Original Research

Rating Pregnancy Wheel Applications Using the APPLICATIONS Scoring System

Kathy Chyjek, MD, Sara Farag, MD, and Katherine T. Chen, MD, MPH

OBJECTIVE: To identify the top-rated pregnancy wheel applications (apps) using a newly developed APPLICATIONS scoring system.

METHODS: A list of pregnancy wheel apps was identified. Consumer-based and inaccurate apps were excluded. The APPLICATIONS scoring system was developed to rate the remaining apps. Application comprehensiveness was evaluated. Objective rating components included price, paid subscription, literature used, in-app purchases, connectivity to the Internet, advertisements, text search field, interdevice compatibility, and other components such as images or figures, videos, and special features. Subjective rating components were ease of navigation and subjective presentation.

RESULTS: A complete list of 55 pregnancy wheel apps was created from three sources. Thirty-nine (71%) were consumer-based, inaccurate, or both, leaving 16 (29%) for analysis using the APPLICATIONS scoring system.

CONCLUSION: More than two thirds of pregnancy wheel apps were excluded from our study secondary to being consumer-based, inaccurate, or both. This highlights the importance of identifying systematically, reviewing critically, and rating the thousands of available apps to health care providers to ensure accuracy and applicability. We propose that our APPLICATIONS scoring system be used to rate apps in all specialties with the

goal of improving health care provider performance and thereby patient outcomes.

The use of mobile technology by health care providers is rising given the increase in ownership of handheld devices such as smart phones, tablets, and phablets (a class of mobile devices designed to combine the form of a smart phone and tablet). Critical to the popularity and functionality of handheld devices are applications (apps), which are self-contained programs or pieces of software designed to perform a specific purpose. However, health care providers are experiencing app overload, navigating the thousands of medical apps in search of useful specialty-related apps.[1] Our previous research showed that less than 15% of 1,800 Apple Operating System apps were considered potentially useful to obstetrician–gynecologists.[2]

In a recent survey among junior physicians, medical calculator apps were preferred over other types of apps.[3] Calculating the estimated date of delivery and gestational age is an important, vital task for providers of obstetric care. In fact, new guidelines for calculating estimated date of delivery were recently developed by the American College of Obstetricians and Gynecologists, the American Institute of Ultrasound in Medicine, and the Society for Maternal-Fetal Medicine.[4] It is notable that pregnancy wheel apps are more accurate than paper wheels.[5] The ultimate responsibility of critically evaluating the accuracy and usefulness of the apps falls on the end user. However, there are many pregnancy wheel apps available and health care providers have no systematic way of rating them. The aim of this study is to develop a scoring system consisting of objective and subjective components for comparing Apple Operating System and Android apps and to apply this scoring system to pregnancy wheel apps.

From the Department of Obstetrics, Gynecology, and Reproductive Science, Icahn School of Medicine at Mount Sinai, New York, New York.

Corresponding author: Katherine T. Chen, MD, MPH, Department of Obstetrics, Gynecology, and Reproductive Science, Icahn School of Medicine at Mount Sinai, 1176 Fifth Avenue, 9/F, Box 1170, New York, NY 10029; e-mail: katherine.chen@mssm.edu.

MATERIALS AND METHODS

This study was exempt from the institutional review board from the Icahn School of Medicine in New York, New York, because the research did not involve or pose any risk to human subjects. A complete list of pregnancy wheel apps was generated from three sources by: 1) including apps from our previous study, which were found between November 18, 2013, and November 30, 2013[2]; 2) adding apps found by Chambliss and Clark on November 2, 2014[5]; and 3) searching the phrase "pregnancy wheel" in both the Apple iTunes store on October 27, 2014, and Google Play store on January 24, 2015, to capture any newly available apps. All of the apps were downloaded and analyzed based on their content. Applications that used patient-centered language and nonmedical jargon were considered consumer apps and were excluded.[2]

The accuracy of the apps was evaluated to ensure that each resulted in a correct estimated date of delivery and gestational age. For example, an app was considered accurate if 1) a given last menstrual period in the year 2014 resulted in the correct estimated date of delivery and gestational age; 2) a given last menstrual period in the leap year 2016 resulted in the correct estimated date of delivery and gestational age; and 3) a given estimated date of delivery resulted in the correct gestational age. The last menstrual period dates chosen were January 1, 2014, January 1, 2016, and the authors' birthdays (April 23, 2014, August 22, 2014, and November 30, 2014). Box 1 shows an example of the measures of accuracy used. We used Calculate by QxMD to verify the calculations.[6] As soon as an app resulted in one incorrect value, it was deemed inaccurate and excluded from further analysis.

