ORIGINAL ARTICLE

Examining pregnancy-specific smartphone applications: what are patients being told?

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OBJECTIVE: The objective of this study is to evaluate the informative content of two free, pregnancy-specific smartphone applications and their accuracy and adherence to prenatal care guidelines.
STUDY DESIGN: This is a qualitative analysis of the information delivered through two free, pregnancy-specific smartphone applications (apps): Text4Baby (T4B) and Baby Center's 'My Pregnancy Today' (BC). All information from conception through 2 weeks postpartum were transcribed and coded independently by two physician researchers. Content was analyzed and assigned thematic codes. The proportion of content each app delivered per theme was then calculated and the χ^2-test was used to compare thematic frequency between apps.
RESULTS: A total of 609 pieces of daily content were transcribed; 698 message themes were coded and analyzed. Most information delivered by T4B was about fetal development (23.8%) or prenatal care (16.6%); most content from BC was about normal pregnancy symptoms (20.1%) or maternal well-being (21.1%); the differences between apps for each of these themes were statistically significant ($P < 0.05$). A total of four messages contained incomplete or ambiguous content; neither app delivered overtly incorrect medical information. T4B and BC had a similar proportion of information that was in-line with the American College of Obstetrics and Gynecology Guidelines for Prenatal Care. Neither app delivered any messages about contraception.
CONCLUSION: T4B and BC are free, pregnancy-specific apps with different focuses. Neither app delivers comprehensive prenatal information, as evidenced by the absence of information about postpartum contraception. More information is needed to determine the role of such apps in prenatal care.

INTRODUCTION

As of 2015, ~ 64% of Americans have a smartphone; of these, 62% have used their smartphone to access health information.[1] Smartphone applications (apps) have been shown to help distribute specific health-related information and improve disease self-management,[2–4] and there are numerous consumer-directed apps related specifically to obstetrics and gynecology.[5]

Pregnancy-specific smartphone apps provide gestational age-specific information to subscribers throughout pregnancy and are in widespread use. Text4Baby (T4B) is currently available as a pregnancy-specific app that was initially developed as a free text messaging service by national agencies and has been supported by the American College of Obstetrics and Gynecology (ACOG) and March of Dimes.[6] Baby Center's 'My Pregnancy Today' (BC) is a pregnancy-specific app that originated as a website and is now supported by the Society of Maternal Fetal Medicine.[7] Although pregnant women frequently use T4B, BC and other pregnancy-specific smartphone applications, the content delivered to patients through this technology is not well described. As digital media continues to be central resource patients turn to, it is important for providers to understand the content of the information patients receive through these sources.

The goal of this study was, therefore, to examine the content of nationally endorsed pregnancy-specific smartphone applications, identify the types and frequencies of information delivered and determine the apps' accuracy and adherence to prenatal care guidelines.

METHODS

This study was a qualitative content analysis of information delivered through T4B and BC. These apps were selected for study, as both are available as free downloads for iPhone and Android phones, and are the only two pregnancy apps that are supported by national professional organizations for physicians. Institutional Review Board approval was not required for this study, as neither information nor participation from human subjects was used.

All daily information from conception through 2 weeks postpartum were transcribed, coded and analyzed. Information available through message boards, polls, videos and links from each application was not included. The latest data available for each app through March 2015 were transcribed and reviewed, and a preliminary codebook was created by two authors (AKL and BEO) through an iterative process based in grounded theory to describe the themes of content delivered through the applications. All content was then independently according to the preliminary codebook using open-coding methodology, where themes were initially identified and defined, then content revisited and codes revised to ensure all themes were represented and clearly defined. Finally, all the content was reviewed again, to ensure the content classified according to the definitions in the revised codebook. Discrepancies in coding categories were resolved after re-examination of the content, discussion between the coders and a detailed review of the data and definitions in the codebook. Data were coded into the 12 most prevalent themes as follows: Normal Pregnancy; Fetal Development; Maternal Well-Being; Seeking Care and Abnormal

