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Current Status of Postnatal Depression Smartphone Applications available on Application Stores: An Information Quality Analysis

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Current Status of Postnatal Depression Smartphone Applications available on Application Stores: An Information Quality Analysis

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assisted in the extraction of the data from the respective app stores. LAZ and TW helped in the
preparation of the tables and the analysis of the results. MZ wrote up the initial draft of the manuscript,
which was further amended and worked upon by all the authors, including that of MZ, RCMH, OW and
SC. OW and SC proof-read and assisted in the preparation of the manuscript for final submission.
Data-sharing statement: All data used for preparation of this manuscript has been included within the
manuscript.

Abstract

Introduction:

The World Health Organization, in its latest report has highlighted that approximately 10% of mothers suffer from depression during their pregnancy. In the recent years, technology has become an integral part of healthcare. E-health (Electronic Health) as well M-Health (Mobile Health) are increasingly being used as tools for healthcare. There remains a paucity of research studies evaluating the potential of m-health and smartphone applications for postnatal depression.

Aims:

Given this, it is the aim of the current research to identify not only some common functionalities of postnatal application, but also to determine the quality of the information content of postnatal depression application using validated scales that have been applied for applications in other specialities.

Methods:

In order to determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 1st and 30th November 2016. The Silberg scale was used in the assessment of the information quality of the smartphone applications.

Results:

Our current results highlighted that whilst there is currently a myriad of applications, only a limited number (n=9) are specifically focused on postnatal depression. In addition, the vast majority of the currently available applications on the store have only disclosed their last date of modification as well as ownership. There remain very limited disclosures about the information of the authors, as well as the references for the information included in the application itself. The average score for the Silberg scale for the postnatal applications we have analysed is that of 3.1

Conclusions:

There remains a need for healthcare professionals and developers to jointly conceptualize new applications with better information quality and evidence base.

Strengths:

1. **Overview of the functionalities of the vast majority of postnatal applications on the store**
2. **Application of validated scales in the assessment of information quality of the applications**
3. **Identification of shortfalls with regards to current conceptualized applications**

Limitations:

1. **Only Singapore based application stores were search and hence some applications might be missing**
2. **Rapid conceptualization of applications would mean that new applications developed outside of the search window were not included**
3. **Silberg scale assess only the information quality and not the other aspects of the application.**

Introduction

The World Health Organization, in its latest report has highlighted that approximately 10% of mothers suffer from depression during their pregnancy [1]. Postnatally, the figures for depression increases to that of 13% [1]. The World Health Organization has pointed out that the prevalence of depression varies in accordance to the regions, with low and middle income developing countries having a higher prevalence of postnatal depression [1]. More importantly, the World Health Organization has highlighted that postnatal depression is associated with significant morbidity and even mortality, as some severely depressed mothers do commit suicide [1]. Clearly, with the significant associated morbidity as well as mortality, there is a clear role for interventional strategies. The World Health Organization in its report published in 2003 [2] has clearly highlighted that there is a need for an early identification as well as an effective treatment model that various countries could base on [2]. In developed countries like in Australia, it has been estimated that postnatal depression would affect every 1 in 7 women; and there are also similar depressive symptoms in new fathers [3]. Even in an Asian country like Singapore, there have been more focus on this significant psychiatric conditions and the current clinical practice guidance recommends that those who are suspected to be having such symptoms be referred to specialist care acutely [4].

Some of the core symptoms in postnatal depression includes that of low mood, marked reduction in self-esteem, loss of interest and enjoyment as well as tearfulness. Some women also report of hopeless as well as excessive fatigue [5]. In addition, it is also not uncommon for mothers to report of increased anxiety with regards to their baby's well-being [5]. Such anxiety symptoms might in turn result in a diminished affection for their baby as well as breastfeeding related difficulties [5]. It is essential for postnatal depression to be screened for and detected early, given that untreated postnatal depression does have consequential effects not only for mothers themselves, but also for their newborn. Clearly, postnatal depression could increase the risk of new mothers harming themselves or their children if they are severely depressed, or if they have had symptoms of psychotic depression. For the newborn, there have been recent studies that have highlighted how the postpartum bonding could be adversely affected due to the presence of depressive symptoms in a new mother [6]. The poor postpartum bonding could also result in consequential attachment issues in the newborn, that could be carried into adulthood [6]. In particular, these newborns tend to have insecure attachment to their parental figures. Aside from attachment related issues, children born of mothers with underlying postnatal depression do commonly have resultant cognitive issues as well as language and expressive issues. From a public policy perspective, postnatal depression and its associated morbidity and mortality would lead to a tremendous burden in healthcare. Studies have been conducted in the United Kingdom, which have

shown that postnatal depression has on the average led to a massive reduction not only in earnings, but also a reduction in the health-related quality of life [7]. Hence, there is thus a need for early identification and various interventions for treatment. Based on the recommendations of the National Institute for Clinical Excellence (NICE) guidelines, there are different approaches to deal with the issue of postnatal depression and the main determinant for this would be that of the severity of the depressive symptoms. Based on the stepped care recommendations of the NICE guidelines, women with sub-threshold levels of depression could receive self-help programs [8]. However, psychological based treatment, such as that of cognitive behavioral therapy, along with medications would be recommended for mothers diagnosed with mild to moderately severe postnatal depression [8]. Medications that are indicated for the treatment of postnatal depression include that of the tricyclic antidepressants as well as the selective serotonin reuptake inhibitors [8]. For mothers with severe depression, who are clearly at risk to either themselves or to their baby, inpatient admission and treatment would be recommended and would be warranted.

In the recent years, technology has become an integral part of healthcare. E-health (Electronic Health) as well M-Health (Mobile Health) are increasingly being used as tools for healthcare. There have been recent studies that has highlighted that new mothers and those who are suffering from postnatal depression are interested in the utilization of a health application [9]. These findings are of significance, as it would mean that new mothers are not averse to the usage of technology in helping them manage their mood related symptoms and conditions. Clearly, one of the major challenges faced by all new mothers is that of time management, and setting time aside for a medical consultation might be difficult. In addition, in some countries like that of Australia and Canada, there might be geographical barriers that prevent these new mothers from seeking the appropriate help. To data, there has been quite a number of trials evaluating the potential primarily of E-Health in supporting new mothers with postnatal depression. Lee et al. (2016) [10] recently conducted a systematic review and have highlighted that E-health is indeed a feasible option and also a cost-effective solution. However, there remains a paucity of research studies evaluating the potential of m-health and smartphone applications for postnatal depression. Most of the published research to date have highlighted how these tools are useful for healthcare workers in the low and middle income countries, and the existing tools only provide basic psycho-educational information [11].

Zhang et al. (2015) [12] have previously highlighted the importance of healthcare professionals' involvement in the conceptualization of smartphone based interventions. More importantly, Zhang et al. (2015) [12] have also highlighted the need for current applications to be further evaluated in terms of their informational contents using validated scales. Such an analysis is critical, given that there is a myriad of other post-natal applications on the application stores. In addition, prior research done on obesity applications [13] as well as cardiovascular applications [14] have highlighted that there are several shortcomings inherent in the applications currently available on the app store.

Given this, it is the aim of the current research to identify not only some common functionalities of postnatal application, but also to determine the quality of the information content of postnatal depression application using validated scales that have been applied for applications in other specialities.

Methodology

Selection of Smartphone Applications

In order to determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 1st and 30th November 2016. The following keywords were utilized in the search strategy, that of "postnatal" and "depression." The search yielded a cumulative total of 67 applications, with 7 from the Apple ITunes store and 60 from the Google Android Play store. After reviewing the description of the applications, a cumulative total of 58 applications were excluded as they were of no relevance (not an application targeted for postnatal depressive disorder or not in English language). In the event that both a free and a paid version were available on the store, only the freely available version was downloaded for further evaluation. Any duplicated smartphone applications were removed. In addition, only English language version of smartphone applications were downloaded and considered in the current review. Each of the respective application were downloaded on either an Apple iPhone 6s device (for the Apple Platform running IOS operating system 10.1) or on a Xiaomi Note 3 (For the Android Platform running Android Marshmallow operating system). At the end, a total of **9** applications were included for the evaluation of their underlying information quality. Figure 1 illustrates the selection process for the smartphone applications.