Characteristic information from the remaining apps was collected. This included the download date, developer or seller, version, interdevice compatibility (iPhone, iPad, or both; Android phone, Android tablet, or both), and price. The popularity

---

Box 1. Example of Measures Used to Determine Accuracy of Pregnancy Wheel Applications

Measures of Accuracy (input→output)

 I. Last menstrual period→estimated date of delivery and gestational age calculated on September 29, 2014
   January 1, 2014→October 8, 2014, 38 5/7 wk
   April 23, 2014→January 28, 2015, 22 5/7 wk
   August 22, 2014→May 29, 2015, 5 3/7 wk
   November 30, 2014→September 6, 2015, invalid

 II. Last menstrual period→estimated date of delivery and gestational age in a leap year
   January 1, 2016→October 7, 2016, invalid

 III. Estimated date of delivery→gestational age calculated on September 29, 2014
   October 8, 2014→38 5/7 wk
   January 28, 2015→22 5/7 wk
   May 29, 2015→5 3/7 wk
   September 6, 2015→invalid

Table 1. The APPLICATIONS Scoring System

Component	Score	Description
Application comprehensiveness[13]	3	1 point for each measure of comprehensiveness
Price[14]	1	0=priced, 1=free
Paid subscription[15]	1	0=required, 1=not required
Literature used[16]	1	0=no references, 1=references used
In-app purchase[17]	1	0=present, 1=absent
Connectivity[14]	1	0=Internet required, 1=Internet not required
Advertisements[18]	1	0=present, 1=absent
Text search field[19]	1	0=no search field, 1=search field present
Interdevice compatibility[20]	1	0=iPhone or iPad, Android phone or Android tablet; 1=iPhone and iPad, Android phone and Android tablet
Other components[21]		
Images or figures	1	0=absent, 1=present
Videos	1	0=absent, 1=present
Special features	1	0=absent, 1=present
Navigation ease[22]	1	0=ease of navigation score less than 3, 1=ease of navigation score 3 or greater
Subjective presentation[20]	1	0=subjective presentation score less than 3, 1=subjective presentation 3 or greater
Total	16	

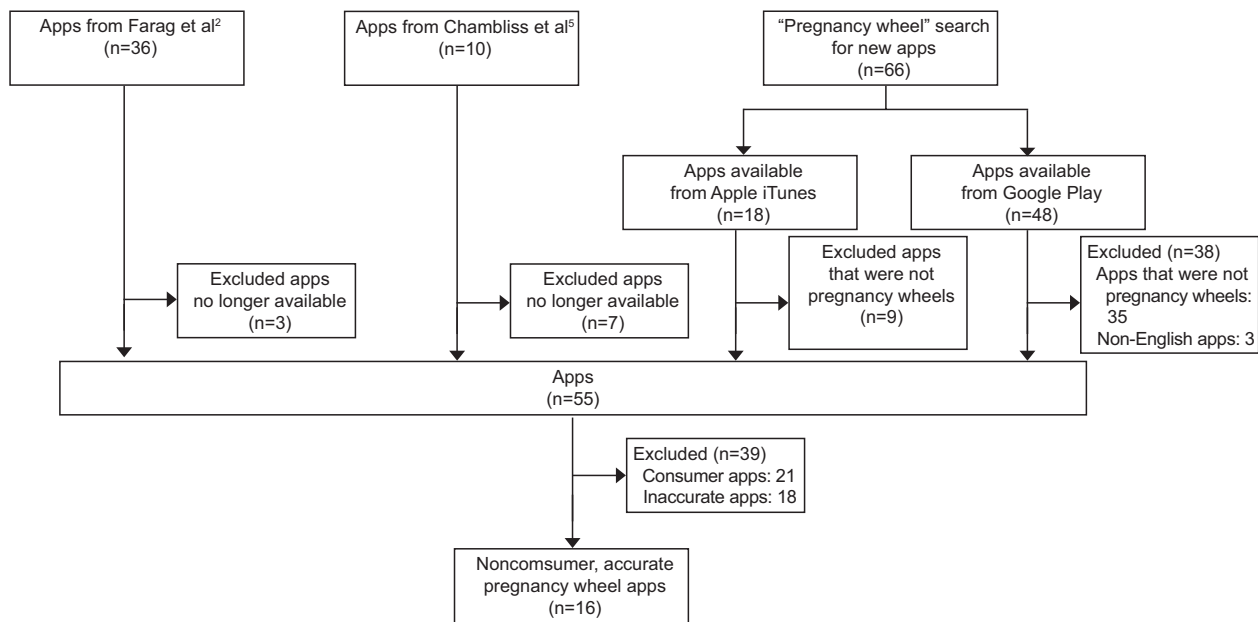Copyright © 2015 Icahn School of Medicine at Mount Sinai.

