Mobile health applications for postnatal care: Review and analysis of functionalities and technical features

Lamyae Sardi[a,*], **Ali Idri**[a,b], **Leanne M. Redman**[c], **Hassan Alami**[d,e], **Rachid Bezad**[d,e], **José Luis Fernández-Alemán**[f]

[a]Software Project Management Research Team, ENSIAS, Mohammed V University, Rabat, Morocco

[b]Complex Systems Engineering, University Mohamed VI Polytechnic, Ben Guerir, Morocco

[c]Reproductive Endocrinology and Women's Health Lab, Pennington Biomedical Research Center, Baton Rouge, LA, USA

[d]Faculty of Medicine, Mohammed V University, Rabat, Morocco

[e]Maternity Les orangers, University Hospital of Rabat, Morocco

[f]Department of Informatics and Systems, Faculty of Computer Science, University of Murcia, Murcia, Spain

Abstract

Background: Providing a continuum of care from antenatal, childbirth and postnatal period results in reduced maternal and neonatal morbidity and mortality. Timely, high quality postnatal care is crucial for maximizing maternal and newborn health. In this vein, the use of postnatal mobile applications constitutes a promising strategy.

Methods: A Systematic Literature Review (SLR) protocol was adopted to perform the selection, data extraction and functional evaluation of the available postnatal apps on iOS and Android platforms. The analysis of the functionalities and technical features of the apps selected was performed according to a 37-items assessment questionnaire developed on the basis of the scientific literature of postnatal care and a preliminary analysis of available postnatal apps

Results: A total of 48 postnatal apps were retrieved from the app repositories of the iOS and Android platforms. The results of the functional content analysis show that the postnatal apps selected relatively achieved low scores owing to the complexity and the ramification of the postnatal care.

Conclusions: The present study helps in identifying areas related to the postnatal care that require further endeavors to be properly addressed. It also provides directions for developers to leverage the advancement and innovation on mobile technology to build complete and well-suited postnatal apps

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*Corresponding author. lamyasardi@gmail.com (L. Sardi).

Keywords

Postnatal care; Apps; Mobile health; Functionality

1. Introduction

The postnatal (or postpartum) period is the most critical, yet the most neglected phase in the lives of mothers and newborn infants. Beginning immediately after childbirth, the postnatal period usually extends for about six weeks as the mother's body returns to its pre-pregnant state. Yet, some evidence indicates that the postnatal period is a continuity of three distinct phases of which the third one lasts up to six months following delivery [1]. The postnatal period marks an important transition in the lives of parents as it brings about major changes in parental roles, responsibilities, and identities. During this period, parents are supposed to make physical, psychological and social re-adjustments to restore balance in their lives [2].

While most expecting mothers focus on potential risks involved during pregnancy and up to delivery, a few closely consider the risks afterward. In fact, the postnatal period poses substantial health risks for both mothers and newborn infants and is the period when most maternal and infant mortalities and morbidities occur. According to recent estimates by the World Health Organization, upwards of 303,000 women died as a result of pregnancy and child birth-related complications and approximately 2.7 million newborn babies died after birth in 2015 [3]. Given that maternal health and newborn health are closely linked, interventions targeting maternal care can likely also improve fetal and neonatal health [4]. Providentially, most maternal and infant mortalities are preventable and healthcare solutions to handle and avoid complications are well-known [5]. In this regard, it is particularly important that all births are attended by skilled health personnel and that all women have access to the appropriate level of care before, during and after pregnancy and childbirth. Timely, high quality postnatal care is crucial for maximizing maternal and newborn health.

Postnatal care (PNC) is the care given to the mother and her newborn infant immediately after the birth and during the postnatal period. Although for most women and newborn infants, the postnatal period is uncomplicated and manageable, effective and adequate care during this period needs to address any deviation from expected recovery after birth and to appropriately intervene in a timely fashion [6]. Nevertheless, PNC services tend to be poorly covered when compared with other reproductive health care services. The inadequacy and the underutilization of PNC services likely emanate from several factors ranging from poor education and poverty to limited access to healthcare facilities [7]. The void in PNC can also be attributable to differing priorities and perceptions of maternal and infant needs among healthcare providers, new mothers and their families which is also likely influenced by regional and cultural practices [8].

Information and Communication Technologies (ICT) have proven to be a powerful prospect in promoting the fields of health care and allowing patient empowerment and disease management [9]. ICT have been efficiently used by patients and health care providers to facilitate communication, manage patient history and handle medical transcriptions, among others [10]. Mobile technology appears to be promising in improving access and efficiency

in health care delivery [11]. Mobile health (mHealth) has great potential in addressing disruptive issues in healthcare, given the ubiquity of mobile devices around the world and the unique aspects of mobile technology including its high reach, cost-effectiveness, and relative simplicity to use. The arrival of internet and smartphones has indeed revolutionized mobile health technology. Smartphones are considered powerful devices that typically combine the conventional features of a mobile phone with sophisticated processing and computing capabilities enabling users to access and run a myriad of mobile applications, commonly called 'apps' [12]. The mobile health (mHealth) app market has been expanding steadily over the last few years with the adoption of new technologies and new workflows that are transforming healthcare [13]. With respect to the PNC, there is an increasing proliferation of apps bringing up new opportunities to improve maternal and infant health care services [14,15].

The main purpose of the present study is to review and analyze features and functionalities of the pool of apps for postnatal care that are currently available in the two most widely used smartphones applications stores: Apple app store and Google Android play store. In the realm of reproductive healthcare, previous studies have scrutinized the functionalities of the available mobile Personal Health Records (mPHRs) for pregnancy monitoring for iOS and Android platforms [16] and those of mobile applications for postpartum depression [17]. To the best of our knowledge, this is the first study that has been conducted to thoroughly analyze the features and functionalities of mobile applications targeting postnatal care.

The remainder of the present paper is structured as follows: Section 2 outlines the research questions and describes the methodology used to search for, select and analyze the functionalities of postnatal care apps. Section 3 answers the research questions and discusses the findings. Section 4 explores the limitations and the threats to validity of the present study. Section 5 draws some concluding remarks and gives a summary of future work.

2. Method

The search for postnatal care apps was addressed through the use of systematic literature review (SLR) methodology [18] that ensures the accuracy and completeness of the search and retrieval process. Prior to performing the search for candidate postnatal care apps, a protocol which outlines the different steps constituting the SLR process developed, was designed in accordance with a set of guidelines delineated by the Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) [19] statement. The PRISMA guidance is said to improve the quality reporting in systematic reviews and provide substantial transparency in the selection process. The review of postnatal care apps was completed through the following steps: (1) framing the research questions, (2) defining search strategy, (3) identifying eligibility criteria for the selection process, (4) determining elements for analysis and (5) formulating assessment questions. Each of these steps was accomplished by two authors (L.S and A.I) independently. Any disagreements and discrepancies were discussed until consensus was reached.

2.1. Framing the research questions (RQs)

To rigorously yield the purpose of the review, a set of five research questions was identified by the authors (Table 1). These research questions were informed by the scientific literature related to the postnatal care for mother or/and newborns [6,20–22] and a preliminary analysis of available postnatal care apps.

2.2. Defining search strategy

The leading app stores namely, Google Play store and Apple app store [23] were considered to perform the search for candidate postnatal care apps. The PICO criteria (Population, intervention, Comparison and Outcome) [24] were used to define a search string that ensures the maximum coverage. The Population considered was that of new mothers and their newborns. The Intervention consisted of free and paid apps which are intended to be used during the postnatal period. Given that the primary focus of the present study was not comparative and did not seek to find evidence about the existing postnatal care apps, the Comparison criterion was disregarded. With respect to the last criterion, all the aspects and outcomes of postnatal care apps were of interest in the present study, of which managing the postnatal period and promoting maternal and infant care were the mostly considered.

The following terms: 'Postnatal' OR 'Postpartum' OR 'After childbirth' OR 'newborn' OR '(Postnatal OR Postpartum OR newborn) AND care' were therefore identified and were primarily applied to the title and description of the apps using the search tools in both app stores. The search process took place in January 2019.

2.3. Identifying eligibility criteria for the selection process

To identify the candidate postnatal care apps and discard the disqualifying ones, a set of eligibility criteria was defined. Apps fulfilling all the inclusion criteria (IC) were included in the present study. These criteria are the following: **IC1.** Free or paid apps obtained using the pre-defined search terms and available in the reviewed app stores. The paid version of a given app was only considered if it presents additional features of functionalities when compared to the free version. **IC2.** Apps pertaining to categories related to health namely, Health & Fitness or Medical. Given that the newborn care is inherently encompassed in the postnatal care, parenting category was also considered for apps in the Google play store. **IC3.** Apps that are mainly focused on any aspect related to PNC for the mother and/or the newborn. Further exclusion criteria (EC) were applied to the apps identified throughout the selection process to eliminate: **EC1.** Duplicates. This exclusion criterion aims to discard duplicates either within the same app store and apps available for both platforms under the same name and have identical content. **EC2.** Apps that are not designed with an English interface, **EC3.** Apps that were lastly updated before the 1st January 2018. This criterion is intended to keep solely the apps that release regular updates that include relevant bug fixes and features. **EC4.** Apps that cannot be installed or accessed to. This criterion excludes all apps presenting any kind of bug or error during or after installation that prevent authors from conducting an appropriate analysis of content.

2.4. Determining elements for analysis

Scientific literature and postnatal care apps available in the app store were reviewed to identify the main components for the evaluation of features and functionalities of the postnatal care apps selected. Two components were determined: (1) app characteristics comprising the common features of any app; and (2) data items including the fundamental functionalities and features to be included in a postnatal care app at a functional and a technical level.

2.4.1.   App characteristics—The app characteristics that should be retrieved from the app store for each app selected include: the full name, the operating system (Android or iOS), cost (free, paid, in-app purchases), the app link in the app store or app website (if available), date of the latest update, user ratings, number of raters and country of origin of app developer.

2.4.2.   Data items—A thematic template was designed containing the data that should be extracted in regard to the functional content of the postnatal care apps selected. This template was piloted using a small sample of published papers, standards and guidelines related to PNC as shown in Table 2; agreement was reached about six blocks for a comprehensive postnatal care app among the first three authors.

<u>**Postnatal care for mothers and newborn infants.:**</u> Services providing postnatal care are supposed to incorporate all the essential elements required for the health of the mother and of her newborn infant in an integrated fashion. This category of data includes information related to the postpartum care and the newborn care. The terms 'postpartum' and 'postnatal' are often used interchangeably [17,25] but sometimes the former refers to the issues pertaining to the mother while the latter refers to those pertaining to the baby. To aid clarity and avoid confusion, the term 'postnatal' was adopted to refer to the care after childbirth for both mothers and babies [20]. The core pillar of a healthy postnatal period is to tackle all aspects of mental and physical health and wellbeing of the mother and the newborn infant.

A typical postpartum care plan provided to new mothers includes tips and advice with regard to the recovery from childbirth as well as to inform of the danger signs and life-threatening conditions in the postnatal period such as hemorrhage, infections and pre-eclampsia [6]. The provision of useful information related to the physiological and metabolic changes that take place during the postnatal period is also of a great importance. New mothers should be aware of the way the body reverts to the non-pregnant state to ensure optimum health-management [26]. To cope with pain associated with these changes, mothers tend to use prescribed medications, adapt some comfort measures or do physical exercises. Physical activity during the postnatal period is proven to not only improve the health and wellbeing of the new mothers but also helps in strengthening the woman's body reducing the risk of developing lifestyle-related diseases such as obesity and cardiovascular diseases [27]. Besides physiological adjustments, the postnatal period brings about other social and emotional changes that render new mothers vulnerable to a range of mental and behavioral disorders such as baby blues, postpartum depression and puerperal psychosis [25]. Amid the postnatal period, many women experience feelings of sadness, anxiety and depressed mood,

especially, in the few days following the childbirth. While many mothers suffer from brief to a mild bout of maternal blues, others suffer from long-lasting and severe depression. If not treated, these mental disorders may carry significant lifetime consequences for mother themselves and for their newborns [17]. Appropriate screening and treatment are subsequently paramount [28]. A myriad of coping strategies should be introduced to new mothers during the postnatal period to lessen the severity of depression. Yet, these strategies should not interfere with their cultural and religious preferences [29].

With regards to newborn infant care, the provision of a complete parenting guide to new mothers is necessary to avoid neonatal morbidities during the postnatal period. This has to include recommendations and advices on how to care for the baby in the first few days and throughout the postnatal period. It is important to provide new mother with practical tips on umbilical cord care, hygiene, and routine practices such as changing diapers, baby holding, feeding, burping and swaddling [20]. Moreover, new mothers should be taught essential instructions to detect and handle suspected and manifest neonatal complications [30].