------ Insert Figure 1-------
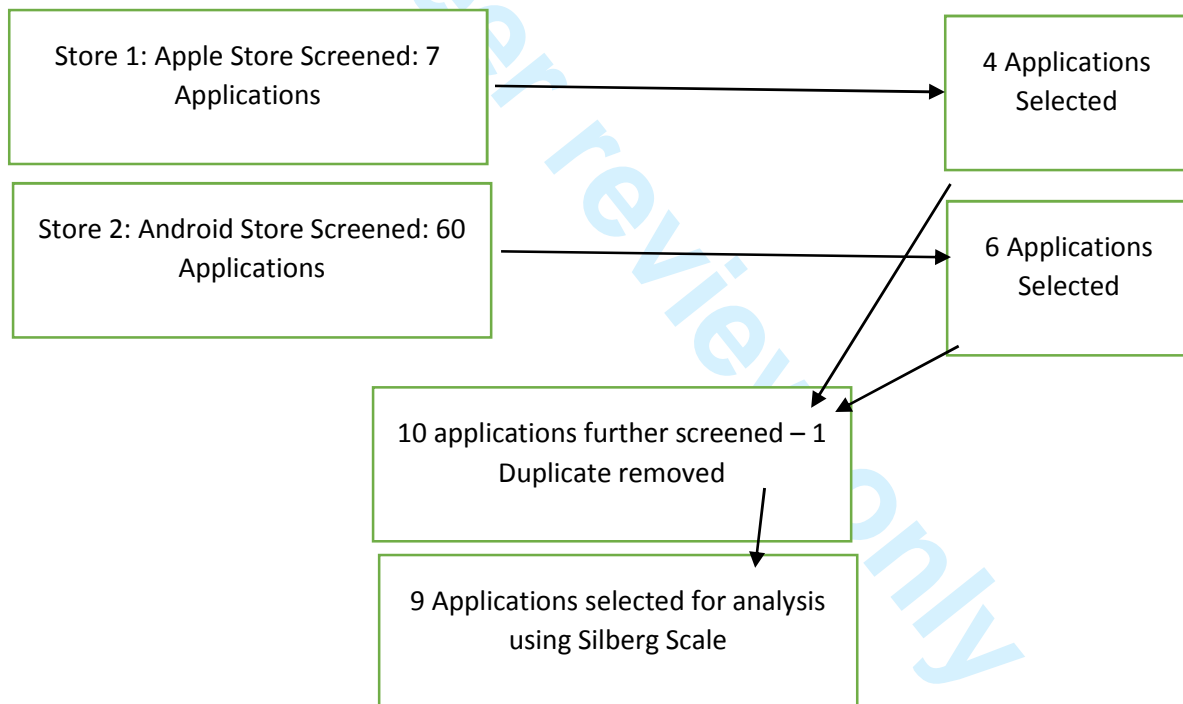
Figure 1: Flow chart showing the selection process of smartphone applications related to postnatal care

Analysis of the Information Quality of Smartphone Applications

To date, there remains no standardized scale that has been recommended by any guidelines for the assessment of application quality as well as for the analysis of the information quality of smartphone applications. Hence, the authors have decided to make use of the 9-points Silberg scale [15], which was initially developed by Griffiths and Christensen (2002) [15] and have been extensively to determine the quality of information furnished via online websites [15] as well as the quality of information inherent in

smartphone applications [14]. Notably, the same scale has been recently utilized by researchers in the analysis of the information quality of bariatric applications as well as cardiovascular applications [13,14]. The Silberg scale takes into consideration the following domains, as illustrated in Table 1. The total cumulative score possible is that of 9 points and a higher score is indicative of better information quality.

------- Insert Table 1 ------

Categories for assessment of information quality	Individual sub-scale items
Authorship	a. Whether authors are identified b. Whether affiliations of author are identified c. Whether credentials of authors are furnished
Attribution of information sources	a. Whether sources are given b. Whether references are given or hyperlinked in text
Disclosure	a. Whether application ownership disclosed b. Whether application sponsorship disclosed
Currency	a. Whether application has been modified in the past month b. Whether application has included a last modification date
Cumulative total score	**9 points**

Table 1: Categories for assessment of information quality based on the Silberg Scale

Methodology of scoring and assessment

The first author MWBZ and the last author RCMH were involved in the extraction of the relevant information and the initial analysis and scoring of each of the respective applications. If there were any disagreements amongst the authors, it was resolved with discussion.

Data analysis

The data collated were analyzed using descriptive statistics. The frequency, mean and standard deviation were computed based on the scores acquired from the Silberg scale.

Results

Core Characteristic of Postnatal Depression Applications

A cumulative total of 9 applications were included for analysis. Table 2 provides an overview of the applications which were identified and further analysed. Table 2 also summarizes the core characteristics of the applications.

------- Insert Table 2 ------

Name of Application	Platform	General Description
Postnatal Yoga	Android	Yoga exercises for postnatal mothers who are suffering from postnatal anxiety or depression.
Baby Care Week by Week Tips	Android	Educational information, audio and videos about postnatal depression

PPD Gone!	Android	Educational information (Week by Week) about how best to manage newborn along with information about postnatal depression
Self Help	Android	Leaflets about Postnatal Depression / Educational Information
Anxiety and Depression Scale	Android	Includes various rating scales / Includes the Edinburgh postnatal depression scale to evaluate for depressive symptoms
New Baby, New Life	Android / Apple	Podcast focusing on hypnosis for management of postnatal depression symptoms
What were we thinking!	Apple	Educational Information with videos and journaling function for postnatal depression
PPD Screening	Apple	Includes the Edinburgh Postnatal depression scale to evaluate for depressive symptoms
Essential Baby Care Guide	Apple	Educational information covering topic such as feeding, sleeping, care and development and first aid skills

Table 2: Core Functionalities of postnatal depression application that are included in the current analysis

Information Quality Analysis

For the 9 applications, the average Silberg score was that of 3.33 with a standard deviation of 1.80, out of a total score of 9 points. Only three out of the total of 10 applications have a score greater than or equal to the mean score of 3.1. Most of the applications have disclosed the date of last modification (100.0%), as well as disclosed the ownership of the applications (88.9%). Some of the applications have identified the authors (33.3%), as well as provided the necessary references (33.3%). The current gaps in the information quality pertains to the currency of the application (whether there have been any modifications in the past month), as well as the disclosure of the affiliations and credentials of the authors. In addition, most of the applications have not also provided references for the information which they have included and have not disclosed their competing interests. Table 3 provides a summary of the mean scores for each of the individual categories.

Table 3 summarizes the mean score for each of category of the criteria in the Silberg scale.

Category	Mean Scores	Standard Deviation
Authorship – Identification of Authors	0.33	0.50
Authorship – affiliations of Authors	0.22	0.44
Authorship – credentials of Authors	0.22	0.44
Attribution – Sources	0.22	0.44
Attribution – Provision of reference	0.33	0.50
Disclosure – Ownership of applications	0.83	0.33
Disclosure – Competing interest	0.11	0.33

Currency – Modification within the past month	0	0
Currency – Disclosure of date of last modification	1.00	0

Discussion

This is perhaps one of the first study that has been conducted to date that looks into the information quality of postnatal depression smartphone applications. To date, there has only been systematic reviews about E-Health innovations for postnatal depression. There remains a lack of analysis about the information quality of smartphone based postnatal depression applications. Our current results highlighted that whilst there is currently a myriad of applications, only a limited number (n=9) are specifically focused on postnatal depression. In addition, the vast majority of the currently available applications on the store have only disclosed their last date of modification as well as ownership. There remain very limited disclosures about the information of the authors, as well as the references for the information included in the application itself. The average score for the Silberg scale for the postnatal applications we have analysed is that of 3.1 This score is significantly inferior as compared to other analysis which have used the same scale for the computation of the information of bariatric [13] as well as cardiovascular applications [14].

