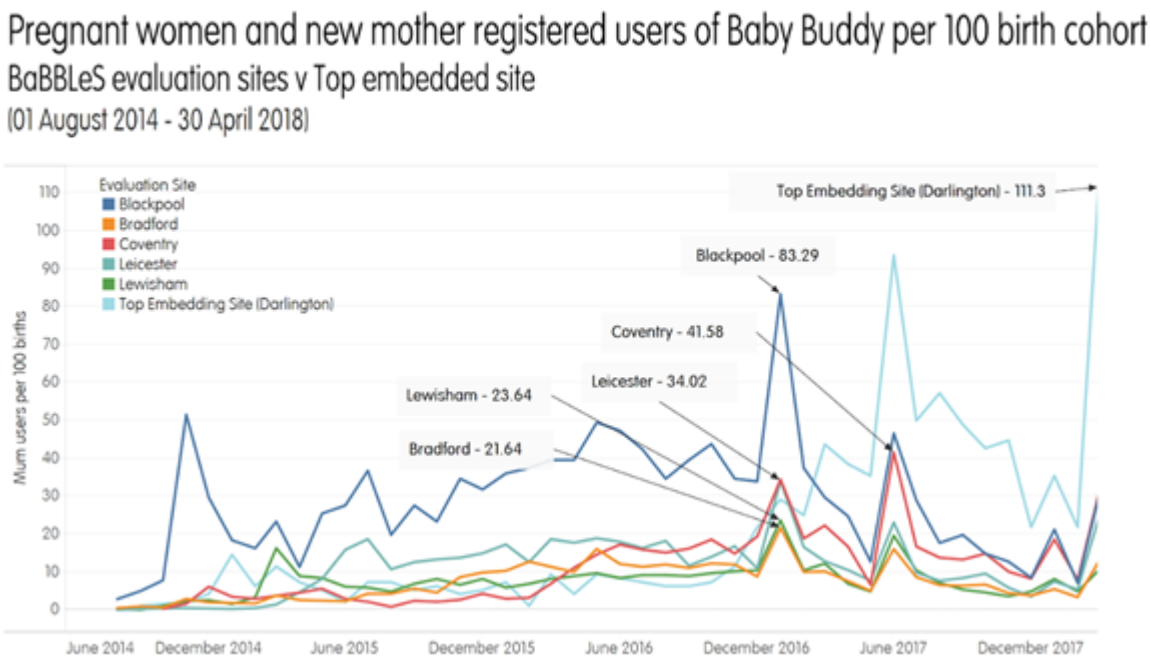
Figure 6c



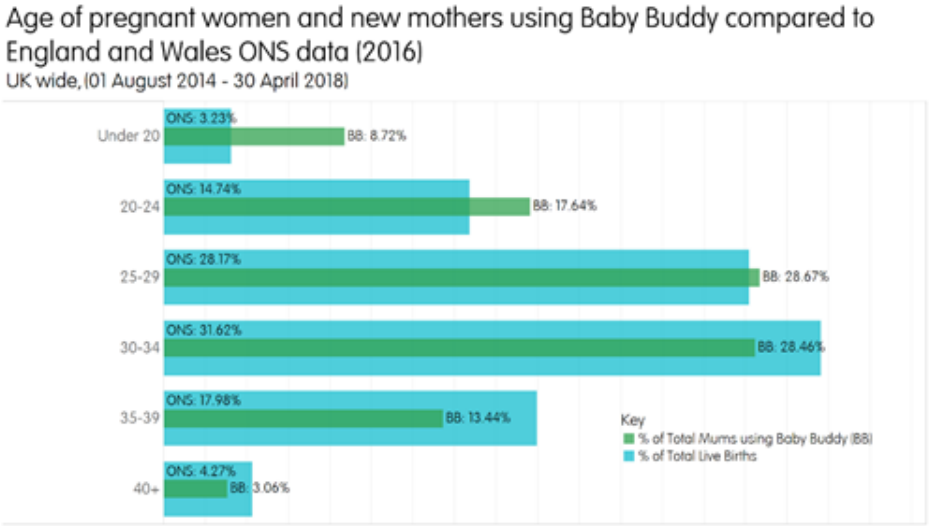


Figure 7 to the left illustrates the distribution of ages of the Baby Buddy users at a national level. The information is mapped onto the ONS (2016) data which compares the Baby Buddy users to the national distribution of age groups. In line with Best Beginnings' aim to take a "proportionate universalism" approach, Baby Buddy is used by women of all ages, with an over representation of younger women who are using the app.

Figure 7

(The research team has not had input to any of the text, graphs or diagrams in this appendix.)