Postnatal Counselling.: Throughout the postnatal period, new mothers should be counselled on various topics including nutrition, hygiene, family planning and infant feeding [31]. To provide positive and successful counselling which engender a considerable support for the new mothers, it is always important to put into practice the following skills: listening; learning; building confidence and giving support [32]. It is recommended to perform counselling session before and after childbirth during the postnatal visits. Cards are often used by counsellors and health specialists to cover all the essential postnatal topics [31,32]. Since PNC is usually considered as the weakest health program among all reproductive and infant health programs [8,20], postnatal counselling sessions are unlikely to take place. By taking advantage of mobile technologies, new mothers can be counselled on the postnatal health issues to maintain their health and that of their newborns. After delivery, new mothers should increase their food intake to cover the energy cost of breastfeeding and for her to recover her normal energy and health. Counselling on maternal nutrition includes advices and recommendations on adopting a balanced and varied healthy food and drink plenty of clean water [33]. Moreover, new mothers should be provided with recommendations about infant feeding and should be encouraged to exclusively breastfeed their newborns up to six months after birth [34]. Besides nutrition and breastfeeding, attention should be drawn to maternal hygiene. New mothers should be counselled on how to take care of their personal hygiene (e.g. Perineal and breast hygiene) to prevent infections [35]. Sexuality is perhaps one of the important elements to be addressed during the postnatal period. Therefore, counselling should cover the resumption of sexual intercourse along with the postpartum family planning. New mothers should be taught about the appropriate contraceptive methods to use to avoid unwanted pregnancies. Research suggests waiting at least 24 months before attempting the next pregnancy to reduce the risk of maternal and infant complications [33].

Reminders and push notifications.: Most of new mothers become busy and frustrated during the postnatal period owing to the multiple needs underlying motherhood. Consequently, they become less attentive to their postnatal check-ups, their newborns' pediatric visits and vaccinations appointments. In this respect, reminders based on a pre-

scheduled events can considerably improve medical appointment attendance [36]. Given that a number of drugs and medicines can be prescribed for both the mother and the newborn during the postnatal period, push notification reminders can play a great role in improving medical adherence and uptake [37].

Notes and records.: Similarly to pregnant women [16], new mothers can record major milestones of their postpartum period and their newborns' development. As regards to newborns, it is important and practical to record routine activities (e.g. diapers changes, bottle feeding and sleeping patterns), the medical care received (vaccination shots, medications) and to keep track of the developmental milestones by entering measurements such as height and weight of the newborn. This can objectively indicate accelerated or delayed newborn growth. New mothers can make use of diary and recording features to take control of some of vital settings in their wellbeing, such as weight and sleep. Recording weight regularly can help the mother remain alerted and effectively manage their postnatal weight so as to avoid obesity [48]. Likewise, keeping a sleep diary on hand is important in evaluating sleeping patterns in order to detect and diagnosis some discomforts such as fatigue, insomnia and anxiety [49].

Social support.: To buffer the fluctuations associated with the postnatal period, new mothers need a large social and emotional support. In addition to providing social support, social media offer another venue for social learning and behaviour acquisition through observation, interaction and encouragement [38]. Sharing experiences with others can be of great help in addressing certain issues about motherhood and raising kids. Social support proved to reduce levels of postanal stress and panic [39] as well as improving the overall health and quality of life [38].

App technical features.: Convenient, secure and easy-to-use mHealth apps have the potential to increase adherence and engagement with the health system as a whole [40]. Security and privacy are considered as the most challenging risks encountered when developing mHealth solutions [41]. Health-related apps, in particular, are dedicated for tracking, recording and managing personal health information (PHI) of users. PHI is extremely sensitive and needs to be highly protected through robust security and confidentiality mechanisms such as encryption and authentication methods. In fact, unauthorized access to health information is a serious threat to privacy and security. Moreover, for users of mHealth apps, the existence of a privacy policy is an important baseline standard to know why, where, and how personal details and PHI will be collected, used, shared and protected [42]. Another app feature worth mentioning is internationalization (i18n). The i18n is the process of designing a software product that is able to adapt to different languages, regions and cultures. Health-related programs and practical guides are often elaborated to respond to all people's needs regardless their cultural environment. Thus, i18n is a relevant aspect that renders mHealth solutions valuable for a wider number of users [43]. The usability, for its part, is identified as one of the decisive factors in building efficient and intuitive apps [44]. It relates to the ease with which users can complete their tasks in a specified context of use [45]. Task structure and interaction style should be optimal to minimize usability flaws [47]. Besides, usability aspects have a great

impact on improving users' interaction with the apps, and ultimately, enhancing the overall user experience [46].

2.5. Formulating assessment questions

To extract relevant data for an optimal analysis of the functional content of the postnatal care apps selected, a set of Yes/No questions was developed (Table A.1 in Appendix A). The developed questionnaire was drawn on the predefined data items and was validated by a gynecologist and pediatrist who are both highly acquainted with mobile technologies. The data obtained using the questionnaire were employed in answering the research questions. Each app was assessed separately for all the questions. The scoring was performed as follows: Yes (Y) = 1 point, the app offers the feature described in the question. No (N) = 0 points, the app does not offer the feature described in the question.

3.   Results and discussion

This section presents and discusses the principal findings of the assessment conducted in the present study. Characteristics, functionalities and technical features of postnatal care apps were retrieved and evaluated using a questionnaire of 37 items. The findings are sorted and grouped by research question.

3.1.   Selection process

The selection process of postnatal care apps and the resulting number of apps after applying the inclusion and exclusion criteria is shown in Fig. A.1 (Appendix A). The app repository search identified 1596 free and paid apps, of which 45% (n = 719) were excluded for not pertaining to the categories defined in the present study. After reviewing the in-store description and screenshots of the 877 remaining apps, only 73 apps were retained for further eligibility assessment. Ten apps were excluded after installation and full review of their contents. Apps designed for Android were downloaded in an OPPO A37fw while iOS dedicated apps were downloaded in an iPhone 6 Plus. Among the 63 apps reviewed, 15 apps were available in both repositories and duplicates were therefore excluded. These apps were counted as one since they provided similar functionalities. However, some differences with regard to the visual design and layout of cross-platform apps were observed. For instance, the menu of *BabyTime* app was displayed in the top and the bottom of the screen in the iOS version while it was fixed as a three-bar menu icon in the top left of the screen in the Android version. The multi-platform publishing is currently considered a norm in mHealth app market [50], which justifies the number of cross-platform apps selected in the present study.

A total of 48 apps were selected for analysis of functional content, of which 25 apps were found in the Google Play Store, 8 apps originated from the Apple App Store and 15 apps were available for both platforms. The disparity across the Android and iOS platforms in terms of the number of postnatal care apps is mainly due to the advantages of the Android platform in terms of the global reach of the market and the simple guidelines and system reviews of the Google play store.

3.2. General app characteristics

The overall characteristics of the apps selected are presented in Table A.2 (Appendix A). Among these, 25 apps were focused on the Health & Fitness category, 9 apps were considered medical and parenting apps accounted for 7. The 7 remaining apps were found in different categories across Android and iOS platforms: (1) *Baby tracker - feeding, sleep and diaper app* was found in parenting category in Android platform and in Health & Fitness in iOS platform; (2) Six apps (e.g. *Baby+*, *Glow Baby Newborn Tracker App*) were found in the parenting category for the Android platform and were considered medical in iOS platform. Among the apps selected, 26 apps were free, 7 apps were paid, and 15 apps offered additional features for purchase. With regard to the country of origin, 22 apps originated from the United States while the remaining apps were developed in various countries including Netherlands, United Kingdom, India, Canada, Egypt, Germany. This confirms the growing interest in developing mobile solutions for the management of the postnatal period across the globe.

3.3. Analysis of functional content

The results obtained from the assessment questionnaire are presented in Appendix B which describe the answers for each app and question. The total score percentage for each app evaluated which illustrates the assessment of its functional content in addition to the total percentage of each question referring to the number of apps fulfilling this question can also be depicted in Appendix B. For better analysis and interpretation, Figs. 1, 2 illustrate these results. Fig. 1 presents the scores obtained by the 48 postnatal care apps for each of the six blocks of assessment questions while Fig. 2 displays the number of apps fulfilling each of the 37 assessment questions.

Based on these results, the maximum score (22 points) was obtained by three apps; *Baby+*, *you + baby* and *baby & me*, while *Postnatal pilates by reform app* obtained the lowest score (3 points). With regards to the assessment questions, the highest score (83%) was reached by the informal writing style question (A34), followed by the intuitive navigation patterns question (A37) which attained a score of 79%. Moreover, the presence of a privacy policy question (A30) achieved a score of 63% and the specification of the newborn's birthday (PN1) was included in 58% of the postnatal care apps. The question related to the ability to create a sleep diary (N25) attained the lowest score (0%).

Prior to answering the research questions, it is worth mentioning that given the complexity of the postnatal period and the various elements it gathers, the postnatal care apps selected in the present study are likely to yield relatively low scores with regard to the features they implement.

1. Which are the common types of the postnatal care apps selected?—
Facilitated by the technological advances, the range of mobile health solutions being designed is constantly expanding. This fundamental shift in mHealth landscape resulted in informed decision-making, improved self-management and increased practice's efficiency and effectiveness. Moreover, mHealth apps have proven to enhance access to basic levels of healthcare and save time for both patients and healthcare providers [13]. There is

a particularly broad array of mHealth applications that serve different purposes such as providing a clinical diagnosis, remote monitoring, self-management, in addition to promoting healthy living and raising healthcare education and awareness. Correspondingly, the postnatal care apps selected fall into three main categories (Fig. 3). Forty percent of apps exclusively included features to track, monitor and record different information of infant development such as routine activities (e.g. diapering, feeding and sleeping), medical history and anthropometric measurements, in addition to the postnatal weight of the mother as in *Baby+* app. Along with *WebMD Baby* app, *Baby+* provide valuable information related to the development milestones of the infant as a reference for growth tracking. Another prevalent category is the provision of information and tips related to the postnatal period. Accounting for 35% of the apps selected, information is generally displayed into categories related to a single postnatal aspect as postpartum haemorrhage (e.g. *Bleeding after birth* app), or multiple aspects encompassing the health-management of the mother and the infant, postnatal counselling (e.g. *Essentia baby* app) and providing parenting tips (e.g. *Pregnancy, parenting advice & baby care tips* app). Of the 17 informative apps, eight offered features of tracking and recording the newborn measurements, doctoral appointments and feeding as in *Telfair baby* and *MH Motherhood* apps. Lastly, a total of 12 apps were designed to encourage weight loss during the postnatal period through physical exercises, nutritional and diet recipes and recommendations (e.g. *Burn fat after pregnancy - weight loss* app). With the aim to hasten postpartum recovery and assist with muscle strength and toning, these apps offer a selection of postnatal workouts through videos as in *After birth exercise* app or step-by-step visual and audio instructions as in *FitMama Lite 5 Minute Workouts* app.

1. Which are the predominant functional characteristics of postnatal care apps?—To answer this research question, the results obtained through the assessment of the functional content of the apps selected were used. As shown in Appendix B, 58% of apps implemented the specification of the newborn's birthday feature (PN1) which stands upon specifying the birthdate of the newborn. This characteristic was found in all apps specially dedicated to the newborn care management. Besides allowing to constantly track the age of the infant, this characteristic helps in providing straightforward developmental milestones as a function of the infant age as in *Baby+* and *Sprout* apps. In these same apps, additional details were required such as the name and the gender of the infant. Another recurrently covered functionality is recording of infant anthropometric measurements (N23) including height, weight and head circumference. At birth, the evaluation of these parameters is performed to mark out fetal growth restriction among newborns [51]. Throughout the postnatal period, recording accurately these measurements is important in monitoring and tracking infant health and growth.

Thus, it may be observed that most of the postnatal care apps analyzed in the present study are limited to the management of the postnatal care of the newborn. Significant efforts are required to address the needs of mothers during the postnatal period. With regards to the technical features, two usability aspects were largely present in the postnatal care apps, namely informal writing style (A34) and intuitive navigation patterns (A37). Familiar writing style and intuitive layout accounted for 83% and 79% of the apps analyzed. Another prevalent feature (A30) which achieved a score of 63% was that of including a privacy

policy that clearly and comprehensively discloses how the app collects, uses and shares information.

1. To what extent do the postnatal care apps comply with the items analyzed?

—This research question approaches the main objective of the present study, which consists on measuring the compliance of the postnatal care apps with the functional characteristics analyzed. Using the assessment results (Appendix B), each block of data items was separately investigated.