Based on the current review, it is obvious that most of the applications are lacking in several aspects and hence the resultant low scores on the Silberg scale. It is of importance that smartphone applications not only contain appropriate information, but smartphone applications do need to have appropriate references as well as cite the authors responsible for the creation of the informational contents. This is especially important for postnatal related applications, as these applications do frequent provide information not only for the new mothers, but also information relating to the care of their newborn babies. As mentioned previously, the scores we have obtained are largely similar to that of bariatric [13] and cardiovascular applications that have been previously reviewed [14]. Zhang et al. [12] have previously proposed and highlighted the importance of having healthcare professionals in the joint conceptualization of smartphone applications, as well as having a governmental regulatory body to help in the assessment of applications which are deemed safe and reliable for the general public to utilize. From our knowledge, the Royal College of Psychiatrists is one of the organization that has provided the general public with mental health leaflets (both in print and online version) that is carefully curated in terms of information quality. The College have been successful in doing so, by ensuring that there is a group of experts to draft as well as to provide periodic timely updates to the mental health leaflets, to ensure that the information is kept current, as well as accurate. This strategy is perhaps how the college has been granted the United Kingdom's information safety standards for the information they have included in their leaflets for dissemination to the general public.

Zhang et al. [13] in their previous analysis of the information quality of bariatric related applications have highlighted several reasons for the lack of provision of references for the information sources. The authors previously pointed out how variations in screen size might results in technical difficulties with the integration of reference sources. However, with the recent advances in smartphone application development, especially with the usage of cross-platform programming techniques, this issue could potentially be overcome, as the newer programming techniques would ensure the compatibility of the

application across a myriad of varying devices as well as screen sizes. In addition, one of the reasons as to why most of the applications have not been updated recently nor indicated a date of last update has to do much with the way the applications have been developed. Most of the current conceptualizations relies heavily on coding informational content within the application, and hence updating the contents within the application would be an issue. In the conceptualization of further applications, it would be recommended for application developers and healthcare professionals to jointly consider the integration of a dynamic content management system, such that the information contents within the application could be updated in real-time and kept current.

One of the major strengths of the current study is that we managed to make use of a validated scale evaluate the information quality of postnatal depression applications that are currently available on the app stores. The usage of the scale has enabled us to determine the limitations in the information quality. In addition, as the same scale has also been utilized in the evaluation of other applications from other disciplines, we are able to compare and elucidate the common issues underlying the gaps in information quality across a spectrum of applications. The findings would be of relevance to regulatory bodies who are planning for policies involving smartphone applications. Despite the aforementioned strengths, there are several limitations of the current study. In our current study, the applications are identified via either the Apple or the Android application stores. Whilst these are the two most common application stores, there might be very different applications available on the other platforms which we have not evaluated. In addition, we have limited the search strategy to applications that are downloaded only in Singapore. Whilst the authors have extracted the applications from the store over a duration of one month, with the rapid development of smartphone applications using new technologies of cross-platform programming, it is not unexpected that new applications deployed onto the store after the period of evaluation are not considered. In addition, the authors have made use of the keywords "Postnatal" and "Depression" to conduct a search of the applications. The search terminologies might not be comprehensive enough to capture all the postnatal applications available on the store. The Silberg scale might have well been validated across several studies for the evaluation of the information quality, but it is not specific for information quality for smartphone applications and does not cover and assess for other aspects of the smartphone application, such as usability and levels of engagement. More recently, researchers have proposed the utilization of the Mobile Application Rating Scale [16] for the evaluation of smartphone applications. Whilst the Mobile Application Rating Scale appears to be comprehensive, one of the concerns the authors have is that there are only 4 questions looking into the information quality, which asked about only the quality, quantity, visual presentation and credulity of sources.

Conclusions

Postnatal depression is highly prevalent and is associated with multiple comorbidities as well as possible mortality. E-health interventions have been demonstrated to be efficacious and there are M-health interventions deployed in low and middle income countries, that has been evaluated by research. However, there remains a myriad of postnatal applications on the application store. It is pertinent for us to determine not only the contents within these applications, as well as apply validated scales to assess their information quality. Similar to bariatric and cardiovascular applications, there remains paucity of disclosures in various domains. Further conceptualizations and research on postnatal M-health interventions should target these areas identified in the current review.

Disclosure statement:

The authors declare that they have no competing interests.

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Abstract

Objectives

It is the aim of the current research to identify not only some common functionalities of postnatal application, but also to determine the quality of the information content of postnatal depression application using validated scales that have been applied for applications in other specialities.

Settings and Participants:

In order to determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 20th through to 31st May. No participants were involved. The inclusion criteria for the application was that it must have been searchable using the keywords "postnatal", "pregnancy", "perinatal", 'postpartum" and "depression" and must be in English language.

Intervention:

The Silberg scale was used in the assessment of the information quality of the smartphone applications.

Primary and Secondary Outcomes Measure:

The information quality score was the primary outcome measure.

Results:

Our current results highlighted that whilst there is currently a myriad of applications, only a limited number (n=14) are specifically focused on postnatal depression. In addition, the vast majority of the currently available applications on the store have only disclosed their last date of modification as well as ownership. There remain very limited disclosures about the information of the authors, as well as the references for the information included in the application itself. The average score for the Silberg scale for the postnatal applications we have analysed is that of 3.0.

Conclusions:

There remains a need for healthcare professionals and developers to jointly conceptualize new applications with better information quality and evidence base.

Trial registration:

Not applicable, as this is a systematic review

Strengths:

1. We have managed to evaluate the information quality of postnatal applications from the 2 most popular application stores using a validated information quality scale.
2. We managed to identify the most common features found in postnatal applications available on the store.
3. We have demonstrated that the overall information quality scores is intermediate between that of bariatric and cardiovascular applications.
4. Our study findings are replicable, in that similar assessment could be conducted for applications in other specialities.
5. We have identified several gaps in information quality, which clinicians and researchers need to be cognizant of.

Limitations:

1. We have not been able to evaluate non-English language applications.
2. The applications available on the app store are rapidly changing in numbers and content; our current analysis is based on a cross-sectional analysis.
3. We have not evaluated the applications for their levels of engagement and aesthetics.

Introduction

The World Health Organization (WHO), in its latest report has highlighted that approximately 10% of mothers suffer from depression during their pregnancy [1]. Postnatally, the figures for depression increases to that of 13% [1]. The World Health Organization has pointed out that the prevalence of depression varies in accordance to the regions, with low and middle income developing countries having a higher prevalence of postnatal depression (PND) [1]. Some of the core symptoms in PND includes that of low mood, marked reduction in self-esteem, loss of interest and enjoyment as well as tearfulness. Some women also report of hopeless as well as excessive fatigue [5]. In addition, it is also not uncommon for mothers to report of increased anxiety with regards to their baby's well-being [5]. Such anxiety symptoms might in turn result in a diminished affection for their baby as well as breastfeeding related difficulties [5]. It is essential for PND to be screened for and detected early, given that untreated PND does have consequential effects not only for mothers themselves, but also for their newborn. Clearly, PND could increase the risk of new mothers harming themselves or their children if they are severely depressed, or if they have had symptoms of psychotic depression. For the newborn, there have been recent studies that have highlighted how the postpartum bonding could be adversely affected due to the presence of depressive symptoms in a new mother [6]. The poor postpartum bonding could also result in consequential attachment issues in the newborn, that could be carried into adulthood [6]. In particular, newborns tend to have insecure attachment to their parental figures. Aside from attachment related issues, children born of mothers with underlying postnatal depression do commonly have resultant cognitive issues [7] as well as language and expressive issues. Other longitudinal studies conducted have demonstrated that PND have a consequential impact on the well-being of children [8].