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Table 1. Codebook

Theme category	Sub-theme	Theme details
Normal pregnancy	Body	Expected body changes and how to handle them
		Normal pregnancy symptoms: nausea/vomiting, morning sickness (and food suggestions for food aversions), fatigue, constipation, heartburn, bloating, lower extremity edema, increased urinary frequency, difficulty sleeping
		Sex during pregnancy
	Management of pregnancy symptoms	Common pregnancy recommendations: Kegels, sleep hygiene, hydration, stretching, back pain
		What to do about normal symptoms
		Walking/stretching to beat fatigue
Fetal development		Fetal development (e.g., 'baby is now size of ***, baby is growing ***, baby can now ***')
Maternal well-being	Issues about weight, diet, exercise	Tips or recommendations for a healthy diet, healthier food options
		Exercise (includes yoga if described for exercise)
		Weight gain parameters
		Vitamin/minerals, supplementation (iron, calcium, vitD)
		Specific 'healthy foods'
		Obtaining food/food security (ie: Women, Infants, and Children (WIC) Food and Nutrition Services Program)
	Maternal mood	Pre-existing or antepartum/postpartum anxiety/depression
		Seeking support with friends, family, your doctor
		Emotions in pregnancy
		Establishing support network, including checking in with a friend, reaching out to other moms
		Stress management
		Relaxation techniques
Seeking care and abnormal symptoms	Information about obtaining care, seeking care for normal and abnormal symptoms	Obtaining insurance, care
		Finding a doctor or midwife
		Abnormal symptoms to seek attention for: includes vaginal bleeding, Preterm premature rupture of membranes, preterm labor, pre-eclampsia symptoms, decreased fetal movement
		Advocating for self to be seen or get tests
		Need for routine care in pregnancy
		Seek oral health care with dentist
	Alternative medications or exercises	Alternative medications, exercises
		Exercises for breech baby
Partner roles	Partner roles	Sharing pregnancy experience with partner
		How partner can help
		What partner should be doing, messages directed at or about partner
Joys of pregnancy and having a newborn	Celebrating pregnancy	Items that celebrate pregnancy (e.g., start a baby journal, take belly pictures, plan a babymoon, start baby announcement)
		Pregnancy humor/jokes about pregnancy
		Plan some adult time: do things you won't be able to as a new parent
	Planning for a newborn	Items to plan for life with a baby (e.g., financial planning/budgeting, childcare, find pediatrician, determine baby's sleeping arrangement and prepare it)
		Parenting
		Create baby registry
		Tackle home improvement projects now
		Baby naming
		Discuss circumcision
Postpartum planning	Breast feeding	Breast feeding
	Information for postpartum care	Information medical baby care after delivery/immediate postpartum period
		What to anticipate after baby is born: screening tests, baby vaccines, cord clamping, baby milestones
		Planning Baby's doctor visits
		Applying for baby's social security
		Jaundice checks
		Normal feeding signs
		Swaddling
		How to hold a baby, how to change a diaper
		Nursing pillow
		Cord blood banking
		Maternal checks for diabetes postpartum
Prevention	Prevention strategies	Maternal vaccines
		Sudden Infant Death Syndrome (SIDS) prevention ('back to sleep')
		Seat belt use
		Hand washing
	Information about potential toxins	Avoiding toxic exposures
		Tobacco
		Alcohol
		Drugs
		Environmental exposures: heat, potentially toxic foods, pesticides
		Dangerous situations (texting/driving; emotional/physical abuse)
		Avoiding sick contacts
		Product safety, product recalls

Table 1. (Continued)

Theme category	Sub-theme	Theme details
	Limits to physical activity in pregnancy	Physical restrictions, limitations in pregnancy
		Travel restrictions in pregnancy
Information about prenatal care, labor, and delivery	Information regarding prenatal care	Issues related to prenatal visits
		What to expect at prenatal visits: doptones, prenatal labs, glucose testing, kick counts, expected fetal movements, antenatal testing
		Prenatal vitamins
		Facts about pregnancy (e.g., 'only 5% of women give birth on their due date')
		Rhogam
		Genetic screening, amnio/Amniocentesis or Chorionic Villus Sampling (CVS)
		Ultrasounds
		Gestational diabetes
		Anemia and iron use
		Suggestion to await for labor at or > 39 weeks
		Information about disease in pregnancy (e.g., Parvovirus B19, hyperthyroidism)
		Oral health recommendations
	Information regarding labor and delivery	Issues related to labor and delivery (e.g., labor signs and symptoms, process of labor induction, pain management in labor, Cesarean delivery)
		Birth plans
		Look into childbirth classes
		Common labor fears
		Arrange hospital tour
		Pack hospital bag
		What to do about family interested in labor progress
		Obtaining a labor doula
Additional information	Recruitment messages	Links or suggestions to enroll friends
		Recruitment for reminder messages
Work and motherhood	Information about work	Issues related to maternal employment and leave
		Family Medical Leave Act (FMLA) rights
		Maternity leave
		When/how to tell employer about pregnancy
		Work modifications
Information about caring for self	Information about Wardrobe	Issues related to appearance
		'Must have' maternity clothes
		Wearing heels during pregnancy
		Buying maternity lingerie
	Information about treating oneself	Do something nice for yourself: manicure/pedicure
		Knit or crotchet to relax
		Moisturize belly

Symptoms; Partner Roles; Joys of Pregnancy; Postpartum Planning; Prevention; Information about Prenatal Care, Labor and Delivery; Additional Information; Work and Motherhood; and Information about Maternal Self Care. Sub-themes were also defined for ease of coding. Content that were coded to more than one theme were identified.