Postnatal care for mothers and newborn infants.: The characteristics of postnatal care were addressed to a large extent (78%) in 9 apps that were predominantly informative. The provision of postnatal fitness recommendations and awareness on postpartum metabolic changes and complications were the features the most commonly disregarded among these apps as in *Telfair baby* and *Pregnancy, parenting advice & baby care tips* apps, respectively. The apps designed for postnatal fitness and weight loss (e.g. *postnatal workouts* app) yielded the lowest score in this category of characteristics (12%). Furthermore, only 6 out of 48 apps (e.g. *guide to newborn care* app) provide practical tips on the basic everyday care of the newborn such as bathing, feeding and soothing. Only 27% of apps addressed maternal mental health. Apps like *WebMD Baby* and *Post pregnancy recovery* help in acquiring knowledge about symptoms, signs and remedies of postpartum depression and associated anxieties. Besides, *Moment Health* was found to be the unique app to offer a clinically-approved screening tool for postnatal depression. By combining symptoms' checking and tracking of emotional changes, this app is said to likely allow a rapid mental recovery. Ultimately, 15 apps provide users with important information on immunizations recommended to newborn infants. *Breastfeeding Tracker Baby Log* app offers the possibility to display the immunizations' list according to the recommendations of 19 countries including United States, France and Brazil.

Postnatal Counselling.: This block of data refers to the features designed to cater support on nutrition, hygiene and family planning. Twenty-seven apps did not include counselling features, while only three apps were found to be extensively supportive, yielding a score of 83% on postnatal counselling characteristics. It was observed that support for family planning and birth spacing was the least addressed among the apps analyzed. Accordingly, *Ovia Parenting: Baby Tracker, Breastfeeding Timer* was the unique app to tackle this topic through placing emphasis on the postnatal contraception and listing the major safe and efficient birth control options to choose during the postnatal period, namely, Lactational Amenorrhea method, implant and Intrauterine Device. This lack of interest with respect to the postnatal contraception is perhaps owing to the existence of fully-fledged family planning apps. What is more, family planning is often closely associated to ethnic and cultural beliefs which hinder the usefulness of the counselling. Further, 38% of the apps analyzed recommend and encourage breastfeeding by highlighting its multiple short and long-term benefits in improving mother's health as well as health of the infant. Breastfeeding was therefore considered as the most recurrently approached topic in postnatal counselling.

Reminders and push notifications.: Principally considered as a promising strategy for enhancing users' engagement, push notifications prompts with contextually tailored messages have proven to be extensively effective in sustaining repeat use of health-related apps [52]. Reminders is one of the most encountered form of notifications. Only one app (*Baby care plus*) implements all the characteristics comprised in this block. Moreover, merely 10% of the apps analyzed allow to schedule reminders for routine and basic needs of the newborn such as feeding (e.g. *WebMD Baby*), sleeping and tummy time (e.g. *ParentLove: Baby Tracker Feedings Diapers Pumping*). In addition to reduce forgetfulness, reminders have a considerable impact on maintaining medical adherence [53]. Therein, five apps include reminders for scheduled medications (e.g. *Baby loggy-newborn log*) and vaccines (e.g. *Baby care plus*). Moreover, it was noted that 38% of apps analyzed give greater control on in-app notifications and reminders. Most of these apps allow to enable or disable notifications by means of a toggle button while barely a few apps offer the possibility to customize the frequency between notifications as in *Baby manager* and *You + Baby* apps. With the possibility to change notification settings, users are able to prioritize their tasks according to their preferences and to cut down on use-less notifications.

Notes and records.: Thirty apps provide the users with recording features. With the exception of the N25 characteristic that stands for the ability to create a sleep diary, *Baby+* was the only app to fully implement postnatal records. Tracking vital parameters of newborn growth was present in 22 apps while only five apps (e.g. *After birth exercise*) offer the possibility to record the postnatal weight of the mother. Among the 22 apps, users are able to add growth details for weight, height and head circumference and visualize these measures plotted on a graph as in *Glow Baby Newborn Tracker App*. Moreover, eight apps allow to track and check the developmental milestones of the newborn infants according to a range of age like 2 months, 4 months and so forth. Each development milestone is shown with reference photo or a video of kid with the reference age (e.g. *Growth chart*), or descriptive information (e.g. *Ovia Parenting: Baby Tracker, Breastfeeding Timer*). The feature of recording basic newborn needs such as feeding including breastfeeding and bottle feeding, diaper changes and sleep patterns was offered in 38% of the apps analyzed (e.g. *Baby tracker - feeding, sleep and diaper*). What is more, these apps allow users to log pumping and play time activities. The medical history of the newborn infant was another recurrently encountered feature. For instance, *UW Baby* app allow users to log vaccinations already given to the newborn and monitor those still needed. Also, it is possible to log temperature and to take note of administered medications by entering the name of the medication, the dosage and date of the first dose, as in *Baby nursing* app. In contrast, none of the apps selected include a sleep diary for the mother. Consequently, these findings highlight the limitation of recording features to the newborn care management in the postnatal care apps.

Social support.: In the light of the overwhelming changes mothers go through after giving birth, social support is perceived as a powerful mechanism in buffering the effects of postnatal anxieties [38]. Nonetheless, only 21 apps include at least one aspect of social support. Among these apps, fifteen apps are integrated with social networks such as Facebook and Twitter through social login as in *parentlove: baby feeding tracker, diapers, pumping* app. Other apps (e.g. *Baby+* and *Sprout Baby*) provide link to their proper

pages on social networks, namely Facebook, Twitter and Instagram. Social sharing is also possible in *FitMama Lite 5 Min* app where users can share fitness achievements on Facebook. Included in nine apps, the FAQ section is generally accessible through app settings (e.g. *MyMedela*). Moreover, eight apps allow users to interact with others through in-app community as in *Moment Health* app, or integrated social media community as in *Postnatal pilates* app, while real-time chat is provided by a single app called *Fit Mommy Project challenge*. Another feature that was perceived to likely enhance social support is friends or family members' referral. *Ovia Parenting: Baby Tracker, Breastfeeding Timer* and *Baby tracker - Newborn Feeding, Diaper, Sleep log* apps allow users to invite their family members to access app content in order to gain further social, emotional and organizational assistance and help.

App technical features.: In light of the massive attention drawn to mHealth industry, privacy and security issues still pose significant challenges for developers and researchers. Among the apps analyzed, only 14 apps offer an authentication mechanism. In addition to the standard authentication using email and password, *WebMD Baby* implements a pin login which allows users to access their data only by typing a 4-digit authentication pin. In contrast, privacy policy is included in a total of 30 apps. With the ongoing proliferation of mHealth apps, privacy policies become increasingly important [42]. This feature was particularly found in apps dealing with private and sensitive data of the mother and/or the newborn. Table C.1 (Appendix C) summarizes all important information about the privacy policies available for the postnatal care apps assessed. While most of the privacy policies discovered ($n = 13$) apply to multiple apps or all services offered by the developer, a total of 11 privacy policies is limited to the single app in question, such as *Baby care plus* and *Lactapp+*. Moreover, six privacy policies assessed were found to be inherently associated with the hospital's website to which certain apps are affiliated (e.g. *Baby & me* and *Telfair Baby*). It was observed that eight privacy policies assessed comply with international and federal laws including "European Union's General Data Protection Regulation (GDPR) 2018" (e.g. *Glow Baby Newborn Tracker App*) and The Health Insurance Portability and Accountability Act of 1996 (HIPAA) (e.g. *Your baby's birth and beyond*). Accordingly, the extant guidance and regulation as regards privacy policies are scarce and only apply to a narrow scope. Endeavors are therefore required to harmonize data protection legislation and broaden the scope of the current policies [42]. Table 3 presents an overview of the content categories addressed by the privacy policies discovered. It was observed that 93% of the privacy policies assessed inform users about the information collected while only 60% disclose the ways information collected is being gathered, used and shared. A total of 22 privacy policies describe the security measures that are likely to protect and ensure the safety of the information collected (See Table C.1). In addition, 53% of the privacy policies assessed include a section that covers cookies and precisely half of the privacy policies focused on privacy of the child which one (*Breastfeeding Tracker Baby Log* app) complied with the US Children's Online Privacy Protection Act (COPPA). Correspondently, these privacy policies assume that individuals under the age 13 are not allowed to gain access to the app in question without a prior consent of a parent or a guardian (e.g. *Glow Baby Newborn Tracker App*). Almost 27% of the privacy policies assessed offer information with regard to the control of personal information. Means for notifying users

on changes to privacy policies or privacy practices are mentioned in 70% of the privacy policies assessed. In view of the importance of privacy policies in mHealth solutions, there remains a significant lack of standardization, transparency and harmonization of their contents. Furthermore, the security of data was addressed in only 4 apps which allow users to back-up and restore the app's content into a local storage (e.g. *Baby care plus*) or into a cloud platform (e.g. *Baby tracker - feeding, sleep and diaper*). Even though cloud platforms offer enormous advantages such as cost-effectiveness, speed, elasticity of resources and dynamic scaling [54], they inherently raise a host of concerns about security threats. Cloud storage, in particular, faces major challenges when it comes to data protection and security of which data segregation and data leakage are of great impact [55]. Besides traditional attacks ranging from data breaches, data loss, account hijacking and Distributed denial-of-service attacks, the multi-tenancy nature of the cloud platforms create new attack surfaces for malicious actors. In view of these various security issues, IT leaders and security professionals are waging a constant battle to ensure proper data security.

Along with the privacy policy statement, four apps (e.g. *Ovia Parenting: Baby Tracker, Breastfeeding Timer*) include a disclaimer of liability which attests that the content of the app in question is provided for educational and informational purposes only and should not be used for diagnosing or treating a health problem or disease.

While security measures help gain users' trust and confidence, the internationalization practices are considered a key element that make users feel prioritized and substantially considered. In this direction, only 8 apps were found to support multiple languages such as French, German, Spanish (e.g. *MyMedela*) and Hindi (e.g. *Pregnancy, parenting advice & baby tips*). Another aspect of internationalization that is provided by 15 apps (e.g. *Baby Tracker - Newborn log*) consists of the possibility to change preferences with regard to the units of measurements related to the growth parameters of the newborn, feeding and temperature units.

With respect to usability, four main features were considered (assessment questions A34–37) to evaluate the writing style, layout and learnability of the apps selected. These features were mainly extracted from previous empirical studies that apply iOS and Android usability guidelines to digital health applications. On the whole, only 12 apps complied with all these usability features. Although, 83% of the apps contained simple and friendly writing style. Keeping the terminology and writing style consistent will help users follow and comprehend the app easily and effectively [45]. Moreover, users feel more engaged with the app when this latter employs a conversational tone. This was approached through the use of contractions (e.g. *Ovia Parenting: Baby Tracker, Breastfeeding Timer* app), the second person (e.g. *Glow baby newborn tracker app*) and the baby's real name as in *Sprout baby* app. Familiar writing is proven to echo a friendly tone [47] and mimic a natural conversation, which by then contribute in seamlessly engaging users. Ensuring that an app's content displays in the orientation (portrait or landscape) preferred by the user is fundamental to gain user's accessibility and satisfaction. Considering their mounted devices, users with dexterity impairments are likely to depreciate apps that restrict the screen to a particular display orientation. Besides, supporting both screen orientations will allow users with low-vision to view content in the orientation that works best for them as to make

the text easily readable. In this regard, only a total of 26 apps handled screen orientation (e.g. *Baby care plus, Essentia baby*). Another feature that affects usability consists of recalling users' preferences over time so that they do not input information each time they gain access to the app's content. A total of 20 apps do not include this feature either because they are purely informative, thus do not implement any kind of settings as in *Skin care after pregnancy* app or require users to re-enter their preferences, for example, as regards measurement units (e.g. *Baby Tracker -Newborn log* app). Lastly, discoverable and accessible navigation patterns were encountered in 37 apps. Users value the layout of an app that is efficient, intuitive, and allows for easy content navigation. Accordingly, hamburger menus (e.g. Lactapp+) and tab bars (e.g. *Breastfeeding tracker baby log*) were the mostly present navigation patterns in the apps analyzed.

Extra features.: In conjunction with the characteristics analyzed, auxiliary features were encountered in different apps. It was noted that most of the apps dealing with newborn care support multiple children and multiple caregivers. In fact, these apps (e.g. *BabyTime*) allow users to synchronize with family members or relatives in regard to the care given to the newborn infant. Another extra feature that was included in the apps selected consists of the ability to upload photos illustrating the development and the special moments of the newborn infant (e.g. *Baby+*). Further, the possibility to export app data (e.g. records) into a CSV, PDF or HTML formats was granted in 10 apps (e.g. *Breastfeeding Tracker Baby Log*).

1. Are user ratings proportionally linked to the apps' characteristics?—The answer to this question will help determine whether there is a relationship between the users' ratings for the apps selected and their corresponding assessment scores. One of the most interesting aspects of the mobile marketplaces (e.g. Google Play Store and Apple App store) is the emphasis on user feedback. In fact, these platforms allow the users to review-comment and rate the published apps between one to five stars according to the level of satisfaction about the app and its features [56]. This process helps developers in obtaining an insight into the users' opinions about their app(s). A recent paper [57] found that star-ratings are a crucial factor in the overall ranking of an app and can drastically affect user downloads. Table C.2 (Appendix C) presents the ratings achieved by each of the apps selected along with the total number of raters as displayed in the app store at the time of the data extraction.