Fig. 1. Analyzed pregnancy wheel applications (apps).

Chyjek. Rating Pregnancy Wheel Applications. Obstet Gynecol 2015.

index was calculated from the product of the average app rating and number of reviews.[7] Applications were initially downloaded and analyzed without Internet connectivity to determine if functionality was dependent on the Internet. Each app was evaluated for the presence or absence of paid subscription fees; literature or references used; in-app purchases; advertisements; text search field; and other components such as images or figures, videos, and special features. In this study, special features included fetal weight, length, or weight and length estimates; prenatal testing recommendations based on gestational age; aneuploidy risk stratification; and patient tracking.

Comprehensiveness was determined by the types of calculations each app could perform. Applications were considered increasingly comprehensive if they could perform one or more of the following functions: 1)

Table 2. Pregnancy Wheel Applications Characteristic Information and APPLICATIONS Scores

Download Date	App	Developer or Seller	Version	iPhone
8/4/14	Due Date Calc OB	Gregory Moore	1	X
8/4/14	Due Dater	Hooah! Software/Nicholas Fogelson	2.2	X
8/10/14	Ferring IVF Wheel (Apple iTunes)	Ferring Pharmaceuticals, Inc.	1.1	X
1/31/15	Ferring IVF Wheel (Google Play)	Ferring Pharmaceuticals, Inc.	1.1	
1/24/15	Ob (Pregnancy) Wheel	Quatertone	7.1	
1/24/15	OB Calc Pro (Obstetrician)	In Pocket Solutions	2.01.04	
1/24/15	Ob Wheel (PRO)	Quatertone	7.5	
1/24/15	Obstetrics (+pregnancy wheel)	Medical Doctor Apps	3.01	
8/10/14	Perfect OB Tracker	Evan Schoenberg	2.2	X
8/5/14	Perfect OB Wheel	Evan Schoenberg	36	X
8/10/14	Preg Wheel	Andrew Yu	3.1	X
8/5/14	The OB Wheel Pro	eNATAL LLC/Don Miller	1	X
8/6/14	The OB Wheel Pro 7—Gestational Age Calculator	eNATAL LLC/Don Miller	1.2	X
10/27/14	The Wheel	eNATAL LLC/Don Miller	1.2	X
8/10/14	The Wheel HD	eNATAL LLC/Don Miller	1.01	
8/6/14	The Wheel SP	eNATAL LLC/Don Miller	1.5	X

App, application; NA, not available.

calculate an estimated date of delivery based on an ultrasonography-determined gestational age; 2) calculate an estimated date of delivery or a gestational age based on assisted reproductive technology dates; and 3) calculate an estimated date of delivery or a gestational age based on biometry measurements.

Navigation ease and subjective presentation were evaluated on a Likert scale with 1=poor, 2=below average, 3=average, 4=above average, and 5=excellent. The three authors' scores were averaged. An average rating of less than 3 received no points and an average rating of 3 or greater received 1 point.

The APPLICATIONS score was developed using 12 objective and subjective components based on references noted in Table 1. All authors independently scored each app to account for any interobserver differences. Objective and subjective measures of each pregnancy wheel app were obtained between August 1, 2014, and October 27, 2014, for Apple iTunes store apps and between January 24, 2015, and January 31, 2015, for Google Play store apps.