From a public policy perspective, postnatal depression and its associated morbidity and mortality would lead to a tremendous burden in healthcare. Studies have been conducted in the United Kingdom, which

have shown that postnatal depression has on the average led to a massive reduction not only in earnings, but also a reduction in the health-related quality of life [9]. Hence, there is thus a need for early identification and various interventions for treatment. Based on the recommendations of the National Institute for Clinical Excellence (NICE) guidelines, there are different approaches to deal with the issue of postnatal depression and the main determinant for this would be that of the severity of the depressive symptoms. Based on the stepped care recommendations of the NICE guidelines, women with sub-threshold levels of depression could receive self-help programs [10]. However, psychological based treatment, such as that of cognitive behavioral therapy, along with medications would be recommended for mothers diagnosed with mild to moderately severe postnatal depression [10]. Medications that are indicated for the treatment of postnatal depression include that of the tricyclic antidepressants as well as the selective serotonin reuptake inhibitors [10]. For mothers with severe depression, who are clearly at risk to either themselves or to their baby, inpatient admission and treatment would be recommended and would be warranted.

In the recent years, technology has become an integral part of healthcare. E-health (Electronic Health) as well M-Health (Mobile Health) are increasingly being used as tools for healthcare. There have been recent studies that has highlighted that new mothers and those who are suffering from postnatal depression are interested in the utilization of a health application [11]. These findings are of significance, as it would mean that new mothers are not averse to the usage of technology in helping them manage their mood related symptoms and conditions. Clearly, one of the major challenges faced by all new mothers is that of time management, and setting time aside for a medical consultation might be difficult. In addition, in some countries like that of Australia and Canada, there might be geographical barriers that prevent these new mothers from seeking the appropriate help. To data, there has been quite a number of trials evaluating the potential primarily of E-Health in supporting new mothers with postnatal depression. Lee et al. (2016) [12] recently conducted a systematic review and have highlighted that E-health is indeed a feasible option and also a cost-effective solution. However, there remains a paucity of research studies evaluating the potential of m-health and smartphone applications for postnatal depression. Most of the published research to date have highlighted how these tools are useful for healthcare workers in the low and middle income countries, and the existing tools only provide basic psycho-educational information [13].

Zhang et al. (2015) [14] have previously highlighted the importance of healthcare professionals' involvement in the conceptualization of smartphone based interventions. More importantly, Zhang et al. (2015) [14] have also highlighted the need for current applications to be further evaluated in terms of their informational contents using validated scales. Such an analysis is critical, given that there is a myriad of other post-natal applications on the application stores. In addition, prior research done on obesity applications [15] as well as cardiovascular applications [16] have highlighted that there are several shortcomings inherent in the applications currently available on the app store.

Given this, it is the aim of the current research to identify not only some common functionalities of postnatal application, but also to determine the quality of the information content of postnatal depression application using validated scales that have been applied for applications in other specialities.

Methodology

Selection of Smartphone Applications

In order to determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 20th through to 31st May 2017.

The following keywords were utilized in the search strategy, that of "postnatal", "pregnancy", "perinatal", 'postpartum" and "depression." The search yielded a cumulative total of 59 applications, with 52 applications from the Google Android store and 7 applications from the Apple ITunes store. 18 applications were excluded from the Android store as they were not in English language. After reviewing the description of the applications, a cumulative total of 22 applications were excluded as they were of no relevance. The details for the exclusion of these applications are included in Figure 1. In the event that both a free and a paid version were available on the store, both versions were downloaded for further evaluation. Any duplicated smartphone applications were removed. In the event that a duplicated version of an application was offered on both platform, only version (that on the android platform) would be downloaded for further evaluation.

Each of the respective application were downloaded on either an Apple iPhone 6s device (for the Apple Platform running IOS operating system 10.1) or on a Xiaomi Note 3 (For the Android Platform running Android Marshmallow operating system). At the end, a total of 15 applications were included for the evaluation of their underlying information quality. Figure 1 illustrates the selection process for the smartphone applications. The selection process of the applications is based on the PRIMSA guidelines [17].

---------- Insert Figure 1 ---------------

Analysis of the Information Quality of Smartphone Applications

 To date, there remains no standardized scale that has been recommended by any guidelines for the assessment of application quality as well as for the analysis of the information quality of smartphone applications. Hence, the authors have decided to make use of the 9-points Silberg scale [18], which was initially developed by Griffiths and Christensen (2002) [18] and have been extensively to determine the quality of information furnished via online websites [18] as well as the quality of information inherent in smartphone applications [14]. Notably, the same scale has been recently utilized by researchers in the analysis of the information quality of bariatric applications as well as cardiovascular applications [15,16]. The Silberg scale takes into consideration the following domains, as illustrated in Table 1. The total cumulative score possible is that of 9 points and a higher score is indicative of better information quality.

------- Insert Table 1 ------

Categories for assessment of information quality	Individual sub-scale items
Authorship	a. Whether authors are identified b. Whether affiliations of author are identified c. Whether credentials of authors are furnished
Attribution of information sources	a. Whether sources are given b. Whether references are given or hyperlinked in text
Disclosure	a. Whether application ownership disclosed b. Whether application sponsorship disclosed

Currency	a. Whether application has been modified in the past month b. Whether application has included a last modification date
Cumulative total score	**9 points**

Table 1: Categories for assessment of information quality based on the Silberg Scale

Methodology of scoring and assessment

The first author MWBZ and authors IAZ and TW were involved in the extraction of the relevant information and the initial analysis and scoring of each of the respective applications. If there were any disagreements amongst the authors, it was resolved with discussion.

Data analysis

The data collated were analyzed using descriptive statistics. The frequency, mean and standard deviation were computed based on the scores acquired from the Silberg scale.

Results

Core Characteristic of Postnatal Depression Applications

A cumulative total of 14 applications were included for analysis. Table 2 provides an overview of the applications which were identified and further analysed. Table 2 also summarizes the core characteristics of the applications.

------- Insert Table 2 ------

Name of Applications	Platform	General Description	Silberg Sore
Anxiety and Depression Scales	Android	Include questionnaire for the evaluation of depression and anxiety	3
Self Help	Android	Include leaflets about various mental health disorder	7
Pregnancy Week by Week	Android	Guide to conception, pregnancy, taking care of baby and being a parent	2
Mental Health Assessments	Android	Include sets of common questionnaires for assessment of various psychiatric disorders	2
Baby Care Week by Week: Tips	Android	Baby development week by week and parenting tips in one baby app. Contains information, audio and video about postnatal depression.	2
First time moms	Android	Pregnancy guide and information about how to deal with postpartum depression	3
New Baby New Life	Android / Apple	Podcasts focusing on hypnosis for postnatal depression	1
GoMum	Android	CBT based activities and information about postpartum depression	4
Postnatal yoga	Android	Yoga exercises for postnatal mothers who are suffering from postnatal depression or anxiety	2
Bump 2 Breast	Android	Information about child caring as well as	3

		postpartum depression	
Your personal health	Android	Collection of surveys and assessment	2
What were we thinking	Apple	Educational information with videos and functions for postnatal depression	5
Essential Baby Care Guide	Apple	Educational information covering topics such as feeding, sleeping, care and development and first aid skills in the form of videos. Also contains video about postnatal depression.	3
PPD Screening	Apple	Includes the Edinburgh postnatal depression scale to evaluate for depressive symptoms	3

Table 2: Core Functionalities of postnatal depression application that are included in the current analysis

Information Quality Analysis

For the 14 applications, the average Silberg score was that of 3.0 with a standard deviation of 1.52, out of a total score of 9 points. 8 out of the total of 15 applications have a score that is greater than or equal to the mean score of 3.0. All the applications (100.0%) have disclosed the date of creation or last modification, but none of the applications have highlighted the last date of modification of the application. Most of the applications have disclosed the ownership of the applications (93.9%). Only 28.6% of the identified applications have provided references for the information they have included.