As portrayed in Table C.2, all apps that provided star-ratings were considered, including those available for both platforms. An independent-samples *t*-test was used to check the existing variances in the user ratings and the total number of raters for the postnatal care apps between the Android and iOS platforms. The *t*-test did not yield a statistically significant difference between the two platforms neither for the users' ratings t $(45) = -1.581$, $p = .06 > .05$, nor for the number of raters $t(45) = -1.207$, $p = .055 > .05$. Thus, it is likely assumed that the ratings of the apps being studied are similarly distributed to a normal distribution.

In an attempt to examine the compliance between the app functional content and user satisfaction, we conducted a Pearson product-moment correlation coefficient. As shown in Table C.3 (Appendix C), the coefficient (r=−=.072) denotes that the linear association

between the two variables studied is very weak. Nevertheless, there is insufficient evidence to assume that this correlation exists given the statistically non-significant p-value (p = .629). The scatter plot in Fig. 4 (Appendix C) illustrates the distribution of the postnatal care apps analyzed around the line of best fit. It can be observed that two apps (*NKCH moments* and *MH Motherhood*) yielded a great assessment score but obtained a low user-rating (1 star). Furthermore, some apps (e.g. *Skin care after pregnancy* and *Maternal and newborn care plans* apps) with five star-ratings only attained a score of 9%. This inconsistency between user feedback and the characteristics of the apps is perhaps due to the relatively low number of raters in such apps given their contingent unpopularity. Device-specific problems determine another plausible factor that creates the discrepancy between the quality and users' reviews of apps, especially for Android platform. It was noted that device-specific problems could impact the ratings assigned to an app, given the varying capabilities of devices (e.g., hardware and software) [58]. Users are likely to complain about the incompatibility of a given app with their device or OS version which negatively influence their feedback as regards the overall quality of the app despite its actual functional richness and responsiveness.

4. Threats to validity

Although the present study was conducted with the aim to yield the most possible accurate and objective findings, there may have been some threats to the validity of the process. Given the limited filtering features in both app stores and the redundancy of the apps resulting from each search round, there were likely some relevant postnatal care apps that were unknowingly discarded. Moreover, the search string used to gather the postnatal care apps may have overlooked pertinent terms leading to an uncomplete set of apps. To alleviate this threat to construct validity, the PICO criteria were used to enrich the search string to the utmost extent. During the elicitation phase of the assessment questions, some important characteristics may have been omitted, therefore threating the internal and conclusion validity. However, this bias was substantially reduced through performing a thorough review in scientific literature and app repositories to select the most significant characteristics in relation to the postnatal period. Moreover, both the development of the assessment questionnaire and the evaluation of the apps selected were performed independently by the first two authors and reviewed by the remaining authors. Another threat to conclusion validity concerned the accuracy of the results obtained. To mitigate this issue, the findings were presented textually and graphically. Lastly, the external validity may have been biased by the unavailability of users' ratings for certain apps. This was solved by only considering the apps that provided users' ratings.

5. Conclusion and future work

The postnatal period is portrayed as a critical phase in both the lives of the mother and the newborn infant. Yet, the care provided during this period is the most neglected area in the health care delivery system. Mobile technology can play a prominent role to improve the quality and the accessibility of the postnatal care. In this respect, the present study aimed to evaluate the relevance of the functionalities and features offered by the postnatal care apps available in Android and iOS app repositories. A total of 48 apps was analyzed based

on a set of 37 assessment questions covering postnatal-related characteristics together with security, usability and internationalization aspects.

The findings to each of the research questions of the present study are as follows:

- **RQ1.** *Which are the common types of the postnatal care apps analyzed?*

  Three main categories were identified with regards the purpose and focus area of the postnatal care apps selected. Roughly 40% of these apps were mostly focused on monitoring and tracking the newborn infant development and activities. Information and tips with respect to newborn care and postpartum care were provided by 35% of the apps while the remaining apps were oriented towards postnatal fitness and weight loss.

- **RQ2.** *Which are the predominant characteristics of postnatal care apps?*

  Functionalities related to the newborn care management were the most frequently included in postnatal care apps, namely, the ability to input the newborn's birthday (PN1) and to record anthropometric newborn measurements (N23). In contrast, allowing the mother to create a sleep diary (N25) was the most neglected characteristic. With respect to the technical features, informal writing style (A34) and intuitive navigation pattern (A37) were the most commonly encountered. In addition to these usability aspects, privacy policy was present in 63% of the apps, hence was considered as the predominant privacy measure of postnatal care apps.

- **RQ3.** *To what extent do the postnatal care apps comply with the items analyzed?*

  It was noted that the scores obtained by the apps analyzed were relatively low. The highest score (59%) was yielded by three apps; *Baby+*, *Baby & me* and *You + Baby*, while three other apps (*Bleeding after birth, Caring for a newborn baby* and *The postpartum cure*) obtained the lowest score (11%). Overall, the postnatal care apps analyzed included essentially postnatal care functionalities (PN-items) and technical app features (A-items).

- **RQ4.** *Are user ratings proportionally linked to the apps' characteristics?*

  There was no enough evidence to assume an existent correlation between the assessment scores of the postnatal care apps and their corresponding users' ratings. Inconsistencies between the two variables were observed for different apps which attained a large score and got low users' ratings or vice-versa.

The findings of the present study denote the need to develop mobile solutions that are likely to cater, in addition to the newborn's care, the mother's needs during the postnatal period, particularly in terms of weight tracking, mental health assistance and family planning. Moreover, developers are required to minimize the usability flaws and security issues. In this regard, the present study can provide a baseline for developing qualified and effective apps that are suited to the needs of new mothers to effectively take care of themselves and their newborns.

As future work, it is intended to comprehensively measure the compliance of the postnatal care apps with usability guidelines and quality characteristics using eminent quality assessment tools (e.g. Mobile App Rating Scale MARS) and international standards (e.g. ISO/IEC 25010). Several studies have performed analysis of various quality characteristics in health-related mobile applications using the ISO/IEC 25010 product quality model and its predecessor ISO/IEC 9126-1 quality model [59–61]. Being particularly important in facilitating user experience and promoting efficiency, effectiveness and user satisfaction, usability is still widely recognized as a key quality factor in the development of successful interactive software applications. In this regard, assessing the fulfillment of usability attributes in postnatal care apps as described in the official design principles guide for both mobile platforms; Android [62] and iOS [63] can be particularly helpful for researchers and developers to improve the design and ergonomics of postnatal care apps which thereby enhances their overall quality. Moreover, there are international standards (ISO 9241 and ISO 25062) that provide guidelines for conducting and reporting on usability testing of mobile apps in terms of the feedback from users. A previous study by Moumane et al. [46] has presented an empirical usability evaluation of two widely used applications: Google Apps and Google Maps using these standards. Similar work could be performed in the digital health to build highly responsive mobile health applications.

Another foreseen investigation consists of developing a reusable requirements' catalog for designing well-suited and complete postnatal care apps. Defining catalogs is extremely useful for the elicitation, specification and validation of useful requirements for a given software's development. Previous studies have established catalogs of reusable requirements for mobile health applications. For instance, Belen et al. [47] have specified an exhaustive set of usability requirements extracted from official recommendations, software engineering and e-health standards and literature. Moreover, repositories of sustainability and internationalization reusable requirements for connected health applications have been suggested in two different studies by Sofia et al. [43,64].

Acknowledgment

Appendix A.
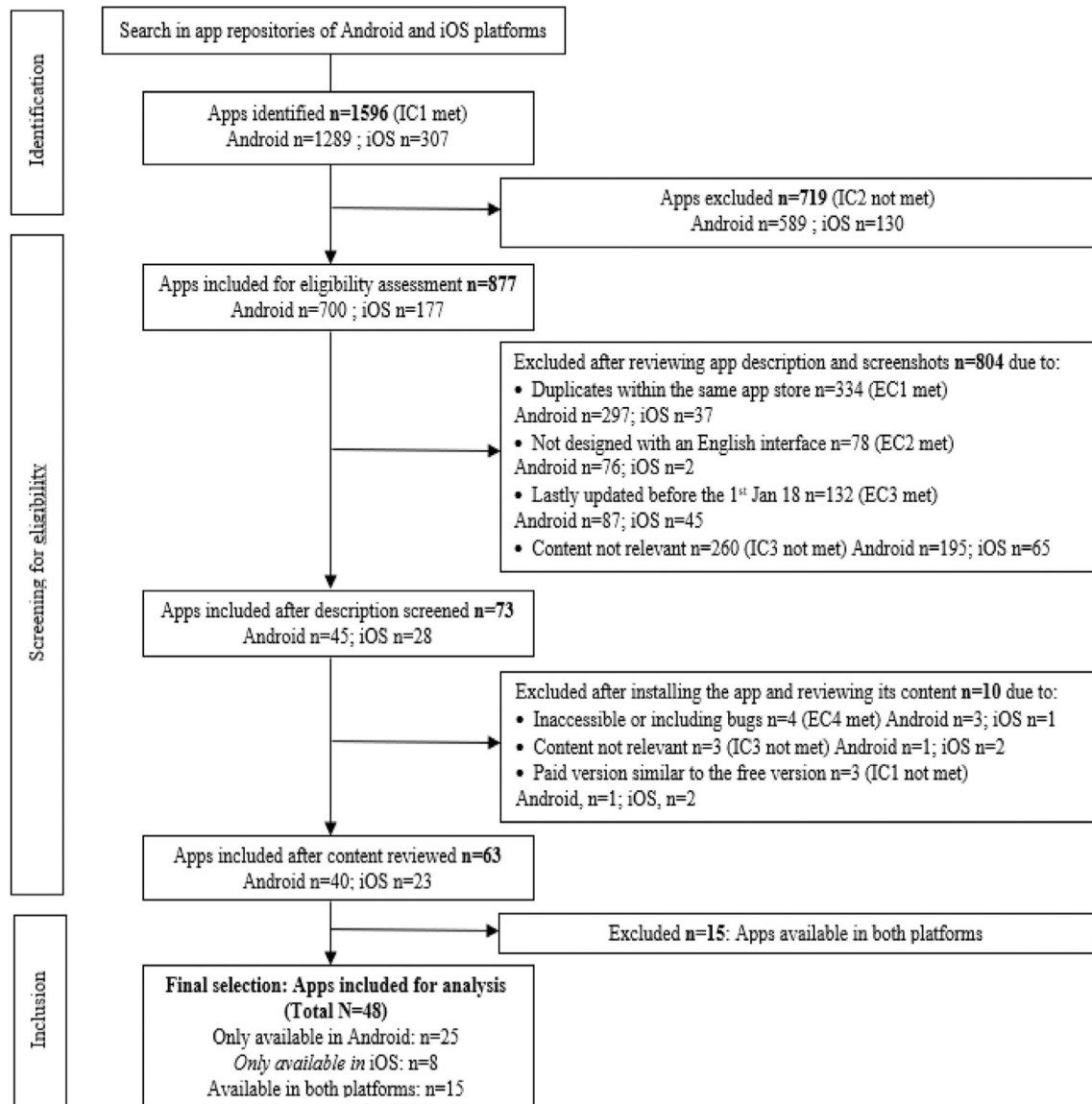
Fig. A.1.
Results of the selection process of postnatal care apps.

Table A.1

Assessment questionnaire.

Data items	Questions	
Postnatal care for mothers and newborn infants (PN)	1	Does the application require specifying the newborn's birthdate?
	2	Does the application provide tips for the postpartum recovery process?
	3	Are postpartum life-threatening conditions identified in the application?
	4	Does the application inform about physiological and metabolic changes occurring during the postnatal period?

Data items	Questions	
	5	Does the application include physical exercises and workouts for women in the postnatal period?
	6	Does the application offer information about postpartum mental disorders such as Postpartum depression and baby blues (e.g. symptoms, coping strategies)?
	7	Does the application provide practical tips on how to take care of the newborn (e.g. hygiene, diapers' changing, burping)?
	8	Does the application include information about manifest neonatal complications and warning signs?
	9	Does the application inform about the immunizations that newborns need?
Postnatal counselling (PC)	10	Does the application provide postnatal nutritional counselling for mothers?
	11	Does the application include infant feeding counselling?
	12	Does the application recommend breastfeeding?
	13	Does the application provide a breastfeeding guide and support?
	14	Does the application include personal hygiene practices for women in the postnatal period?
	15	Does the application encompass methods for postpartum family planning and birth spacing?
Reminders and push notifications (R)	16	Does the application allow to set reminders for medical appointments (e.g. postnatal check-ups, pediatric visits, vaccination)?
	17	Does the application include push notification reminders for scheduled medications/ Vaccines?
	18	Does the application allow to schedule reminders for routine activities (e.g. diapering, feeding, pumping, sleep)?
	19	Does the application allow users to change reminders and notifications settings?
Notes and records (N)	20	Does the application allow to record routine activities of the newborn (e.g. diapers changes, bottle feeding, sleeping patterns)?
	21	Does the application allow to take note of the medical care the newborn has received (e.g. medications and vaccination shots)?
	22	Does the application allow to track the newborn's developmental milestones?
	23	Does the application record anthropometric measurements of the newborn (e.g. height, weight and head circumference)?
	24	Does the application record measurements of the mother's postnatal weight?
	25	Does the application allow the mother to create a sleep diary?
Social support (S)	26	Is the application integrated with social networks (e.g. Facebook, Twitter)?
	27	Is there an FAQ page in the application?
	28	Does the application provide users with social mechanisms to interact with each other and share experiences (e.g. Community, forum, chat)?
App technical features (A)	29	Does the application ask users for authentication?
	30	Does the application present a privacy policy?
	31	Is there a possibility to back-up/restore data within the application?
	32	Does the application have a multi-language support?
	33	Does the application allow users to update their unit preferences?
	34	Does the application use a tone that is simple, informal and friendly?
	35	Does the application adapt to screen orientation (portrait and landscape)?
	36	Does the application learn user's preferences over time?