RESULTS

From an initial list of 36 pregnancy wheel apps potentially useful to obstetrician–gynecologists, as published by Farag et al,[2] 33 were included in our study, because three were no longer available. Ten additional pregnancy wheel apps were reconciled from the Chambliss and Clark study,[5] although seven were no longer available. Searching "pregnancy wheel" in the Apple iTunes store yielded 18 new apps; however, nine were nonpregnancy wheel apps and

therefore excluded. Similarly, searching "pregnancy wheel" in the Google Play store yielded 48 new apps, 35 of which were nonpregnancy wheel apps and three of which were non-English apps and therefore excluded. As a result, a complete list of 55 pregnancy wheel apps was created. We excluded 21 of 55 (38%) of the apps because they were consumer-based. Of the remaining apps, 18 of 34 (53%) were found to be inaccurate, leaving 16 of 34 (47%) for analysis (Fig. 1). All apps were found under the medical category in the Apple iTunes and Google Play stores. Characteristic information and APPLICATIONS scores are listed in Table 2 and the Appendix (the Appendix is available online at http://links.lww.com/AOG/A644). To account for interobserver differences, the APPLICATIONS scoring system was validated by having each author individually rate the 10 objective and two subjective components of each app. The objective component reporting error rate was seven of 160 (4.4%), meaning that the authors independently assigned the same score to a given objective component of an app more than 95% of the time.

DISCUSSION

Accurate dating of pregnancy is a research and public health imperative.[4] We present a list of 16 nonconsumer accurate pregnancy wheel apps that are useful to health care providers of all levels in both rural and urban settings. We further developed the APPLICATIONS scoring system to rate the apps in response to a call for an alternative model for app review that is sustainable and free of conflict

iPad	Android Phone	Android Tablet	Price ($)	Popularity Index	APPLICATIONS Total Score
X			1.99	159	9
			2.99	85	7
X			0.00	NA	10
	X	X	0.00	42	10
	X	X	0.00	6,821	9
	X	X	1.99	42	10
	X	X	2.85	202	7
	X	X	1.99	88	9
X			4.99	48	8
X			1.99	2,308	7
X			0.00	63	8
X			1.99	NA	8
X			1.99	NA	8
X			0.99	117	6
X			1.99	20	9
X			1.99	108	8

of interest.[8] The popularity index is not reliable because the pregnancy wheel apps with the highest APPLICATIONS scores received low popularity index values.

We are concerned that more than half of pregnancy wheel apps that were not consumer-based were inaccurate. An accurately assigned estimated date of delivery is among the most important results of evaluation and history-taking in early prenatal care. This information is vital for timing of appropriate obstetric care, scheduling and interpreting certain antepartum tests, determining the appropriateness of fetal growth, and implementing interventions to prevent preterm births, postterm births, and related morbidities.[4] In March 2014, the U.S. Food and Drug Administration announced that they will now regulate certain apps, specifically those intended to be used as an accessory to a medical device, those that transform a mobile platform into a medical device, or those that pose risk to patients.[9] However, pregnancy wheel apps do not fit these categories and as a result would not be regulated.

We believe our evaluation of pregnancy wheel apps is of high quality because we fulfilled the eight-question checklist described by BinDhim et al.[10] In addition, we have provided references for choosing the various components of our scoring system. Lastly, the APPLICATIONS score includes assessing for comprehensiveness of the apps. As per the American College of Obstetricians and Gynecologists Committee Opinion: 1) ultrasound measurement in the first trimester is the most accurate method to establish or confirm gestational age; and 2) age of the embryo and date of transfer should be used to determine the estimated date of delivery for an in vitro fertilization pregnancy.[4] The apps, Ferring IVF Wheel and Due Dater, are both able to perform these functions.

We searched the Apple iTunes and Google Play stores given the dominance in the market share of these two stores. The majority (69%) of health care providers have iPhones and a lesser number (19.9%) use Android phones.[11] Searching all available platforms could have decreased ascertainment bias but was beyond the scope of this study.

The ability to identify newly developed apps since our initial download of pregnancy wheel apps would have improved our study. Unfortunately, the Apple iTunes and Google Play stores do not list apps in order of date of development or entry into the market. Application development is also constantly changing with new apps created and old apps deleted everyday. Additionally, we did not capture all available apps with pregnancy wheels. For example, general medical calculator apps such as Medscape and Calculate by QxMD were not included because they were not specific to obstetrics and gynecology.

Authors in the *Journal of the American Medical Association* have said that given the sheer number of apps, it is unlikely that all will ever be meaningfully reviewed by a single organization.[8] We thus advocate that individual specialties in health care form committees to review apps specific to their discipline. Such a committee should be composed of unbiased members who do not develop apps and have strict conflict of interest rules. The goal of the committee should be to determine the accuracy of apps and then rate them according to a certain set of criteria. We propose that our APPLICATIONS scoring system be an example. This study could have been improved if our newly developed scoring system had a reference standard with which to compare. However, to our knowledge, there is no other scoring system. Also, we have an objective component reporting error rate of 4.4% and future studies to validate the scoring system are warranted.