Content was additionally assessed for accuracy of information provided by physician researchers. Content that was deemed to be inaccurate or incomplete was flagged and marked as such. The theme of such content was still categorized as described above. Finally, the 'Guidelines for Perinatal Care' from the ACOG and the American Academy of Pediatrics[8] was reviewed and content that specifically outlined an aspect of the guidelines were identified.

The frequency and proportion of information each app delivered per main theme and subtheme described in the codebook was calculated. Frequency and proportion of inaccurate or ambiguous content, as well as content in accordance with the Perinatal Care Guidelines were also calculated. The χ^2-test was then used to compare apps with each other, with regard to each main theme. STATA-13 statistical software (StataCorp, College Station, TX, USA) was used for all analyses.

RESULTS

A total of 609 pieces of content from T4B and BC were transcribed and coded, and all content was captured by the themes and subthemes outlined in Table 1. A piece of content was defined as the entry that was available for each corresponding week of the pregnancy. Each app had multiple entries per each week of pregnancy: T4B had 155 entries (~4 per each of weeks 4 to 42 of pregnancy), BC had 454 entries (11 to 13 per each of weeks 4 to 42 of pregnancy and 2 postpartum weeks). Several entries contained multiple themes, resulting in 698 coded themes (T4B: 181 themes coded; BC: 517 themes coded).

Table 2 outlines the distribution and frequency of thematic content delivered by each app per main theme and Table 3 does the same per subtheme. When analyzing each app's message distribution by the main theme category, the greatest proportion of T4B's information was about fetal development (23.8%); the greatest proportion of information delivered through Baby Center was about maternal well-being (21.1%) or normal pregnancy symptoms and management (20.1%). When stratified by sub-theme, fetal development was still the most common message sub-theme in T4B, but BC's most frequent sub-theme became information about weight, diet and nutrition (16.1%).

Content was then compared between apps for each main theme and subtheme. T4B had more information about fetal development compared with BC (23.8% vs 7.5%, $P < 0.001$). BC had significantly more messages about normal pregnancy and maternal well-being compared with T4B (20.1% vs 13.3% and 21.1% vs 10.5%, respectively; $P < 0.05$). When stratified by subtheme, T4B had significantly more information about fetal development, planning for baby's arrival, prenatal care and prevention than BC. BC had significantly more information about management of normal pregnancy symptoms, weight, diet and nutrition, information for postpartum maternal or baby care and what to expect during labor and delivery than T4B ($P < 0.05$ for all comparisons above).

Between the two apps, there were a total of four messages with content that contained incomplete or ambiguous information—

Table 2. Distribution of messages delivered, by main category

	Text4Baby, N = 181 (%)	Baby Center, N = 517 (%)	P-value
Normal pregnancy	24 (13.3)	104 (20.1)	0.04
Fetal development	43 (23.8)	39 (7.5)	< 0.001
Maternal well-being	19 (10.5)	109 (21.1)	0.002
Seeking care and abnormal symptoms	10 (5.5)	25 (4.8)	0.71
Partner roles	3 (1.7)	10 (1.9)	0.81
Joys of pregnancy and having a newborn	28 (15.5)	68 (13.2)	0.44
Postpartum planning	2 (1.1)	15 (2.9)	0.18
Prenatal care, labor, and delivery	30 (16.6)	68 (13.2)	0.25
Prevention	14 (7.7)	49 (9.4)	0.48
Additional information	0	5 (1.0)	0.18
Work and motherhood	3 (1.7)	4 (0.8)	0.30
Caring for self	5 (2.8)	20 (3.9)	0.49