Data items	Questions	
	37	Does the application implement intuitive and predictable navigation patterns?

Table A.2

Characteristics of the 48 apps evaluated for postnatal care of mothers and newborn infants.

Application name	OS	Category	Latest update	Free /Paid	App website/ URL	Country of origin	Extra features	
Ovia Parenting: Baby Tracker, Breastfeeding Timer	Android	Medical	07-Jan-19	Free	https://www.oviahealth.com/	USA	•	Take or upload pictures (newborn's special moments)
							•	Support multiple children
							•	Track developmental milestones
	iOS		24-Jan-19					
WellMama free post pregnancy yoga poses	Android	Health & Fitness	31-Mar-18	Free	http://www.behappymum.com/	UK		
	iOS		05-Apr-18					
FitMama Lite 5Min	Android	Health & Fitness	15-Jan-18	Free	http://www.behappymum.com/	UK		
	iOS							
Glow Baby Newborn Tracker App	Android	Parenting	23-Jan-19	In-app purchase	https://glowing.com/	USA	•	Take or upload pictures (newborn's special moments)
							•	Plot growth measures
							•	Support multiple children
							•	Export data into PDF report
	iOS	Medical	18-Dec-18					
Baby tracker - Newborn Feeding, Diaper, Sleep log	Android	Parenting	11-Mar-18	In-app purchase	http://nighp.com/babytracker/	Hong Kong	•	Take or upload pictures (newborn's special moments)
							•	Compare growth measures against World Health

Application name	OS	Category	Latest update Free /Paid		App website/ URL	Country of origin	Extra features
							• Organization averages
							• Plot growth measures
							• Adjust growth chart for premature baby
							• Support multiple children
							• Export data via email
	iOS	Medical	10-Dec-18				
Baby manager	Android	Parenting	13-Jun-18	Paid	http:// babymanagerapp.tumblr.com/	Canada	• Plot growth measures, feeding, diapering and pumping
							• Support multiple children
							• Export data into CSV file
	iOS	Medical	25-Apr-18				
Baby+	Android	Parenting	26-Sep-18	Free	https://www.health-and-parenting.com/	Netherlands	• Activities and Toys by Age information.
							• Take or upload pictures (newborn's special moments)
							• Support multiple children
							• Create a yearbook
							• Lullabies and white nose to help baby sleep
							• Compare growth measures against World Health Organization averages
							• Doctor visit planner
	iOS	Medical	20-Sep-18				

Application name	OS	Category	Latest update Free /Paid		App website/ URL	Country of origin	Extra features	
Fit Mommy Project Challenge	Android	Health & Fitness	06-Dec-18	Paid	https://www.kimmysmithfit.com/	USA		
	iOS		20-Mar-18					
Postnatal workouts	Android	Health & Fitness	21-May-18	In-app purchase	https://bit.ly/2Nx3xnK	USA	•	Workout challenges
	iOS		01-Jun-18		https://apple.co/2IIfR62			
BabyTime	Android	Parenting	28-Jan-19	In-app purchase	https://www.babytime.care/	Republic of Korea	•	Take or upload pictures (newborn's special moments)
							•	Health record information
							•	Music Box to help baby Sleep
							•	Plot growth measures, feeding, diapering and pumping
							•	Support multiple children and caregivers
							•	Export data
	iOS	Medical	15-Jan-19					
WebMD Baby	Android	Health & Fitness	24-Jan-19	Free	https://wb.md/2H9W50D	USA	•	Take or upload pictures (newborn's special moments)
							•	Support multiple children and caregivers
	iOS		12-Dec-18					
Breastfeeding Tracker Baby Log	iOS	Medical	26-Feb-18	In-app purchase	https://apple.co/2RA8XjF	USA	•	Take or upload pictures (newborn's special moments)
							•	Plot growth measures
							•	Track location to know where the baby has been fed.

Application name	OS	Category	Latest update Free /Paid		App website/ URL	Country of origin	Extra features	
							•	Support multiple children and caregivers
							•	Export data into CSV or HTML format
	Android	Parenting	30-Nov-18		https://bit.ly/2NToVUm			
Moment Health	Android	Health & Fitness	23-Jul-18	In-app purchase	https://momenthealth.io/	UK		
	iOS		06-Jul-18					
Baby tracker - feeding, sleep and diaper	Android	Parenting	24-Jan-19	In-app purchase	https://amila.io/	Canada	•	Plot growth measures
	iOS	Health & Fitness	20-Nov-18					
MH motherhood	Android	Medical	11-Oct-18	Free	https://bit.ly/2EmtQJm	USA	•	Pregnancy monitoring
							•	Information on labor and birth
	iOS		03-Oct-18					
Baby loggy -newborn log	iOS	Medical	03-Jan-19	In-app purchase	http://babyloggy.com/	USA	•	Support multiple children
							•	Send an email summary of all the baby's care to a caregiver or a doctor.
							•	Apple watch support
30-day fit mommy Challenge	iOS	Health & Fitness	22-Dec-18	In-app purchase	https://apple.co/2VuS62X	USA		
Oh baby! Mom and baby exercise	iOS	Health & Fitness	02-Mar-18	In-app purchase	https://apple.co/2tGmsn5	USA		
Caring for a newborn baby	iOS	Health & Fitness	17-Apr-18	Paid	https://apple.co/2UbUDyz	USA		
MyMedela	iOS	Health & Fitness	15-Nov-18	Free	https://apple.co/2SwUG6v	Switzerland	•	Upload baby's picture
							•	Breastfeeding Confidence Assessment
Postnatal pilates	iOS	Health & Fitness	18-Jan-18	Paid	https://apple.co/2EmTaPh	Australia		

Application name	OS	Category	Latest update Free /Paid		App website/ URL	Country of origin	Extra features	
Postnatal pilates by reform	iOS	Health & Fitness	01-Oct-18	Paid	https://apple.co/2EDEDzW	Ireland		
Sprout Baby	iOS	Health & Fitness	16-Jan-19	In-app purchase	https://apple.co/2UaF8XG	USA	•	Plot growth measures
							•	Compare growth measures against WHO averages
							•	Support multiple children
							•	Export data via email
Guide to newborn care	Android	Parenting	13-Nov-18	Free	https://bit.ly/2Nz3kk9	India		
After birth exercise	Android	Health & Fitness	08-Jan-18	In-app purchase	https://www.rueckbildung-app.de/	Germany		
Pregnancy, parenting advice & baby care tips app	Android	Parenting	19-Jan-19	Free	https://www.parentune.com/	India		
Bleeding after birth	Android	Health & Fitness	02-Oct-18	Free	https://bit.ly/2TpHt3O	Egypt		
Burn fat after pregnancy - weight loss	Android	Health & Fitness	24-Oct-18	Free	https://bit.ly/2T92JvB	N/A		
Losing weight after pregnancy	Android	Health & Fitness	24-Sep-18	Free	https://bit.ly/2IL4R7U	Pakistan		
Telfair baby	Android	Health & Fitness	7-Apr-18	Free	https://www.sjchs.org/default.aspx	USA	Pregnancy monitoring	
							•	Information on labor and birth
Post pregnancy recovery	Android	Health & Fitness	19-Jun-18	Free	https://bit.ly/2EDEOLI	Kenya		
Growth Chart, Development Milestones & Vaccination	Android	Parenting	07-Dec-18	Free	https://www.growthbookapp.com/	India	•	Plot growth measures
LactApp+	Android	Health & Fitness	28-Feb-18	Free	https://bit.ly/2XqT026	Philippines	•	Plot growth measures, feeding, diapering
							•	Back to work preparation
NKCH moments	Android	Medical	21-Oct-18	Free	https://www.customizedinc.com/	USA	Pregnancy monitoring	
							•	Information on labor and birth

Application name	OS	Category	Latest update Free /Paid		App website/ URL	Country of origin	Extra features	
Parentlove: baby feeding tracker, diapers, pumping	Android	Parenting	13-Jan-19	In-app purchase	https://parentlove.me/	USA		
Maternal & newborn care plans	Android	Medical	10-Oct-18	Free	https://bit.ly/2NxSWct	Singapore		
Essentia baby	Android	Medical	26-Jan-18	Free	https://www.essentiahealth.org/	USA	•	Pregnancy monitoring
							•	Information on labor and birth
Your baby's birth & beyond	Android	Health & Fitness	11-Oct-18	Free	https://www.pinnaclehealth.org/	USA	•	Pregnancy monitoring
							•	Information on labor and birth
Baby care plus	Android	Medical	29-Jan-18	Paid	https://bit.ly/2TmQBpP	China	•	Support multiple children
							•	plot growth measures
							•	Export data into CSV file
The postpartum cure	Android	Health & Fitness	12-Jul-18	Paid	http://thepostpartumcure.com/	USA		
UWBaby	Android	Medical	21-Oct-18	Free	https://bit.ly/2EGhWeR	USA	•	Pregnancy monitoring
							•	Information on labour and birth
Skin care after pregnancy	Android	Health & Fitness	18-Sep-18	Free	https://bit.ly/2IHI90g	India	•	Tips to take care of the skin after having a baby
Elebaby simple	Android	Parenting	07-Aug-18	In-app purchase	https://bit.ly/2tIPsL2	USA	•	Support Android wear watch
							•	Plot growth measures
							•	Support multiple children and caregivers
Baby Tracker - Newborn Log	Android	Parenting	24-Nov-18	In-app purchase	https://bit.ly/2H8ZkW9	Netherlands	•	plot growth measures
							•	Take or upload pictures (newborn's

Application name	OS	Category	Latest update	Free /Paid	App website/ URL	Country of origin	Extra features	
								special moments)
Mother and baby 2019	Android	Parenting	05-Oct-18	Free	https://bit.ly/2EnJJz5	Egypt		
C-section recovery	Android	Health & Fitness	13-Oct-18	Free	https://bit.ly/2EjDwEf	India	•	Information about pregnancy, labour and birth
You + Baby	Android	Medical	26-Jan-18	Free	http://www.gundersenhealth.org/	USA	•	Pregnancy monitoring
							•	Information on labor and birth
Baby& me	Android	Health & Fitness	26-Feb-18	Free	https://www.slhn.org/	USA	•	Pregnancy monitoring
							•	Information on labor and birth

Appendix B

Table B.1

Assessment results (Part 1).