The current gaps in the information quality pertains to the currency of the application (whether there have been any modifications in the past month) (0%), as well as the disclosure of the affiliations (14.2%) and credentials of the authors (7.14%). In addition, a good proportion of the applications also did not disclose whether there are sponsorship for the application (7.14%). Table 3 provides a summary of the mean scores for each of the individual categories, as well, as the mean percentage of applications fulling the each of the criteria.

Category	Mean Scores	Standard Deviation
Authorship – Identification of Authors	0.143	0.363
Authorship – affiliations of Authors	0.143	0.363
Authorship – credentials of Authors	0.071	0.267
Attribution – Sources	0.286	0.469
Attribution – Provision of reference	0.286	0.469
Disclosure – Ownership of applications	0.929	0.267
Disclosure – Sponsorship	0.071	0.267
Currency – Modification within the past month	0.0	0
Currency – Disclosure of date of	1.0	1.0

last modification		

Discussion

This is perhaps one of the first study that has been conducted to date that looks into the information quality of postnatal depression smartphone applications. To date, there has only been systematic reviews about E-Health innovations for postnatal depression. There remains a lack of analysis about the information quality of smartphone based postnatal depression applications. Our search revealed that only a limited number of applications (n=14) contains information or has functionalities related to postnatal depression, among the myriad of applications yielded when we initially applied our search strategy. Our current research highlighted that the average Silbeg score for postnatal applications was that of 3.0, with a standard deviation of 1.52. 8 out of the cumulative total of 14 applications scored more than or equal to the average score. Whilst the vast majorities of the applications have provided information about creation dates and ownership of applications, only a limited number have furnished information pertaining to the references for the information shared within the application. Prior studies have utilized the same scale for cardiovascular applications and the average score was that of 2.87 [16]. Other studies have utilized the scale for obesity applications and the average score was 4.0 [15]. There are commonalities in the domains in which information is deemed to be lacking. Zhang et al. [15] reported that amongst the 39 obesity applications sampled, the vast majorities did not provide information about references, full disclosure of sponsorship and whether the application has been modified in the last month. Xiao Q et al. [14] have also reported similar findings.

Based on the current review, it is obvious that most of the applications are lacking in several aspects and hence the resultant low scores on the Silberg scale. It is of importance that smartphone applications not only contain appropriate information, but smartphone applications do need to have appropriate references as well as cite the authors responsible for the creation of the informational contents. This is especially important for postnatal related applications, as these applications do frequent provide information not only for the new mothers, but also information relating to the care of their newborn babies. Zhang et al. [14] have previously proposed and highlighted the importance of having healthcare professionals in the joint conceptualization of smartphone applications, as well as having a governmental regulatory body to help in the assessment of applications which are deemed safe and reliable for the general public to utilize. From our knowledge, the Royal College of Psychiatrists is one of the organization that has provided the general public with mental health leaflets (both in print and online version) that is carefully curated in terms of information quality. The College have been successful in doing so, by ensuring that there is a group of experts to draft as well as to provide periodic timely updates to the mental health leaflets, to ensure that the information is kept current, as well as accurate. This strategy is perhaps how the college has been granted the United Kingdom's information safety standards for the information they have included in their leaflets for dissemination to the general public.

Zhang et al. [15] in their previous analysis of the information quality of bariatric related applications have highlighted several reasons for the lack of provision of references for the information sources. The authors previously pointed out how variations in screen size might results in technical difficulties with the integration of reference sources. However, with the recent advances in smartphone application development, especially with the usage of cross-platform programming techniques, this issue could potentially be overcome, as the newer programming techniques would ensure the compatibility of the

application across a myriad of varying devices as well as screen sizes. In addition, one of the reasons as to why most of the applications have not been updated recently nor indicated a date of last update has to do much with the way the applications have been developed. Most of the current conceptualizations relies heavily on coding informational content within the application, and hence updating the contents within the application would be an issue. In the conceptualization of further applications, it would be recommended for application developers and healthcare professionals to jointly consider the integration of a dynamic content management system, such that the information contents within the application could be updated in real-time and kept current.

In our current study, we have managed to identify some of the core functionalities of postnatal applications. Most of the identified applications are limited to the provision of pregnancy related information and psycho-educational information to new mothers. Several of these applications provide validated screening tools for the assessment of postnatal depressive symptoms. To our knowledge, there has only been one application that has included a cognitive behavioral therapy component as an intervention. From a clinical perspective, it would be helpful if there are more applications that have included a therapeutic component within the application.

One of the major strengths of the current study is that we managed to make use of a validated scale evaluate the information quality of postnatal depression applications that are currently available on the app stores. The usage of the scale has enabled us to determine the limitations in the information quality. In addition, as the same scale has also been utilized in the evaluation of other applications from other disciplines, we are able to compare and elucidate the common issues underlying the gaps in information quality across a spectrum of applications. The findings would be of relevance to regulatory bodies who are planning for policies involving smartphone applications. Despite the aforementioned strengths, there are several limitations of the current study. In our current study, the applications are identified via either the Apple or the Android application stores. Whilst these are the two most common application stores, there might be very different applications available on the other platforms which we have not evaluated. In addition, we have limited the search strategy to applications that are in English language. We do acknowledge that there are multiple applications in other languages such as Spanish. Whilst the authors have extracted the applications from the store over a duration of one month, with the rapid development of smartphone applications using new technologies of cross-platform programming, it is not unexpected that new applications deployed onto the store after the period of evaluation are not considered. The Silberg scale might have well been validated across several studies for the evaluation of the information quality, but it is not specific for information quality for smartphone applications and does not cover and assess for other aspects of the smartphone application, such as usability and levels of engagement. More recently, researchers have proposed the utilization of the Mobile Application Rating Scale [16] for the evaluation of smartphone applications. Whilst the Mobile Application Rating Scale appears to be comprehensive, one of the concerns the authors have is that there are only 4 questions looking into the information quality, which asked about only the quality, quantity, visual presentation and credibility of sources.

Conclusions

Postnatal depression has an impact on the well-being of new mothers as well as their offspring, and hence it is clearly a disorder of importance, that warrants early screening and intervention. E-health interventions have been demonstrated to be efficacious and there are M-health interventions deployed

in low and middle income countries, that has been evaluated by research. However, there remains a myriad of postnatal applications on the application store. It is pertinent for us to determine not only the contents within these applications, as well as apply validated scales to assess their information quality. Similar to bariatric and cardiovascular applications, there remains paucity of disclosures in various domains. Further conceptualizations and research on postnatal M-health interventions should target these areas identified in the current review.

Acknowledgements

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Disclosure statement:

The authors declare that they have no competing interests.

Figure Legends:

Figure 1: Flow chart showing the selection process of smartphone applications related to postnatal care

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BMC Med Inform Decis Mak. 2016 Jul 7;16:83. doi: 10.1186/s12911-016-0323-2.