Mobile technology provides the promise of improved performance of health care providers and better patient outcomes. Applications are convenient and may lead to better clinical decision-making, improved accuracy, and enhanced productivity.[12] We have devised the APPLICATIONS scoring system and have used it to rate pregnancy wheel apps. We believe the APPLICATIONS scoring system can be used to rate other apps used in other specialties to ease health care provider uncertainty about using apps.

REFERENCES

1. Van Velsen L, Beaujean D, van Gemert-Pijnen J. Why mobile health app overload drives us crazy, and how to restore the sanity. BMC Med Inform Decis Mak 2013;13:23.

2. Farag S, Chyjek K, Chen K. Identification of iPhone and iPad applications for obstetrics and gynecology providers. Obstet Gynecol 2014;124:941–5.

3. Payne K, Wharrad H, Watts K. Smartphone and medical related App use among medical students and junior doctors in the United Kingdom (UK): a regional survey. BMC Med Inform Decis Mak 2012;12:121.

4. Method for estimating due date. Committee Opinion No. 611. American College of Obstetricians and Gynecologists. Obstet Gynecol 2014;124:863–6.

5. Chambliss LR, Clark SL. Paper gestational age wheels are generally inaccurate. Am J Obstet Gynecol 2014;210:145. e1–4.

6. Bierbrier R, Lo V, Wu RC. Evaluation of the accuracy of smartphone medical calculation apps. J Med Internet Res 2014;16:e32.

7. Tripp N, Hainey K, Liu A, Poulton A, Peek M, Kim J, et al. An emerging model of maternity care: smartphone, midwife, doctor? Women Birth 2014;27:64–7.

8. Powell AC, Landman AB, Bates DW. In search of a few good apps. JAMA 2014;311:1851–2.

9. Mobile medical applications. 2014. Available at: http://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/ConnectedHealth/MobileMedicalApplications/default.htm. Retrieved September 18, 2014.

10. BinDhim NF, Hawkey A, Trevena L. A systematic review of quality assessment methods for smartphone health apps. Telemed J E Health 2015;21:97–104.

11. Black Book rankings 2014 survey results. Top ranked virtualized & native mobile EHR applications. Tampa (FL): Black Book Market Research; 2014.

12. Ventola CL. Mobile devices and apps for health care professionals: uses and benefits. P T 2014;39:356–64.

13. Varshneya R. 4 essentials for successful mobile apps. 2015. Available at: http://www.entrepreneur.com/article/226732. Retrieved February 4, 2015.

14. Kharrazi H, Chisholm R, VanNasdale D, Thompson B. Mobile personal health records: an evaluation of features and functionality. Int J Med Inform 2012;81: 579–93.

15. Wang J. 6 lessons in how to build a successful app. 2015. Available at: http://www.entrepreneur.com/article/224013. Retrieved February 4, 2015.

16. Butcher R, MacKinnon M, Gadd K, LeBlanc-Duchin D. Development and Examination of a Rubric for Evaluating Point-of-Care Medical Applications for Mobile Devices. Med Ref Serv Q 2015;34:75–87.

17. Apple Inc. In-app purchase for developers. 2015. Available at: https://developer.apple.com/in-app-purchase/. Retrieved February 4, 2015.

18. Spring T. Sneaky mobile ads invade Android phones. 2015. Available at: http://www.techhive.com/article/245305/sneaky_mobile_ads_invade_android_phones.html. Retrieved February 4, 2015.

19. Advertising without compromising user experience. 2015. Available at: http://developer.android.com/training.monetization/ads-and-ux.html. Retrieved February 4, 2015.

20. Zapata BC, Fernandez-Alemán JL, Idri A, Toval A. Empirical studies on Usability of mHealth apps: a systematic literature review. J Med Syst 2015;39:1.

21. Husain I. Smartphone choice for doctors and medical students is iPhone, not Android. 2011. Available at: http://www.imedicalapps.com/2011/04/smartphone-doctor-medical-students-iphone-android. Retrieved May 18, 2014.

22. Huckvale K, Car M, Morrison C, Car J. Apps for asthma self-management: a systematic assessment of content and tools. BMC Med 2012;10:144.