Table 3. Distribution of messages delivered, by all sub-categories

	Text4Baby, N = 181 (%)	Baby Center, N = 517 (%)	P-value
Normal pregnancy			
Body	19 (10.5)	57 (11.0)	0.84
Management of pregnancy symptoms	5 (2.8)	47 (9.1)	0.005
Fetal development	43 (23.8)	39 (7.5)	< 0.001
Maternal well-being			
Issues about weight, diet and exercise	12 (6.6)	83 (16.1)	0.001
Maternal mood	7 (3.9)	26 (5.0)	0.55
Seeking care and abnormal symptoms			
Information about obtaining care, seeking care for normal and abnormal symptoms	10 (5.5)	23 (4.5)	0.59
Alternative medications or exercises	0	2 (0.39)	0.79
Partner roles	3 (1.7)	10 (1.9)	0.81
Joys of pregnancy and having a newborn			
Celebrating pregnancy	9 (5.0)	46 (8.9)	0.09
Planning for a newborn	19 (10.5)	22 (4.3)	0.002
Postpartum planning			
Breast feeding	2 (1.1)	4 (0.8)	0.67
Information for postpartum care	0	11 (2.1)	0.05
Information about prenatal care, labor and delivery			
Information regarding prenatal care	30 (16.6)	48 (9.3)	0.007
Information regarding labor and delivery	0	20 (3.9)	0.007
Prevention			
Prevention strategies	8 (5.3)	8 (1.6)	0.03
Information about potential toxins	6 (3.3)	34 (6.6)	0.1
Limits to physical activity in pregnancy	0	7 (1.4)	0.12
Additional information			
Recruitment messages	0	5 (1.0)	0.18
Work and motherhood	3 (1.7)	4 (0.8)	0.30
Caring for self			
Clothes	3 (1.7)	4 (0.8)	0.30
Treat yourself	2 (1.1)	16 (3.1)	0.15

one in T4B (0.65%) and three in BC (0.66%). Excerpts are listed in Table 4. None of the information in either app was overtly medically incorrect. App content was compared with Perinatal Care Guidelines outlined by ACOG and American Academy of Pediatrics (see Table 5). T4B and BC had no statistically significant difference in the number of messages that specifically emphasized components of the Perinatal Care Guidelines (29 (18.7%) versus 87 (19.2%), respectively; *P* = 0.90).

Neither app delivered any messages or information about contraception. In addition, none of the applications addressed specific prenatal care issues for women who may have pre-existing medical diseases, such as hypertension or diabetes. BC had one message (0.22%) with information specific to a twin pregnancy.

DISCUSSION

Smartphone applications and mobile media have emerged as widely used sources of patient information potential patient intervention.[2–4] Because of the widespread use of mobile phone applications in multiple disciplines of medicine, in September 2013 the Federal Drug Administration released guidelines on mobile medical applications.[9] Specifically, the Federal Drug Administration notes that 'mobile apps that provide periodic educational information, reminders, or motivational guidance to… pregnant women' are examples of mobile apps for which Federal Drug Administration intends to exercise enforcement discretion. However, there is very limited data on the content that is delivered to pregnant women through pregnancy-specific applications.[5,10,11]

Our study found that the thematic content delivered through T4B and BC, two pregnancy-specific apps endorsed by national societies of obstetricians and perinatologists (ACOG and Society of Maternal Fetal Medicine), varies widely. BC provided a wider breadth of content, specifically including information on alternative medications and exercises, limitations to physical activity, labor and delivery, and information for postpartum care, whereas T4B did not deliver any information on these topics. Our study also demonstrates that although information is available daily through these mobile media sources, < 20% of the messages delivered by either app contained information that explicitly addressed recommended prenatal care content. In addition, although generally few in number, we did find examples of what could be perceived as incomplete or confusing information. As reproductive-aged women increasingly turn to the Internet and pregnancy-specific apps for information during pregnancy,[12,13] it

is particularly important that the content of digital health media be closely evaluated to avoid patient misinformation or incomplete education.

Finally, our study noted a significant gap in educational content, as there was a complete absence of information about postpartum contraception planning, despite it being an aspect of prenatal care addressed in the Guidelines of Perinatal Care.[8] This gap was particularly striking for these ACOG- and Society of Maternal Fetal Medicine-supported resources, given the association of short interpregnancy interval with adverse pregnancy outcomes. Patients should be advised that these apps do not provide comprehensive prenatal care counseling, and that these apps currently do not include content specific to women with high-risk pregnancies or pre-existing medical diseases.

Our findings should be considered in the context for which these apps were created. T4B originated as a free text messaging service that could deliver messages to a cell phone that receives

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Table 4.	Inaccurate or incomplete information by App
Text4Baby (N = 1)	*Baby Center (N = 3)*
At 17 weeks: 'You might also feel off balance, so avoid wearing high heels.'	At 37 weeks: 'Your due date is very close now, but doctors don't consider your baby 'full term' until 39 weeks.' At 41 weeks: 'About 5 to 6 percent of women have prolonged pregnancies that extend three or more weeks beyond their estimated due dates. But waiting that long to deliver also increases your chance of developing an infection in your uterus that could be dangerous for your baby.' At 41 weeks: 'There's a good chance you'll go into labor on your own this week, and if you don't, you'll be induced by 42 weeks, or earlier if you or your baby has any problems.'