Android Store searched: 52 applications
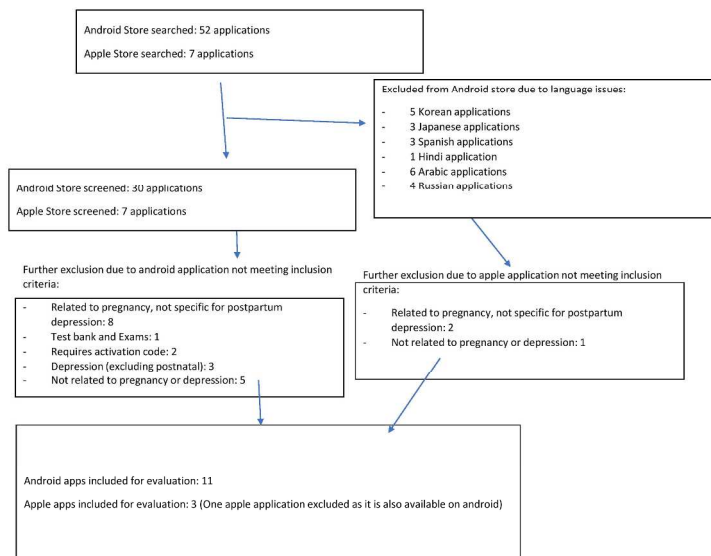
Apple Store searched: 7 applications

Excluded from Android store due to language issues:

- 5 Korean applications
- 3 Japanese applications
- 3 Spanish applications
- 1 Hindi application
- 6 Arabic applications
- 4 Russian applications

Android Store screened: 30 applications

Apple Store screened: 7 applications

Further exclusion due to android application not meeting inclusion criteria:

- Related to pregnancy, not specific for postpartum depression: 8
- Test bank and Exams: 1
- Requires activation code: 2
- Depression (excluding postnatal): 3
- Not related to pregnancy or depression: 5

Further exclusion due to apple application not meeting inclusion criteria:

- Related to pregnancy, not specific for postpartum depression: 2
- Not related to pregnancy or depression: 1

Android apps included for evaluation: 11

Apple apps included for evaluation: 3 (One apple application excluded as it is also available on android)

Figure 1: Flowchart of the selection of smartphone applications

338x190mm (300 x 300 DPI)

App Name	Remarks	Reviewer	Authors ci	Author afi	Author credentials
Postnatal Yoga	Google	MZ	0	0	0
Baby Care Week by Weeks. Tips	Google	MZ	0	0	0
Self Help	Google	MZ	1	1	1
Anxiety and Depresion Scale	Google	MZ	0	0	0
New Baby, New Life	Google	MZ	0	0	0
Pregnancy Week by Week	Google	MZ	0	0	0
Mental Health Assessments	Google	MZ	0	0	0
First time Moms	Google	MZ	0	0	0
GoMum	Google	MZ	0	0	0
Bump 2 breast	Google	MZ	0	0	0
Your personal health	Google	MZ	0	0	0
What were we thinking!	Apple	MZ	1	1	0
PPD screening	Apple	MZ	0	0	0
Essential Baby Care Guide - The essential parer	Apple	MZ	0	0	0

Information sources	References given/hy	Application ownersh	Sponsorship disclose	Application modified
0	0	1	0	0
0	0	1	0	0
1	1	1	0	0
0	1	1	0	0
0	0	0	0	0
0	0	1	0	0
0	0	1	0	0
1	0	1	0	0
1	1	1	0	0
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Current Status of Postnatal Depression Smartphone Applications available on Application Stores: An Information Quality Analysis

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Current Status of Postnatal Depression Smartphone Applications available on Application Stores: An Information Quality Analysis

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2nd Revision: DF & JC provided guidance for the 2nd revision. The 2nd revision of the manuscript was undertaken by MZ and RCMH. The 3rd revision of the manuscript was undertaken by MZ.

All authors have proof-read the manuscript prior to submission.

Data-sharing statement: All data used for preparation of this manuscript has been included within the manuscript.

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Abstract

Objectives

It is the aim of the current research to identify not only some common functionalities of postnatal application, but also to determine the quality of the information content of postnatal depression application using validated scales that have been applied for applications in other specialities.

Settings and Participants:

To determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 20th through to 31st May. No participants were involved. The inclusion criteria for the application was that it must have been searchable using the keywords "postnatal", "pregnancy", "perinatal", 'postpartum" and "depression" and must be in English language.

Intervention:

The Silberg scale was used in the assessment of the information quality of the smartphone applications.

Primary and Secondary Outcomes Measure:

The information quality score was the primary outcome measure.

Results:

Our current results highlighted that whilst there is currently a myriad of applications, only fourteen applications are specifically focused on postnatal depression. In addition, the majority of the currently available applications on the store have only disclosed their last date of modification as well as ownership. There remain very limited disclosures about the information of the authors, as well as the references for the information included in the application itself. The average score for the Silberg scale for the postnatal applications we have analysed is that of 3.0.

Conclusions:

There remains a need for healthcare professionals and developers to jointly conceptualize new applications with better information quality and evidence base.

Trial registration:

Not applicable, as this is a systematic review

Strengths:

1. We have made use of a comprehensive search strategy to characterize the functionalities of the postnatal applications that are currently available on the 2 most popular application stores.
2. We have applied the Silberg scale, which is a validated information quality scale in the assessment of the information quality of postnatal application.
3. Our study findings are replicable, in that similar assessment could be conducted for applications in other specialities.
4. We have identified several gaps in information quality, which clinicians and researchers need to be cognizant of.

Limitations:

1. We have not been able to evaluate non-English language applications.
2. The applications available on the app store are rapidly changing in numbers and content; our current analysis is based on a cross-sectional analysis.
3. We have not evaluated the applications for their levels of engagement and aesthetics.

Introduction

The World Health Organization (WHO), in its latest report has highlighted that approximately 10% of mothers suffer from depression during their pregnancy [1]. Postnatally, the figures for depression increases to that of 13% [1]. The World Health Organization has pointed out that the prevalence of depression varies in accordance to the regions, with low and middle income developing countries having a higher prevalence of postnatal depression (PND) [1]. Some of the core symptoms in PND includes that of low mood, marked reduction in self-esteem, loss of interest and enjoyment as well as tearfulness. Some women also report of hopeless as well as excessive fatigue [2]. In addition, it is also not uncommon for mothers to report of increased anxiety with regards to their baby's well-being [2]. Such anxiety symptoms might in turn result in a diminished affection for their baby as well as breastfeeding related difficulties [2]. It is essential for PND to be screened for and detected early, given that untreated PND does have consequential effects not only for mothers themselves, but also for their newborn. Clearly, PND could increase the risk of new mothers harming themselves or their children if they are severely depressed, or if they have had symptoms of psychotic depression. For the newborn, there have been recent studies that have highlighted how the postpartum bonding could be adversely affected due to the presence of depressive symptoms in a new mother [3]. The poor postpartum bonding could also result in consequential attachment issues in the newborn, that could be carried into adulthood [3]. In particular, newborn tend to have insecure attachment to their parental figures. Aside from attachment related issues, children born of mothers with underlying postnatal depression do commonly have resultant cognitive issues [4] as well as language and expressive issues. Other longitudinal studies conducted have demonstrated that PND have a consequential impact on the well-being of children [5].

From a public policy perspective, postnatal depression and its associated morbidity and mortality would lead to a tremendous burden in healthcare. Studies have been conducted in the United Kingdom, which have shown that postnatal depression has on the average led to a massive reduction not only in earnings, but also a reduction in the health-related quality of life [6]. Hence, there is thus a need for early identification and various interventions for treatment. Based on the recommendations of the National Institute for Clinical Excellence (NICE) guidelines, there are different approaches to deal with the issue of postnatal depression and the main determinant for this would be that of the severity of the depressive symptoms. Based on the stepped care recommendations of the NICE guidelines, women with sub-threshold levels of depression could receive self-help programs [7]. However, psychological based treatment, such as that of cognitive behavioral therapy, along with medications would be recommended for mothers diagnosed with mild to moderately severe postnatal depression [7]. Medications that are indicated for the treatment of postnatal depression include that of the tricyclic antidepressants as well as the selective serotonin reuptake inhibitors [7]. For mothers with severe depression, who are clearly at risk to either themselves or to their baby, inpatient admission and treatment would be recommended and would be warranted. It is of importance to recognize that the NICE guidelines [7] recommend the provision of pertinent information related to mental health to all women of childbearing potential. Information provision to postnatal mothers is of utmost importance as prior research (Youash S et al., 2013) have highlighted that there was a correlation with the amount of pre-and postnatal health information provided and the subsequent scores on the depressive scale [8]. There has also been research highlighting the importance or prenatal education in ensuring that women receive information about postnatal depression [9].