Application name	PN1	PN2	PN3	PN4	PN5	PN6	PN7	PN8	PN9	PC10
Ovia Parenting: Baby Tracker, Breastfeeding Timer	Y	N	N	N	N	Y	N	N	Y	N
WellMama free post pregnancy yoga poses	N	N	N	N	Y	N	N	N	N	N
FitMama Lite 5Min	N	N	N	N	Y	N	N	N	N	N
Glow Baby Newborn Tracker App - Breastfeeding Timer Diaper Log	Y	N	N	N	N	N	Y	Y	Y	N
Baby tracker - Newborn Feeding, Diaper, Sleep log	Y	N	N	N	N	N	N	N	N	N
Baby manager	Y	N	N	N	N	N	N	N	N	N
Baby+	Y	N	N	N	Y	N	Y	N	N	Y
Fit Mommy Project Challenge	N	N	N	N	Y	N	N	N	N	N
Postnatal workouts	N	N	N	N	Y	N	N	N	N	N
BabyTime	Y	N	N	N	N	N	N	N	N	N
WebMD Baby	Y	N	N	N	Y	Y	Y	Y	Y	N
Breastfeeding Tracker Baby Log	Y	N	N	N	N	N	N	N	Y	N
Moment Health	Y	N	N	N	N	Y	N	N	N	N
Baby tracker - feeding, sleep and diaper	Y	N	N	N	N	N	N	N	N	N
MH motherhood	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Baby loggy -newborn log	Y	N	N	N	N	N	N	N	N	N

Application name	PN1	PN2	PN3	PN4	PN5	PN6	PN7	PN8	PN9	PC10
30-day fit mommy Challenge	N	N	N	N	Y	N	N	N	N	N
Oh baby! Mom and baby exercise	Y	N	N	N	Y	N	N	N	N	N
Caring for a newborn baby	N	N	N	N	N	N	Y	N	N	N
MyMedela	Y	N	N	N	N	N	N	N	N	N
Postnatal pilates	N	N	N	N	Y	N	N	N	N	N
Postnatal pilates by reform	N	N	N	N	Y	N	N	N	N	N
Sprout Baby	Y	N	N	N	N	N	N	N	N	N
Guide to newborn care	N	N	N	N	N	N	Y	Y	Y	N
After birth exercise	N	N	N	N	Y	N	N	N	N	N
Pregnancy, parenting advice & baby care tips app	Y	Y	N	N	Y	Y	Y	Y	Y	Y
Bleeding after birth	N	N	Y	N	N	N	N	N	N	N
Burn fat after pregnancy - weight loss	N	N	N	Y	Y	N	N	N	N	N
Losing weight after pregnancy	N	N	N	N	Y	N	N	N	N	Y
Telfair baby	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Post pregnancy recovery	N	Y	Y	Y	Y	Y	N	N	N	Y
Growth Chart, Development Milestones & Vaccination	Y	N	N	N	N	N	N	N	Y	N
LactApp+	N	N	N	N	N	N	N	N	N	N
NKCH moments	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Parentlove: baby feeding tracker, diapers, pumping	Y	N	N	N	N	N	N	N	N	N
Maternal & newborn care plans	N	N	Y	N	N	N	N	Y	N	N
Essentia baby	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Your baby's birth & beyond	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Baby care plus	Y	N	N	N	N	N	N	N	N	N
The postpartum cure	N	N	N	N	Y	N	N	N	N	Y
UWBaby	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Skin care after pregnancy	N	Y	N	N	N	N	N	N	N	Y
Elebaby simple	Y	N	N	N	N	N	N	N	N	N
Baby Tracker - Newborn Log	Y	N	N	N	N	N	N	N	N	N
Mother and baby 2NY9	N	N	N	N	N	N	N	Y	N	N
C-section recovery	N	Y	N	N	Y	N	N	N	N	Y
You + Baby	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Baby& me	Y	Y	Y	Y	N	Y	N	Y	Y	Y
Total (N)	**28**	**12**	**11**	**10**	**18**	**13**	**6**	**14**	**15**	**15**
Total (%)	**58%**	**25%**	**23%**	**21%**	**38%**	**27%**	**13%**	**29%**	**31%**	**31%**

Table B.2

Assessment results (part 2).

Application name	PC11	PC12	PC13	PC14	PC15	R16	R17	R18	R19	N20
Ovia Parenting: Baby Tracker, Breastfeeding Timer	Y	Y	Y	Y	Y	N	N	N	Y	Y
WellMama free post pregnancy yoga poses	N	N	N	N	N	N	N	N	N	N
FitMama Lite 5Min	N	N	N	N	N	N	N	N	N	N
Glow Baby Newborn Tracker App - Breastfeeding Timer Diaper Log	N	N	N	N	N	N	N	N	N	Y
Baby tracker - Newborn Feeding, Diaper, Sleep log	N	N	N	N	N	N	N	N	N	Y
Baby manager	N	N	N	N	N	N	Y	Y	Y	Y
Baby+	N	Y	Y	N	N	Y	Y	N	N	Y
Fit Mommy Project Challenge	N	N	N	N	N	N	N	N	N	N
Postnatal workouts	N	N	N	N	N	N	N	N	N	N
BabyTime	N	N	N	N	N	N	N	N	N	Y
WebMD Baby	Y	Y	Y	N	N	N	N	Y	Y	Y
Breastfeeding Tracker Baby Log	N	N	N	N	N	Y	Y	N	Y	N
Moment Health	N	N	N	N	N	N	N	N	N	N
Baby tracker - feeding, sleep and diaper	N	N	N	N	N	N	N	Y	N	Y
MH motherhood	N	Y	Y	Y	N	Y	N	N	Y	N
Baby loggy -newborn log	N	N	N	N	N	N	Y	N	Y	Y
30-day fit mommy Challenge	N	N	N	N	N	N	N	N	N	N
Oh baby! Mom and baby exercise	N	N	N	N	N	N	N	N	N	N
Caring for a newborn baby	N	N	N	N	N	N	N	N	N	N
MyMedela	N	Y	Y	N	N	N	N	N	Y	Y
Postnatal pilates	N	N	N	N	N	N	N	N	N	N
Postnatal pilates by reform	N	N	N	N	N	N	N	N	N	N
Sprout Baby	N	N	N	N	N	Y	N	N	Y	Y
Guide to newborn care	Y	Y	Y	N	N	N	N	N	N	N
After birth exercise	N	N	N	N	N	N	N	N	N	N
Pregnancy, parenting advice & baby care tips app	Y	Y	Y	N	N	N	N	N	N	N
Bleeding after birth	N	N	N	N	N	N	N	N	N	N
Burn fat after pregnancy - weight loss	N	N	N	N	N	N	N	N	N	N
Losing weight after pregnancy	N	N	N	N	N	N	N	N	N	N
Telfair baby	N	Y	Y	Y	N	Y	N	N	Y	N
Post pregnancy recovery	N	Y	N	Y	N	N	N	N	N	N
Growth Chart, Development Milestones & Vaccination	N	N	N	N	N	N	N	N	Y	N
LactApp+	N	Y	Y	N	N	N	N	N	N	N

Application name	PC11	PC12	PC13	PC14	PC15	R16	R17	R18	R19	N20
NKCH moments	N	Y	Y	N	N	N	N	N	Y	Y
Parentlove: baby feeding tracker, diapers, pumping	N	N	N	N	N	Y	N	Y	Y	Y
Maternal & newborn care plans	N	N	N	N	N	N	N	N	N	N
Essentia baby	N	Y	Y	Y	N	Y	N	N	Y	N
Your baby's birth & beyond	N	Y	Y	Y	N	Y	N	N	Y	N
Baby care plus	N	N	N	N	N	Y	Y	Y	Y	Y
The postpartum cure	N	N	N	N	N	N	N	N	N	N
UWBaby	N	Y	Y	Y	N	Y	N	N	Y	N
Skin care after pregnancy	N	Y	N	N	N	N	N	N	N	N
Elebaby simple	N	N	N	N	N	N	N	N	N	Y
Baby Tracker - Newborn Log	N	N	N	N	N	N	N	N	N	Y
Mother and baby 2NY9	Y	Y	Y	N	N	N	N	N	N	N
C-section recovery	N	N	N	N	N	N	N	N	N	N
You + Baby	Y	Y	Y	Y	N	Y	N	N	Y	Y
Baby& me	Y	Y	Y	Y	N	Y	N	N	Y	Y
Total (N)	**7**	**18**	**16**	**9**	**1**	**12**	**5**	**5**	**18**	**18**
Total (%)	**15%**	**38%**	**33%**	**19%**	**2%**	**25%**	**10%**	**10%**	**38%**	**38%**

Table B.3

Assessment results (part 3).

Application name	N21	N22	N23	N24	N25	S26	S27	S28	A29	A30
Ovia Parenting: Baby Tracker, Breastfeeding Timer	N	Y	N	N	N	N	N	Y	Y	Y
WellMama free post pregnancy yoga poses	N	N	N	N	N	Y	Y	N	N	Y
FitMama Lite 5Min	N	N	N	N	N	N	Y	N	N	Y
Glow Baby Newborn Tracker App - Breastfeeding Timer Diaper Log	Y	Y	Y	N	N	N	N	Y	Y	Y
Baby tracker - Newborn Feeding, Diaper, Sleep log	Y	N	Y	Y	N	Y	Y	N	N	Y
Baby manager	Y	N	Y	N	N	Y	N	Y	N	Y
Baby+	Y	Y	Y	Y	N	Y	Y	N	Y	Y
Fit Mommy Project Challenge	N	N	N	N	N	N	N	Y	N	Y
Postnatal workouts	N	N	N	N	N	N	N	N	N	N
BabyTime	Y	N	Y	N	N	Y	Y	N	Y	Y
WebMD Baby	N	Y	Y	N	N	N	N	N	Y	Y
Breastfeeding Tracker Baby Log	Y	N	Y	N	N	N	N	N	Y	Y
Moment Health	N	N	N	N	N	N	Y	Y	Y	N
Baby tracker - feeding, sleep and diaper	Y	N	Y	N	N	N	N	N	N	Y
MH motherhood	Y	N	Y	N	N	Y	N	N	N	N
Baby loggy -newborn log	Y	N	Y	N	N	N	N	N	N	N

Application name	N21	N22	N23	N24	N25	S26	S27	S28	A29	A30
30-day fit mommy Challenge	N	N	N	N	N	N	N	N	N	N
Oh baby! Mom and baby exercise	N	N	N	N	N	N	N	N	N	N
Caring for a newborn baby	N	N	N	N	N	Y	N	N	N	N
MyMedela	N	N	Y	N	N	Y	Y	N	Y	Y
Postnatal pilates	N	N	N	Y	N	Y	Y	Y	Y	N
Postnatal pilates by reform	N	N	N	N	N	N	N	N	N	N
Sprout Baby	Y	Y	Y	N	N	Y	N	N	N	Y
Guide to newborn care	N	N	N	N	N	N	N	N	N	N
After birth exercise	N	N	N	Y	N	N	Y	N	N	N
Pregnancy, parenting advice & baby care tips app	N	Y	N	Y	N	Y	N	Y	Y	Y
Bleeding after birth	N	N	N	N	N	N	N	N	N	Y
Burn fat after pregnancy - weight loss	N	N	N	N	N	N	N	N	N	Y
Losing weight after pregnancy	N	N	N	N	N	N	N	N	N	N
Telfair baby	N	N	Y	N	N	N	N	N	N	Y
Post pregnancy recovery	N	N	N	N	N	N	N	N	N	N
Growth Chart, Development Milestones & Vaccination	Y	Y	Y	N	N	Y	N	N	Y	Y
LactApp+	N	N	N	N	N	Y	N	Y	Y	Y
NKCH moments	N	N	Y	N	N	N	N	N	N	N
Parentlove: baby feeding tracker, diapers, pumping	N	N	Y	N	N	Y	N	N	Y	Y
Maternal & newborn care plans	N	N	N	N	N	N	N	N	N	Y
Essentia baby	Y	N	Y	N	N	N	N	N	N	N
Your baby's birth & beyond	N	N	Y	N	N	N	N	N	N	Y
Baby care plus	N	N	Y	N	N	Y	N	N	N	Y
The postpartum cure	N	N	N	N	N	N	N	N	N	N
UWBaby	Y	N	Y	N	N	N	N	N	N	Y
Skin care after pregnancy	N	N	N	N	N	N	N	N	N	N
Elebaby simple	N	N	N	N	N	N	N	N	Y	N
Baby Tracker - Newborn Log	N	N	N	N	N	N	N	N	N	Y
Mother and baby 2NY9	N	Y	N	N	N	N	N	N	N	Y
C-section recovery	N	N	N	N	N	N	N	N	N	Y
You + Baby	Y	N	Y	N	N	N	N	N	N	Y
Baby& me	Y	N	Y	N	N	N	N	N	N	Y
Total (N)	**15**	**8**	**22**	**5**	**0**	**15**	**9**	**8**	**14**	**30**
Total (%)	**31%**	**17%**	**46%**	**10%**	**0%**	**31%**	**19%**	**17%**	**29%**	**63%**

Table B.4

Assessment results (part 4).