Table 5.	Outline of ACOG and AAP guidelines for perinatal care
Topic	*Discussion*
Frequency	Every 4 weeks for first 28 weeks, then Every 2 weeks until 36 weeks, then weekly
First prenatal visit	Scope of care provided
	Labs and indications
	Expected course of pregnancy
	Signs and symptoms to be reported and how to do so (e.g., vaginal bleeding, rupture of membranes, decreased fetal movement)
	Role of members of health care team
	Anticipated schedule of visits
	Provider schedule and Labor & Delivery coverage
	Cost to patient of prenatal care and delivery
	Practices to promote health maintenance (e.g., seat belts)
	Risk counseling (e.g., substance use and abuse)
	Psychosocial topics in pregnancy and postpartum: depression, intimate partner violence)
	Nutrition: diet, dietary allowance of vitamins and minerals; weight gain based on IOM guidelines; exercise
	Desire for pregnancy
Early in pregnancy	Determination of estimated date of delivery
	Fetal ultrasound
	Baseline urine dip, urine culture
	Prenatal labs: blood type, antibody screen, complete blood count, syphilis screen, hepatitis B screening, HIV screening, chlamydia/gonorrhea screening, tuberculosis screening (if high risk)
	Counseling: dental care nausea/vomiting, vitamin/mineral toxicity, teratogens, air travel
Routine visits	Blood pressure, weight, uterine size in relation to estimated due date
	Fetal cardiac motion, when appropriate
	Fetal movement assessment, when appropriate
	Assessment of contractions, leakage of fluid, vaginal bleeding
	Urine dip if at risk for hypertensive disorders, diabetes, autoimmune disorders
	Second and third trimesters: working, childbirth classes, choosing pediatrician, anticipating labor, preterm labor, breech presentation at term, trial of labor after cesarean, options for intrapartum care, cord blood banking, breastfeeding, choice of postpartum contraception, preparation for hospital discharge
	Glucose screen early, and 24–28 weeks
	Complete blood count in third trimester
	Group B Strep (GBS) at 35–37 weeks
	Vaccines: flu vaccine (in season); tdap, Hepatitis A, Hepatitis B, pneumococcal, if indicated
	Genetic screening pretest counseling, screening
Abbreviations: AAP, American Academy of Pediatrics; ACOG, American College of Obstetrics and Gynecology.	

text messages, with the aim of reaching underserved populations.[6] BC is a member of the Johnson & Johnson company and does not specify a target population.[7] Although the differences in thematic content could be due to the different objectives T4B and BC originated from, the public is probably not aware of these differences and may view and reference these apps in a similar manner.

A strength of our study is that we compared the content of two similarly structured apps, which are both free and available on iPhone and Android smartphone interfaces, the two most popular smartphone systems in the United States.[14] Information is delivered in a similar manner between the apps, with a subscriber entering her estimated due date and the app listing information of interest daily, according to the woman's given gestational age.

The continuous updating and revisions that take place with smartphone technology poses a significant limitation to our study.

The content of the apps is accurate as of the preparation of this manuscript, but it is understood that the content will probably change and evolve as a response to consumer feedback. In addition, our analysis was limited to the information available through each app's daily information feed; it did not include all information that each app could exhaustively provide, as there are endless links, websites, chatrooms and videos that a women can access. Although our study could not possibly capture all possible information available through these apps, we captured all passively delivered information through each app.

In our study, we have described the thematic content and distribution of messages that are delivered through two popular smartphone applications and have highlighted areas where information is incomplete. Although this is a first step toward understanding patient-directed education through smartphone applications in the perinatal setting, the efficacy of such mobile

media-based education on perinatal outcomes is not known. T4B's original short-messaging text program is the only pregnancy-specific mobile messaging platform that has been studied to date.[6,15–17] Although the findings of these studies suggest healthier attitudes and behaviors among women enrolled in T4B text messaging, it is still unknown whether smartphone apps provide sufficient information to improve prenatal care and improve obstetric outcomes. Therefore, a future direction should be to evaluate patient understanding of prenatal care guidelines and improvement in perinatal outcomes with the use of pregnancy-specific apps and to determine patient acceptability of and reception to pregnancy-specific smartphone applications as a means of patient education. Ultimately, development of a comprehensive, more medically tailored app that conveys more prenatal care guidelines and function as a companion to prenatal care is needed to deliver more complete health-related messages and patient education during pregnancy.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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