Figure 8 illustrated the age of mothers using Baby Buddy is captured from all people using Baby Buddy. In addition, the app offers up pop-up questions including asking app users what their first language is.

Figure 8

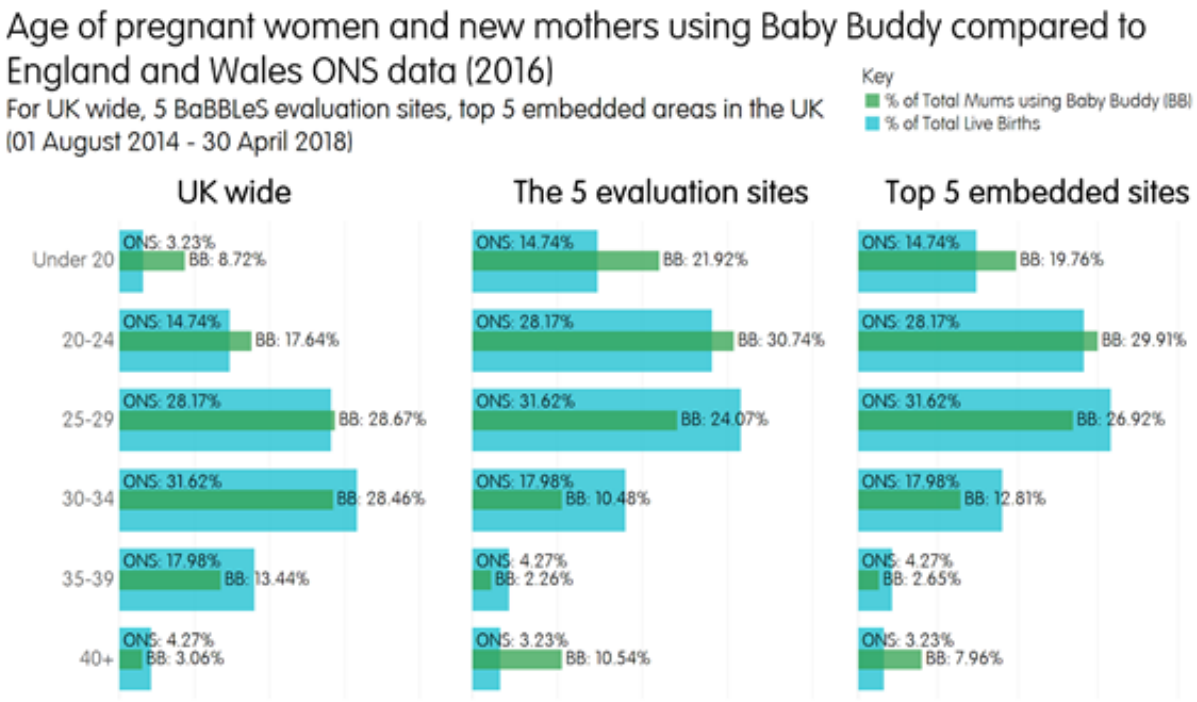


Figure 9a below, compares this data to the ONS reported distribution of first languages nationally. The data shows that a disproportionate number of women using Baby Buddy do not have English as their first language with a notable overrepresentation of Polish, Punjabi, Urdu, French, Romanian, Spanish and Portuguese speakers. This data demonstrates that the charity is delivering to its mission of reaching women whose children are at increased risk of poor outcomes with accessible evidence-based information. In figure 9b below, the UK wide first language of Baby Buddy users is compared to the percentage of populations in the evaluation sites and the top 5 embedding sites.