Application name	A31	A32	A33	A34	A35	A36	A37	Total (N)	Total (%)
Ovia Parenting: Baby Tracker, Breastfeeding Timer	N	N	N	Y	N	Y	Y	17	46%
WellMama free post pregnancy yoga poses	N	N	N	Y	N	Y	N	6	16%
FitMama Lite 5Min	N	N	N	Y	N	Y	N	5	14%
Glow Baby Newborn Tracker App - Breastfeeding Timer Diaper Log	N	N	Y	Y	N	N	Y	14	38%
Baby tracker - Newborn Feeding, Diaper, Sleep log	N	N	Y	N	N	Y	N	10	27%
Baby manager	N	N	Y	Y	N	Y	Y	14	38%
Baby+	N	Y	Y	Y	N	Y	Y	22	59%
Fit Mommy Project Challenge	N	N	N	Y	Y	Y	Y	7	19%
Postnatal workouts	N	Y	N	N	Y	Y	Y	5	14%
BabyTime	N	N	Y	Y	N	Y	Y	12	32%
WebMD Baby	N	N	N	Y	N	N	Y	18	49%
Breastfeeding Tracker Baby Log	Y	N	Y	Y	N	N	Y	13	35%
Moment Health	N	N	N	Y	N	N	Y	7	19%
Baby tracker - feeding, sleep and diaper	Y	N	Y	Y	N	Y	Y	11	30%
MH motherhood	N	N	N	Y	Y	Y	Y	20	54%
Baby loggy -newborn log	N	N	Y	N	N	Y	N	8	22%
30-day fit mommy Challenge	N	N	N	Y	Y	Y	Y	5	14%
Oh baby! Mom and baby exercise	N	N	N	Y	Y	N	Y	5	14%
Caring for a newborn baby	N	N	N	Y	Y	N	N	4	11%
MyMedela	N	Y	Y	Y	N	Y	Y	15	41%
Postnatal pilates	N	N	Y	Y	Y	N	N	9	24%
Postnatal pilates by reform	N	N	N	Y	N	N	Y	3	8%
Sprout Baby	N	Y	Y	Y	N	Y	Y	14	38%
Guide to newborn care	N	N	N	Y	Y	N	N	8	22%
After birth exercise	N	N	Y	Y	N	Y	Y	7	19%
Pregnancy, parenting advice & baby care tips app	N	Y	N	Y	N	Y	Y	21	57%
Bleeding after birth	N	N	N	N	Y	N	Y	4	11%
Burn fat after pregnancy - weight loss	N	N	N	Y	Y	N	Y	7	19%
Losing weight after pregnancy	N	N	N	Y	Y	N	Y	5	14%
Telfair baby	N	N	N	Y	Y	Y	Y	19	51%
Post pregnancy recovery	N	N	N	Y	Y	N	N	10	27%
Growth Chart, Development Milestones & Vaccination	N	Y	N	Y	N	N	N	11	30%
LactApp+	N	N	N	N	Y	N	Y	8	18%
NKCH moments	N	N	N	Y	Y	Y	Y	17	39%

Application name	A31	A32	A33	A34	A35	A36	A37	Total (N)	Total (%)
Parentlove: baby feeding tracker, diapers, pumping	Y	N	Y	Y	N	Y	Y	14	33%
Maternal & newborn care plans	N	N	N	N	Y	N	Y	5	14%
Essentia baby	N	N	N	Y	Y	Y	Y	19	51%
Your baby's birth & beyond	N	N	N	Y	Y	Y	Y	19	51%
Baby care plus	Y	Y	Y	Y	Y	Y	Y	16	43%
The postpartum cure	N	N	N	Y	N	N	Y	4	11%
UWBaby	N	N	N	Y	Y	Y	Y	20	54%
Skin care after pregnancy	N	N	N	Y	Y	N	Y	6	16%
Elebaby simple	N	N	N	N	N	Y	Y	5	14%
Baby Tracker - Newborn Log	N	N	Y	N	Y	N	Y	6	16%
Mother and baby 2NY9	N	Y	N	Y	Y	Y	Y	11	30%
C-section recovery	N	N	N	Y	Y	N	N	6	16%
You + Baby	N	N	N	Y	Y	Y	Y	22	59%
Baby& me	N	N	N	Y	Y	Y	Y	22	59%
Total (N)	**4**	**8**	**15**	**40**	**26**	**28**	**38**		
Total (%)	**8%**	**17%**	**31%**	**83%**	**54%**	**58%**	**79%**		

Appendix C

Table C.1

Information about the privacy policies available in the postnatal care apps.

Application name	Privacy policy content categories		Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
Ovia parenting	•	Type of Information collected	Multiple apps	No	Yes	https://www.oviahealth.com/dynamic-privacy
	•	Rationale for collection				
	•	Use and sharing of information				
	•	Controlling Personal data				
	•	Use of cookies				
	•	Security practices				
	•	Children's privacy				
	•	Third-party services				
	•	Changes to the privacy policy				

Application name	Privacy policy content categories		Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
WellMama free post pregnancy yoga poses	•	Type of Information collected	Multiple apps	GDPR[1]	No	http://www.behappymum.com/privacy-policy/
	•	Rationale for collection				
FitMama Lite 5Min	•	Controlling personal data				
	•	Use of cookies				
	•	Security practices				
	•	Third party services				
	•	Changes to the privacy policy				
Glow baby	•	Type of Information collected	Multiple apps	GDPR[1]	No	https://glowing.com/privacy
	•	Rationale for collection				
	•	Rights of users				
	•	Controlling Personal data				
	•	Use of cookies				
	•	Security practices				
	•	Retention				
	•	Third party services				
	•	Children's privacy				
	•	Data transfer				
	•	Changes to the privacy policy				
Baby tracker - Newborn Feeding, Diaper, Sleep log	•	Type of Information collected	Single app	No	No	http://nighp.com/babytracker/privacy.html
	•	Rights of users				
	•	Security practices				
	•	Retention				

Application name	Privacy policy content categories		Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	•	Changes to the privacy policy				
Baby manager	•	Type of Information collected	Single app	No	No	https://babymanagerapp.tumblr.com/privacy-policy
	•	Rationale for collection				
	•	Use and sharing of information collected				
	•	Children's privacy				
	•	Third party services				
	•	Security practices				
	•	Data integrity				
	•	Changes to the privacy policy				
Baby+	•	Type of Information collected	Multiple apps	No	No	https://www.philips.co.uk/c-w/privacy/pregnancy-and-baby.html
	•	Rationale for collection				
	•	Use and sharing of information				
	•	Protection of information				
	•	Use of cookies				
	•	Retention				
	•	Third-party services				
	•	Changes to the privacy policy				
Fit Mommy Project Challenge	•	Type of Information collected	Website	APPs[2]	No	https://www.kimmysmithfit.com/privacy_policy/privacy-policy/
	•	Rationale for collection				
	•	Use and sharing of information				

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Use of cookies				
	• Security practices				
	• Third-party services				
	• Changes to the privacy policy				
BabyTime	• Type of Information collected	All developer's services	No	No	https://www.simfler.com/private-policy/
	• Use of cookies				
	• Security practices				
	• Third-party services				
	• Data transfer				
	• Children's privacy				
	• Changes to the privacy policy				
WebMD Baby	• Type of Information collected	Multiple apps	No	No	https://www.webmd.com/about-webmd-policies/about-privacy-policy
	• Rationale for collection				
	• Use and sharing of information collected				
	• Use of cookies				
	• Rights of users				
	• Security practices				
	• Retention				
	• Third-party services				
	• Data transfer				
	• Children's privacy				
	• Changes to the privacy policy				

Application name	Privacy policy content categories		Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
Baby breastfeeding tracker	•	Type of Information collected	All developer's services	COPPA[3]	No	https://www.sevenlogics.com/privacy/index.php
	•	Rationale for collection				
	•	Use and sharing of information collected				
	•	Use of cookies				
	•	Security practices				
	•	Third-party services				
	•	Children's privacy				
	•	Changes to the privacy policy				
MyMedela	•	Type of Information collected	Single app	HIPAA[4]	No	https://bit.ly/2LtI40f
	•	Rationale for collection				
	•	Use and sharing of information collected				
	•	Use of cookies				
	•	Security practices				
	•	Rights of users				
Sprout Baby	•	Type of Information collected	Single app	No	Yes	http://sprout-apps.com/privacy-policy.html
	•	Security practices				
Pregnancy, parenting advice & baby care tips app	•	Protection of information	Website	No	No	https://www.parentune.com/privacy-policy
	•	Security practices				
Baby tracker - Feeding, sleep	•	Type of Information collected	All developer's services	No	No	https://amila.io/apps/babytracker/privacy.html

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Rationale for collection				
	• Retention				
	• Data Transfer				
	• Third party services				
	• Security practices				
	• Rights of users				
	• Children's rights				
Bleeding after birth	• Type of Information collected	All developer's services	No	No	https://bit.ly/2XEaFWR
	• Rationale for collection				
	• Use and sharing of information collected				
	• Data Transfer				
	• Third party services				
	• Security practices				
	• Children's rights				
	• Changes to the privacy policy				
Burn fat after pregnancy - weight loss	• Type of Information collected	All developer's services	No	No	http://appsgility.blogspot.com/2018/08/privacy-policy.html
	• Rationale for collection				
	• Use and sharing of information collected				
	• Changes to the privacy policy				
Telfair baby	• Type of Information collected	Hospital website	No	No	https://bit.ly/322eW5S

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Rationale for collection				
	• Use and sharing of information collected				
	• Rights of users				
Growth Chart, Development Milestones & Vaccination	• Type of Information collected • Rationale for collection	Single app	No	No	https://growthbookapp.com/core/privacy
LactApp+	• Type of Information collected • Rationale for collection • Protection of information • Third party services • Changes to the privacy policy	Single app	No	No	https://bit.ly/2RIKYiN
parentlove: baby feeding tracker, diapers, pumping	• Type of Information collected • Use and sharing of information collected • Controlling personal data • Security practices • Children's privacy	All developer's services	No	No	https://parentlove.me/policies/PrivacyPolicy.htm
Maternal & newborn care plans	• Type of Information collected • Use and sharing of information collected • Use of cookies	All developer's services	No	No	https://bit.ly/2LsBvuU

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Security practices				
	• Third party services				
	• Children's privacy				
	• Changes to the privacy policy				
Your baby's birth & beyond	• Type of Information collected	Hospital website	HIPPA[4]	No	https://bit.ly/2IXRLlK
	• Use and sharing of information collected				
	• Controlling personal data				
	• Use of cookies				
	• Security practices				
	• Third party services				
	• Children's privacy				
	• Changes to the privacy policy				
Baby care plus	• Type of Information collected	Single app	No	No	https://bit.ly/2XESRej
	• Use and sharing of information collected				
	• Controlling personal data				
	• Retention				
	• The rights of users				
	• Changes to the privacy policy				
UWBaby	• Type of Information collected	University website	No	Yes	http://www.washington.edu/online/privacy/
	• Use and sharing of information collected				

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Controlling personal data				
	• Protection of information				
	• Children's privacy				
	• Rights of users				
	• Changes to the privacy policy				
Baby Tracker - Newborn Log	• Type of Information collected	Single app	No	No	http://fm.stefanroobol.com/privacy-policy/babytracker
	• Use and sharing of information collected				
	• Use of cookies				
	• Transfer of data				
	• Security practices				
	• Children's privacy				
	• Changes to the privacy policy				
Mother and baby 2019	• Type of Information collected	Single app	No	No	http://alaaappsprivacypolicy.blogspot.com/2018/10/privacy-policy.html
	• Use of cookies				
	• Security practices				
	• Third party services				
	• Children's privacy				
	• Changes to the privacy policy				
C-section recovery	• Type of Information collected	Single app	No	No	https://kabirapps.github.io/
	• Use of cookies				
	• Security practices				

Application name	Privacy policy content categories	Privacy policy scope	Compliance with international regulations	Disclaimer of medical content	Link
	• Third party services				
	• Children's privacy				
	• Changes to the privacy policy				
You + Baby	• Type of Information collected	Single app	No	Yes	https://www.gundersenhealth.org/privacy/
	• Use and sharing of information collected				
	• Use of cookies				
	• Security practices				
Baby & me	• Use and sharing of information	Hospital website	HIPPA[4] and HITECH[5]	No	https://www.slhn.org/Privacy
	• Rights of users				

Table C.2

Users' ratings of the apps selected.

ID	Application name	OS	Ratings (Number of stars)	Total of raters
A1	Ovia Parenting: Baby Tracker, Breastfeeding Timer	Android	4.7	7188
A2		iOS	4.7	1109
A3	WellMama free post pregnancy yoga poses	Android	3.9	5
		iOS	-	-
A4	FitMama Lite 5Min	Android	4	31
		iOS	-	-
A5	Glow Baby Newborn Tracker App	Android	4.7	6790
A6		iOS	5	3975
A7	Baby tracker - Newborn Feeding, Diaper, Sleep log	Android	4.6	15925
A8		iOS	4.5	41773
A9	Baby manager	Android	4.8	13680
A10		iOS	2.8	29
A11	Baby+	Android	4.5	8056
A12		iOS	5	2979
A13	Fit Mommy Project Challenge	Android	4.9	11
		iOS	-	-

ID	Application name	OS	Ratings (Number of stars)	Total of raters
A14	Postnatal workouts	Android	3	3
		iOS	-	-
A15	BabyTime	Android	4.7	11769
A16		iOS	4.7	75
A17	WebMD Baby	Android	4.1	5497
A18		iOS	4.3	384
A19	Breastfeeding Tracker Baby Log	iOS	4	658
A20		Android	4.1	507
	Moment Health	iOS	-	-
A21		Android	4.1	9
	Baby tracker - feeding, sleep and diaper	iOS	-	-
A22		Android	4.9	22444
	MH motherhood	iOS	-	-
A23		Android	1	1
A24	Baby loggy -newborn log	iOS	4.5	158
	30 day fit mommy Challenge	iOS	-	-
	Oh baby! Mom and baby exercise	iOS	-	-
	Caring for a newborn baby	iOS	-	-
A25	MyMedela	iOS	4.5	844
	Postnatal pilates	iOS	-	-
	Postnatal pilates by reform	iOS	-	-
A26	Sprout Baby	iOS	5	11943
A27	Guide to newborn care	Android	4.7	31
A28	After birth exercise	Android	4.5	109
A29	Pregnancy, parenting advice & baby care tips app	Android	4.1	2795
A30	Bleeding after birth	Android	2.1	3
A31	Burn fat after pregnancy - weight loss	Android	3	2
	Losing weight after pregnancy	Android	-	-
	Telfair baby	Android	-	-
A32	Post pregnancy recovery	Android	5	5
A33	Growth Chart, Development Milestones & Vaccination	Android	4.9	189
A34	LactApp+	Android	1	1
A35	NKCH moments	Android	1	1
A36	Parentlove: baby feeding tracker, diapers, pumping	Android	4.7	277
A37	Maternal & newborn care plans	Android	5	2
A38	Essentia baby	Android	4	7
A39	Your baby's birth & beyond	Android	2.5	9
A40	Baby care plus	Android	4.3	644
	The postpartum cure	Android	-	-
A41	UWBaby	Android	3.5	9
A42	Skin care after pregnancy	Android	5	6

ID	Application name	OS	Ratings (Number of stars)	Total of raters
A43	Elebaby simple	Android	4	16
	Baby Tracker - Newborn Log	Android	-	-
A44	Mother and baby 2019	Android	4.3	19
A45	C-section recovery	Android	4	2
A46	You + Baby	Android	3	1
A47	Baby & me	Android	3.1	10

Table C.3

Person correlation results.