In the recent years, technology has become an integral part of healthcare. E-health (Electronic Health) as well M-Health (Mobile Health) are increasingly being used as tools for healthcare. There have been recent studies that has highlighted that new mothers and those who are suffering from postnatal depression are interested in the utilization of a health application [10]. These findings are of significance, as it would mean that new mothers are not averse to the usage of technology in helping them manage their mood related symptoms and conditions. Clearly, one of the major challenges faced by all new mothers is that of time management, and setting time aside for a medical consultation might be difficult. In addition, in some countries like that of Australia and Canada, there might be geographical barriers that prevent these new mothers from seeking the appropriate help. To data, there has been quite a few trials evaluating the potential primarily of E-Health in supporting new mothers with postnatal depression. Lee et al. (2016) [11] recently conducted a systematic review and have highlighted that E-health is indeed a feasible option and a cost-effective solution. However, there remains a paucity of research studies evaluating the potential of m-health and smartphone applications for postnatal depression. Most of the published research to date have highlighted how these tools are useful for healthcare workers in the low and middle-income countries, and the existing tools only provide basic psycho-educational information [12].

Zhang et al. (2015) [13] have previously highlighted the importance of healthcare professionals' involvement in the conceptualization of smartphone based interventions. More importantly, Zhang et al. (2015) [13] have also highlighted the need for current applications to be further evaluated in terms of their informational contents using validated scales. Such an analysis is critical, given that there is a myriad of other post-natal applications on the application stores. In addition, prior research done on obesity applications [14] as well as cardiovascular applications [15] have highlighted that there are several shortcomings inherent in the applications currently available on the app store.

Given this, it is the main aim of the current research to determine the quality of the information content of postnatal application using validated scales that have been applied for applications in other specialities. It is also the secondary aim of the current research to systematically characterize some of the common functionalities of postnatal applications.

Methodology

Selection of Smartphone Applications

To determine the information quality of the postnatal depression smartphone applications, the two most widely used smartphone application stores, namely that of Apple ITunes as well as Google Android Play store were searched between 20th May 2017 through to 31st May 2017.

The following keywords were utilized in the search strategy, that of "postnatal", "pregnancy", "perinatal", 'postpartum" and "depression." The search yielded a cumulative total of 59 applications, with 52 applications from the Google Android store and 7 applications from the Apple ITunes store. 18 applications were excluded from the Android store as they were not in English language and the authors have had difficulties with evaluation of these applications given the language barriers. After reviewing the description of the applications, a cumulative total of 22 applications were excluded as they were of no relevance. The details for the exclusion of these applications are included in Figure 1. If both a free

and a paid version were available on the store, both versions were downloaded for further evaluation. Any duplicated smartphone applications were removed. If a duplicated version of an application was offered on both platform, only version (that on the android platform) would be downloaded for further evaluation.

Each of the respective application were downloaded on either an Apple iPhone 6s device (for the Apple Platform running IOS operating system 10.1) or on a Xiaomi Note 3 (For the Android Platform running Android Marshmallow operating system). At the end, a total of 14 applications were included for the evaluation of their underlying information quality. Figure 1 illustrates the selection process for the smartphone applications.

---------- Insert Figure 1 --------------

Analysis of the Information Quality of Smartphone Applications

 To date, there remains no standardized scale that has been recommended by any guidelines for the assessment of application quality as well as for the analysis of the information quality of smartphone applications. Hence, the authors have decided to make use of the 9-points Silberg scale [16], which was initially developed by Griffiths and Christensen (2002) [16] and have been extensively to determine the quality of information furnished via online websites [16] as well as the quality of information inherent in smartphone applications [16]. Notably, the same scale has been recently utilized by researchers in the analysis of the information quality of bariatric applications as well as cardiovascular applications [14,15]. The Silberg scale takes into consideration the following domains, as illustrated in Table 1. The total cumulative score possible is that of 9 points and a higher score is indicative of better information quality.

------- Insert Table 1 ------

Categories for assessment of information quality	Individual sub-scale items
Authorship	a. Whether authors are identified b. Whether affiliations of author are identified c. Whether credentials of authors are furnished
Attribution of information sources	a. Whether sources are given b. Whether references are given or hyperlinked in text
Disclosure	a. Whether application ownership disclosed b. Whether application sponsorship disclosed
Currency	a. Whether application has been modified in the past month b. Whether application has included a last modification date
Cumulative total score	**9 points**

Table 1: Categories for assessment of information quality based on the Silberg Scale

Methodology of scoring and assessment

The first author MWBZ and authors IAZ and TW were involved in the extraction of the relevant information and the initial analysis and scoring of each of the respective applications. If there were any disagreements amongst the authors, it was resolved with discussion.

Data analysis

The data collated were analyzed using descriptive statistics. The frequency, mean and standard deviation were computed based on the scores acquired from the Silberg scale.

Results

Core Characteristic of Postnatal Depression Applications

A cumulative total of 14 applications were included for analysis. Table 2 provides an overview of the applications which were identified and further analysed. Table 2 also summarizes the core characteristics of the applications.

------- Insert Table 2 ------

Name of Applications	Platform	General Description	Silberg Sore
Anxiety and Depression Scales	Android	Include questionnaire for the evaluation of depression and anxiety	3
Self Help	Android	Include leaflets about various mental health disorder	7
Pregnancy Week by Week	Android	Guide to conception, pregnancy, taking care of baby and being a parent	2
Mental Health Assessments	Android	Include sets of common questionnaires for assessment of various psychiatric disorders	2
Baby Care Week by Week: Tips	Android	Baby development week by week and parenting tips in one baby app. Contains information, audio and video about postnatal depression.	2
First time moms	Android	Pregnancy guide and information about how to deal with postpartum depression	3
New Baby New Life	Android / Apple	Podcasts focusing on hypnosis for postnatal depression	1
GoMum	Android	CBT based activities and information about postpartum depression	4
Postnatal yoga	Android	Yoga exercises for postnatal mothers who are suffering from postnatal depression or anxiety	2
Bump 2 Breast	Android	Information about child caring as well as postpartum depression	3
Your personal health	Android	Collection of surveys and assessment	2
What were we thinking	Apple	Educational information with videos and functions for postnatal depression	5
Essential Baby Care Guide	Apple	Educational information covering topics such as feeding, sleeping, care and development and first aid skills in the form of videos. Also contains video about postnatal depression.	3
PPD Screening	Apple	Includes the Edinburgh postnatal depression scale to evaluate for depressive symptoms	3

Table 2: Core Functionalities of postnatal depression application that are included in the current analysis

Information Quality Analysis

For the 14 applications, the average Silberg score was that of 3.0 with a standard deviation of 1.52, out of a total score of 9 points. 8 out of the total of 14 applications have a score that is greater than or equal to the mean score of 3.0. All the applications (100.0%) have disclosed the date of creation or last modification, but none of the applications have highlighted the last date of modification of the application. Most of the applications have disclosed the ownership of the applications (93.9%). Only 28.6% of the identified applications have provided references for the information they have included.

The current gaps in the information quality pertains to the currency of the application (whether there have been any modifications in the past month) (0.0), as well as the disclosure of the affiliations (0.143), identification of the authors (0.143) and credentials of the authors (0.071). In addition, a good proportion of the applications also did not disclose whether there are sponsorship for the application (0.071). Table 3 provides a summary of the mean scores for each of the individual categories, as well, as the mean percentage of applications fulling the each of the criteria.