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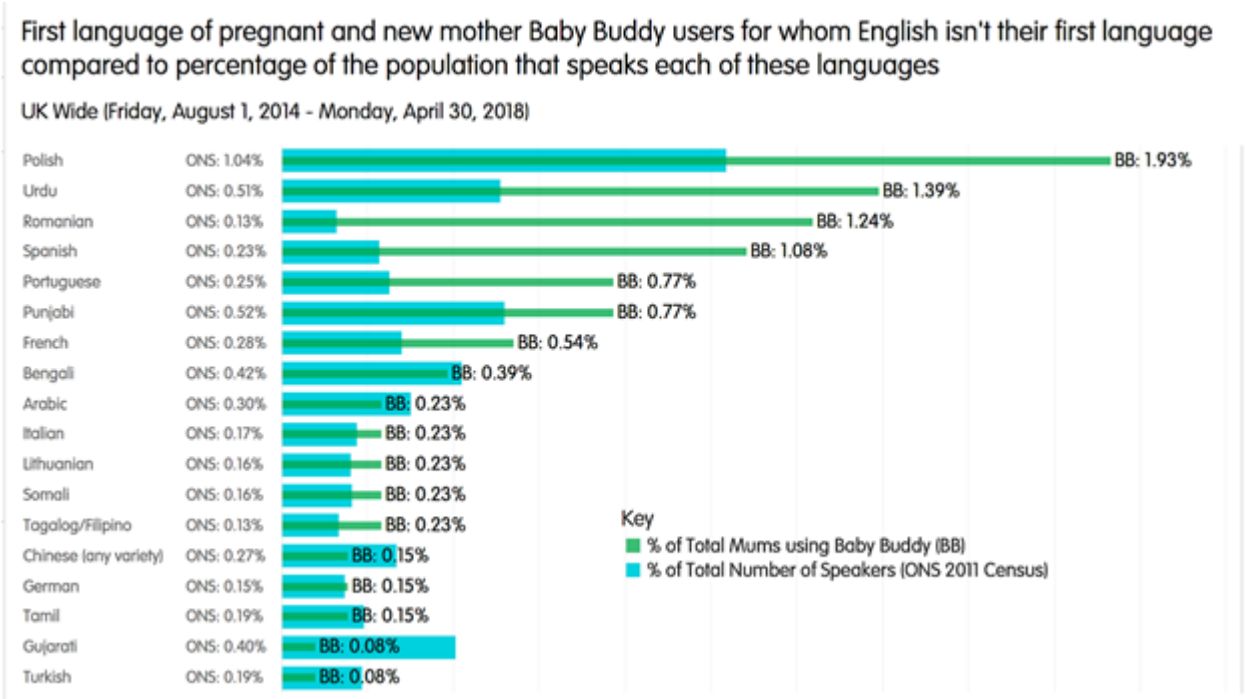