		User's rating	Assessment score (%)
Users' rating	Pearson Correlation	1	−.072
	Sig. (2-tailed)		.629
	N	47	47
Assessment score (%)	Pearson Correlation	−.072	1
	Sig. (2-tailed)	.629	
	N	47	47

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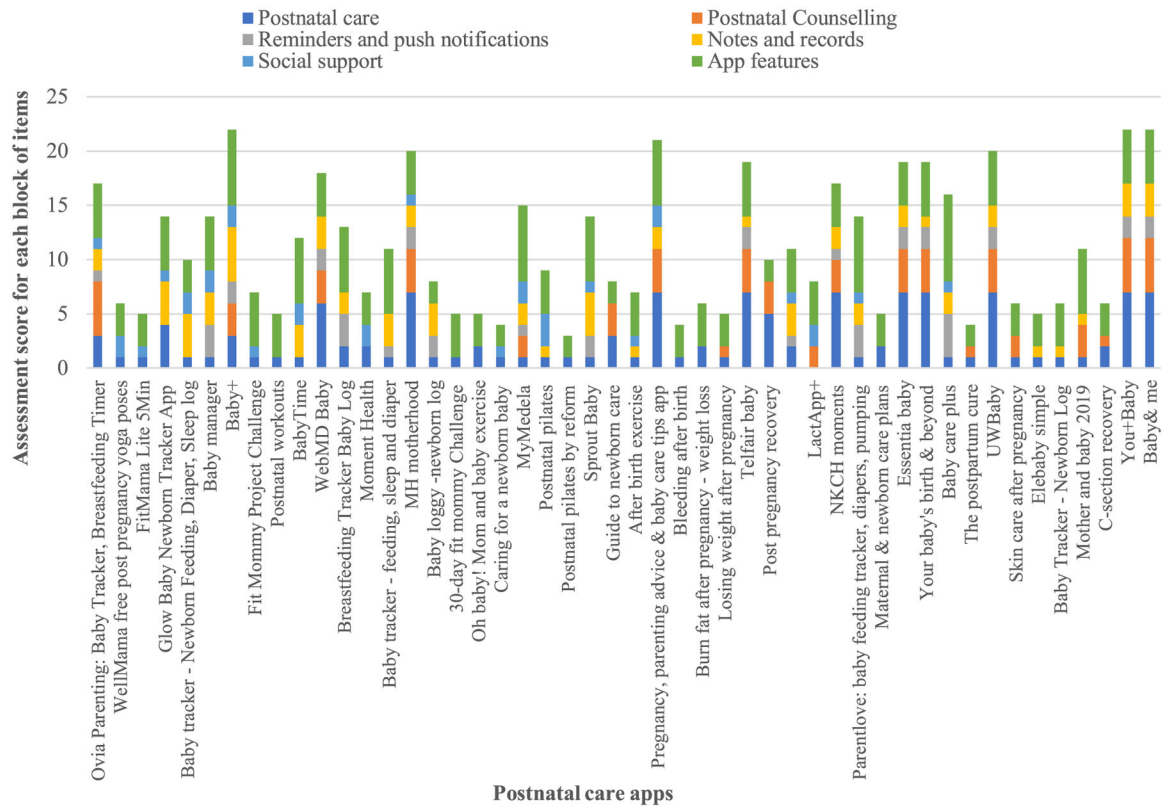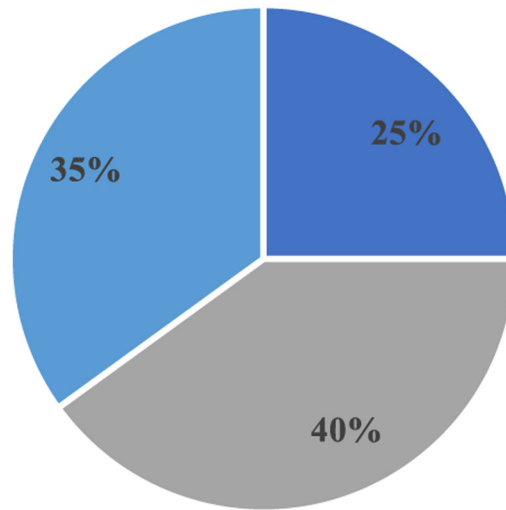
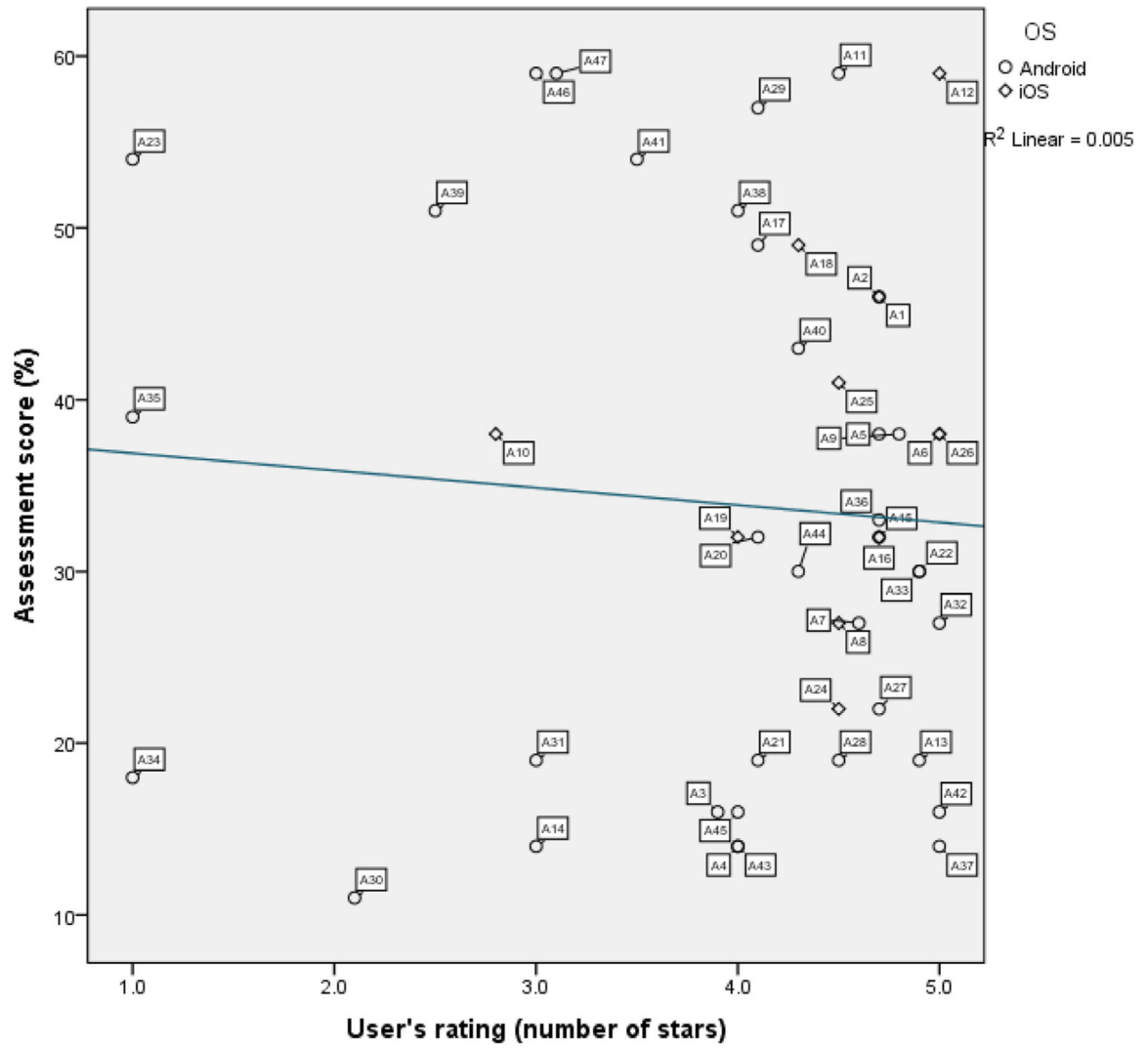**Fig. 1.**
Classification score of the 48 postnatal care apps.
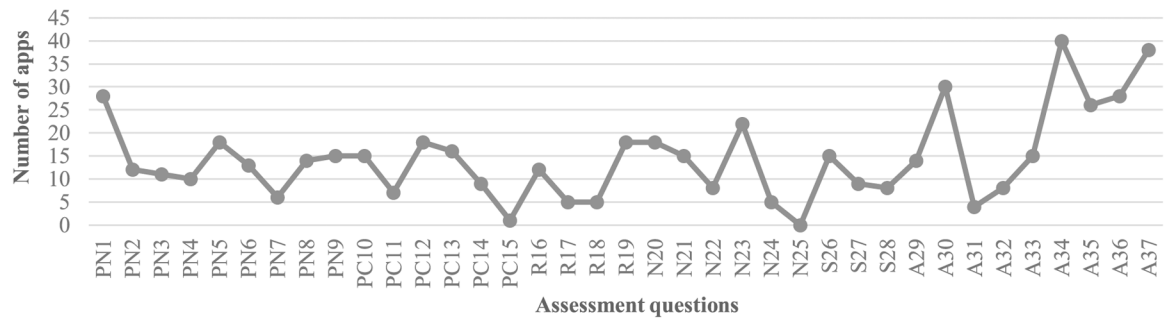
Fig. 2.
Number of apps fulfilling each of the assessment questions.

■ Fitness and weight loss   ■ Monitoring and tracking   ■ Information and tips

Fig. 3.
Classification of the postnatal care apps selected.

Fig. 4.
Scatter plot for the apps' scores and ratings.

Table 1

Research questions.

Research Question (RQ)	Rationale
RQ1. Which are the common types of the postnatal care apps selected?	Determine the classification of the apps selected in terms of their purpose.
RQ2. Which are the predominant characteristics of postnatal care apps?	Identify the common functionalities and features among the postnatal care apps.
RQ3. To what extent do the postnatal care apps comply with the items analyzed?	Examine the comprehensiveness of the apps selected in terms of functionalities and features.
RQ4. Are user ratings proportionally linked to the apps' characteristics?	Investigate the relationship between users' perception of the quality of the apps selected and the relevance of the functional content of these apps.

Table 2

Relevant sources of information for each block of items.

Data items	Relevant sources of information
Postnatal care for mothers and newborn infants	• Recommendations and guidelines on postnatal care [6,20]
	• Studies about maternal health during the postpartum period [17,25–30]
Postnatal counselling	• Counselling guides for maternal and newborn health care [31–34]
Reminders and push notifications	• Studies tackling the use of reminders in mobile apps for maternal health medication adherence [36,37]
Notes and records	• A study analyzing functionalities of personal health records for prenatal care [16]
Social support	• Studies endorsing the importance of social support in improving maternal well-being during the postpartum period [38,39]
App technical features	• Studies about security and privacy concerns in mobile health applications [40–42]
	• Internationalization requirements catalog for health applications [43]
	• Studies evaluating mobile health applications' compliance with usability guidelines and standards [44–46]
	• Reusable usability requirements repository for mobile health applications [47]

Table 3

Assessment of the privacy policies available in 30 postnatal care apps.

Privacy policy content		Total of privacy policies N (%)
Categories	**Sub-categories**	
Collection and disclosure of data	Type of information collected	28 (93%)
	Rationale for collection	16 (53%)
	Use and sharing of information collected	18 (60%)
	Third party services	16 (53%)
	Data transfer	5 (17%)
Security and privacy	Security practices	22 (73%)
	Retention	6 (20%)
	Children's privacy	15 (50%)
	Use of cookies	16 (53%)
Users' controls	Rights of users	9 (30%)
	Controlling personal data	8 (27%)
Changes to the privacy policy	21 (70%)	