Category	Mean Scores	Standard Deviation
Authorship – Identification of Authors	0.143	0.363
Authorship – affiliations of Authors	0.143	0.363
Authorship – credentials of Authors	0.071	0.267
Attribution – Sources	0.286	0.469
Attribution – Provision of reference	0.286	0.469
Disclosure – Ownership of applications	0.929	0.267
Disclosure – Sponsorship	0.071	0.267
Currency – Modification within the past month	0.0	0
Currency – Disclosure of date of last modification	1.0	1.0
Average Silberg Score	**3.0**	**1.52**

Table 3: Mean scores on the individual sub-items on the Silberg scale

Discussion

This is perhaps one of the first study that has been conducted to date that looks at the information quality of postnatal depression smartphone applications. To date, there has only been systematic reviews about E-Health innovations for postnatal depression. There remains a lack of analysis about the information quality of smartphone based postnatal depression applications. Our search revealed that only a limited number of applications (n=14) contains information or has functionalities related to postnatal depression, among the myriad of applications yielded when we initially applied our search

strategy. Our current research highlighted that the average Silbeg score for postnatal applications was that of 3.0, with a standard deviation of 1.52. 8 out of the cumulative total of 14 applications scored more than or equal to the average score. Whilst the vast majorities of the applications have provided information about creation dates and ownership of applications, only a limited number have furnished information pertaining to the references for the information shared within the application. Prior studies have utilized the same scale for cardiovascular applications and the average score was that of 2.87 [15]. Other studies have utilized the scale for obesity applications and the average score was 4.0 [14]. There are commonalities in the domains in which information is deemed to be lacking. Zhang et al. [14] reported that amongst the 39 obesity applications sampled, the vast majorities did not provide information about references, full disclosure of sponsorship and whether the application has been modified in the last month. Xiao Q et al. [15] have also reported similar findings.

Based on the current review, it is obvious that most of the applications are lacking in several aspects and hence the resultant low scores on the Silberg scale. It is of importance that smartphone applications not only contain appropriate information, but smartphone applications do need to have appropriate references as well as cite the authors responsible for the creation of the informational contents. This is especially important for postnatal related applications, as these applications do frequent provide information not only for the new mothers, but also information relating to the care of their newborn babies. Zhang et al. [13] have previously proposed and highlighted the importance of having healthcare professionals in the joint conceptualization of smartphone applications, as well as having a governmental regulatory body to help in the assessment of applications which are deemed safe and reliable for the public to utilize. From our knowledge, the Royal College of Psychiatrists is one of the organization that has provided the public with mental health leaflets (both in print and online version) that is carefully curated in terms of information quality. The College have been successful in doing so, by ensuring that there is a group of experts to draft as well as to provide periodic timely updates to the mental health leaflets, to ensure that the information is kept current, as well as accurate. This strategy is perhaps how the college has been granted the United Kingdom's information safety standards for the information they have included in their leaflets for dissemination to the public.

Zhang et al. [14] in their previous analysis of the information quality of bariatric related applications have highlighted several reasons for the lack of provision of references for the information sources. The authors previously pointed out how variations in screen size might results in technical difficulties with the integration of reference sources. However, with the recent advances in smartphone application development, especially with the usage of cross-platform programming techniques, this issue could potentially be overcome, as the newer programming techniques would ensure the compatibility of the application across a myriad of varying devices as well as screen sizes. In addition, one of the reasons as to why most of the applications have not been updated recently nor indicated a date of last update has to do much with the way the applications have been developed. Most of the current conceptualizations relies heavily on coding informational content within the application, and hence updating the contents within the application would be an issue. In the conceptualization of further applications, it would be recommended for application developers and healthcare professionals to jointly consider the integration of a dynamic content management system, such that the information contents within the application could be updated in real-time and kept current.

In our current study, we have managed to identify some of the core functionalities of postnatal applications. Most of the identified applications are limited to the provision of pregnancy related

information and psycho-educational information to new mothers. Several of these applications provide validated screening tools for the assessment of postnatal depressive symptoms. To our knowledge, there has only been one application that has included a cognitive behavioral therapy component as an intervention. From a clinical perspective, it would be helpful if there are more applications that have included a therapeutic component within the application.

One of the major strengths of the current study is that we managed to make use of a validated scale evaluate the information quality of postnatal depression applications that are currently available on the app stores. The usage of the scale has enabled us to determine the limitations in the information quality. In addition, as the same scale has also been utilized in the evaluation of other applications from other disciplines, we are able to compare and elucidate the common issues underlying the gaps in information quality across a spectrum of applications. The findings would be of relevance to regulatory bodies who are planning for policies involving smartphone applications. Despite the strengths, there are several limitations of the current study. In our current study, the applications are identified via either the Apple or the Android application stores. Whilst these are the two most common application stores, there might be very different applications available on the other platforms which we have not evaluated. In addition, we have limited the search strategy to applications that are in English language. We do acknowledge that there are multiple applications in other languages such as Spanish. Whilst the authors have extracted the applications from the store over a duration of one month, with the rapid development of smartphone applications using new technologies of cross-platform programming, it is not unexpected that new applications deployed onto the store after the period of evaluation are not considered. The Silberg scale might have well been validated across several studies for the evaluation of the information quality, but it is not specific for information quality for smartphone applications and does not cover and assess for other aspects of the smartphone application, such as usability and levels of engagement. More recently, researchers have proposed the utilization of the Mobile Application Rating Scale [17] for the evaluation of smartphone applications. Whilst the Mobile Application Rating Scale appears to be comprehensive, one of the concerns the authors have is that there are only 4 questions looking into the information quality, which asked about only the quality, quantity, visual presentation and credibility of sources.

Conclusions

Postnatal depression has an impact on the well-being of new mothers as well as their offspring, and hence it is clearly a disorder of importance, that warrants early screening and intervention. E-health have been demonstrated to be efficacious and there are M-health technologies deployed in low and middle income countries, that has been evaluated by research. However, there remains a myriad of postnatal applications on the application store. It is pertinent for us to determine not only the contents within these applications, as well as apply validated scales to assess their information quality. Like the bariatric and cardiovascular applications, there remains paucity of disclosures in various domains. Further conceptualizations and research on postnatal M-health technologies should target these areas identified in the current review.

Acknowledgements

Disclosure statement:

The authors declare that they have no competing interests.

Figure Legends:

Figure 1: Flow chart showing the selection process of smartphone applications related to postnatal care

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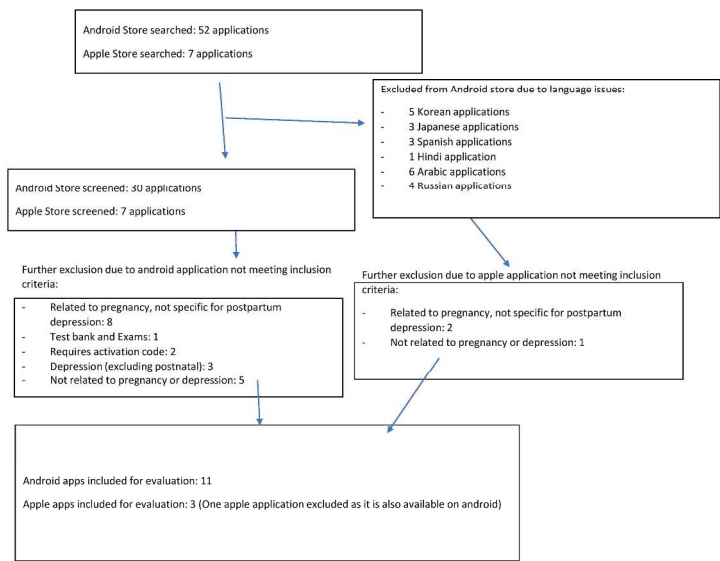
Android Store searched: 52 applications

Apple Store searched: 7 applications

Excluded from Android store due to language issues:

- 5 Korean applications
- 3 Japanese applications
- 3 Spanish applications
- 1 Hindi application
- 6 Arabic applications
- 4 Russian applications

Android Store screened: 30 applications

Apple Store screened: 7 applications

Further exclusion due to android application not meeting inclusion criteria:

- Related to pregnancy, not specific for postpartum depression: 8
- Test bank and Exams: 1
- Requires activation code: 2
- Depression (excluding postnatal): 3
- Not related to pregnancy or depression: 5

Further exclusion due to apple application not meeting inclusion criteria:

- Related to pregnancy, not specific for postpartum depression: 2
- Not related to pregnancy or depression: 1

Android apps included for evaluation: 11

Apple apps included for evaluation: 3 (One apple application excluded as it is also available on android)

Figure 1: Flowchart of the selection of smartphone applications

338x190mm (300 x 300 DPI)