Figure 9a

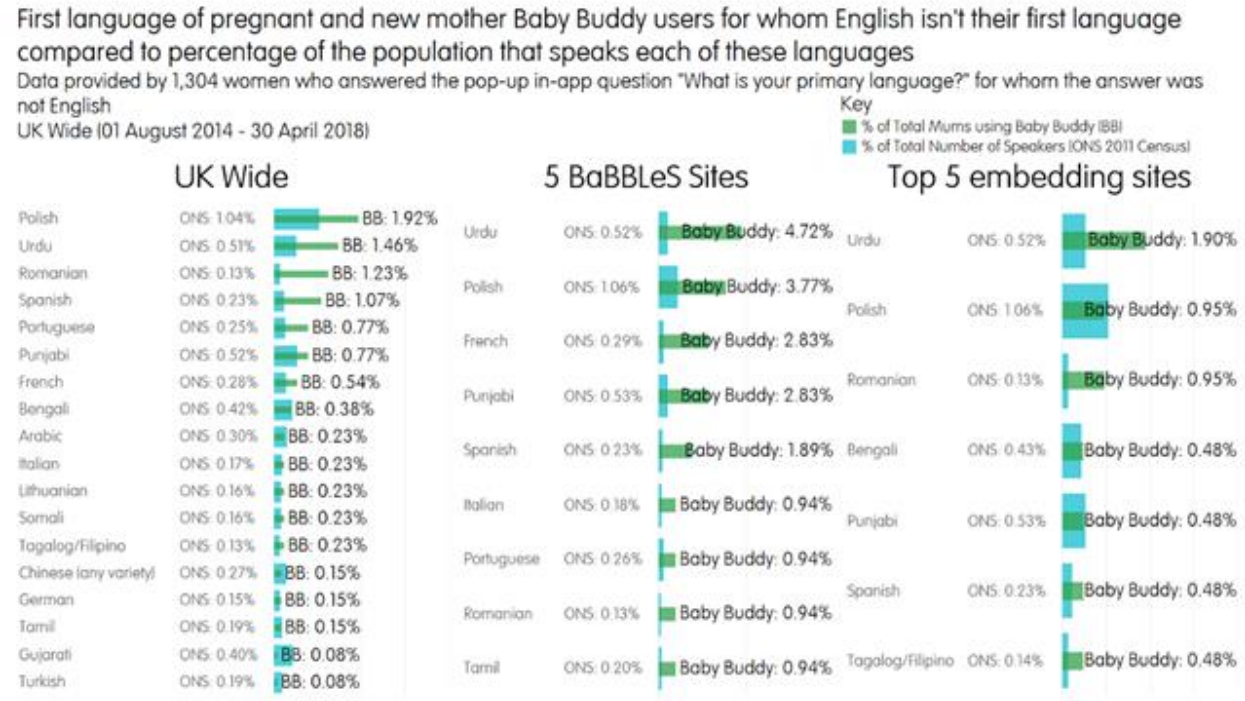

Figure 9b

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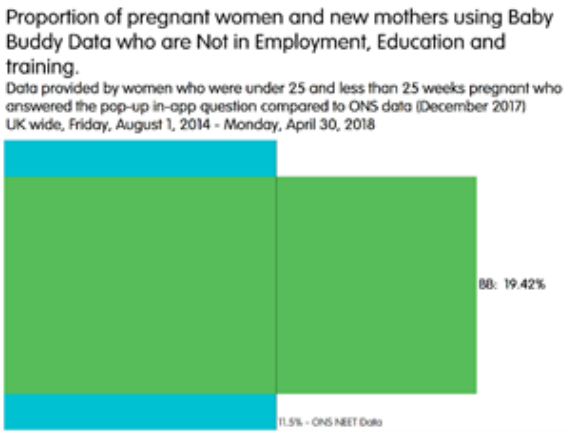

A further pop-up in-app question is about employment, education and training status of users of Baby Buddy. From this data Best Beginnings' in-house evaluation team has extracted data from women who are under 25 and under 25 weeks pregnant, ie: in the right age range for NEET status and also not "not working" or not "in training" because they have just had a baby. As Figure 9 below shows, NEETS represent almost 20% of the under 25 cohort of Baby Buddy users. Again, this is encouraging to the charity and gives them confidence that Baby Buddy is reaching the families who need it most

Figure 10

What follows below in Figure 10 are the findings from answers to the in-app feedback questions. The data suggests that the iterative co-creation approach underpinnings Baby Buddy's development has paid dividends with more than 99% of users finding the app easy to use and understand. In addition, the data suggests that Baby Buddy is delivering to its intended aim of being "as well as" not "instead of" with 86% of respondents reporting that Baby Buddy is helping them get more out of their appointments. The charity is also heartened but not surprised by the findings from the survey with regards to the other in-app questions.

Pregnant women and new mums completing pop-up in-app surveys to 31/08/17 report the following about Baby Buddy:

- **Easy to use (n=9757): >99%**
- **Easy to understand (n=9707): >99%**
- **Helps me get more out of my appointments (n=5549): 86%**
- **Helps me look after my mental health (n=2,254): 87%**
- **Helps me look after my physical health (n=2,277): 90%**
- **Helps me feel closer to my baby (n=2955): 90%**
- **Helps me feel more confident caring for my baby (n=2753): 98%**

Figure 10

The above in-app data is in the process of being submitted for publication to Implementation Science as part of a paper mapping the breastfeeding content and functionality of Baby Buddy onto the Michie et al Behaviour Change wheel.

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The level of app usage of Baby Buddy is presented in figure 11 below as number of app opens per Baby Buddy user

Figure 11

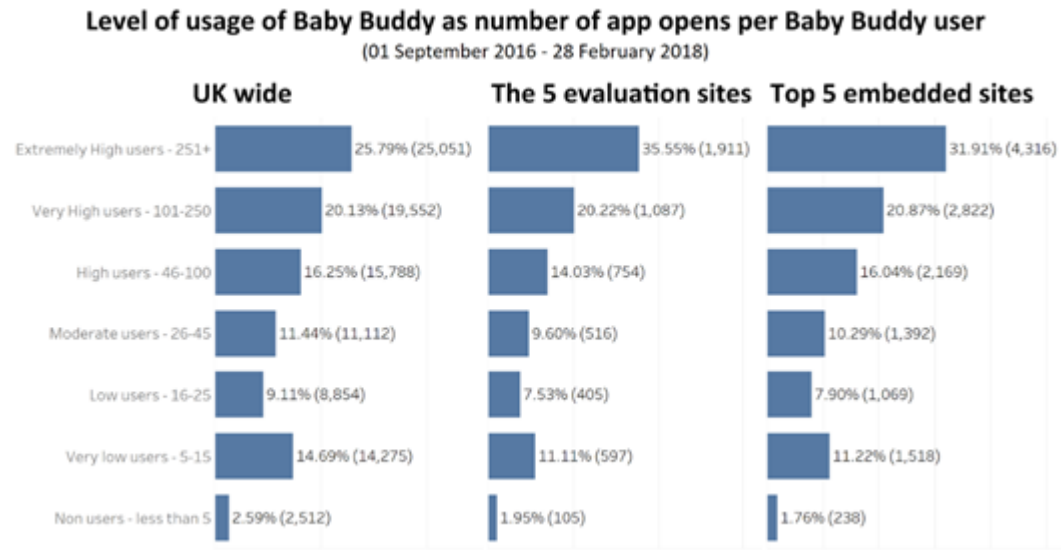

Figure 12

Responses to the in-app question "How did you find out about Baby Buddy"

1st August 2014 to 1st January 2018