Mobile application as a prenatal education and engagement tool:

A randomized controlled pilot

Christy J.W. LEDFORD
Department of Family Medicine
Uniformed Services University of the Health Sciences
Bethesda, USA

Mollie Rose CANZONA
Department of Communication
Wake Forest University
Winston Salem, USA

Lauren A. CAFFERTY
Department of Communication Studies
Texas State University
San Marcos, USA

Joshua A. HODGE
Department of Family Medicine
Fort Belvoir Community Hospital
Fort Belvoir, USA

Corresponding author at
4301 Jones Bridge Road, FAM
Bethesda, MD 20815
301-295-0703; fax 301-295-3100
Christian.ledford@usuhs.edu

Word count abstract: 191 Word count main text: 2,141

Presented as *StorkTracker: A randomized controlled pilot of a prenatal mobile application* at the 2014 International Conference on Communication in Healthcare, Amsterdam.

Disclaimer: The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Air Force, the Uniformed Services University of the Health Sciences, or the Department of Defense at large.

Acknowledgements: The authors acknowledge clinic champions Teresa Simpson, Yolanda Stowe, and Dr. Melissa Terry for their enthusiasm and effort in support of this study. This study was conducted within the Military Primary Care Research Network.

Abstract

Objectives: Research has shown that mobile applications provide a powerful alternative to traditional paper diaries; however, little data exists in comparing apps to the traditional mode of paper as a patient education and engagement tool in the clinical setting. This study was designed to compare the effectiveness of a mobile app versus a spiral-notebook guide throughout prenatal care.

Methods: This randomized (n=173) controlled pilot was conducted at an East Coast community hospital. Chi-square and repeated-measures analysis of variance was used to test intervention effects in the sample of 127 pregnant mothers who completed their prenatal care in the healthcare system.

Results: Patients who were distributed the mobile application used the tool to record information about pregnancy more frequently ($p = .04$) and developed greater patient activation ($p = .02$) than patients who were distributed notebooks. No difference was detected on interpersonal clinical communication.

Conclusion: A mobile application successfully activated a patient population in which self-management is a critical factor. Patients who received the mobile app reported that providers gave more emotional support and better explained in-clinic procedures.

Practice implications: This study shows that particularly for young women mobile apps can prompt greater use and result in more activated patients and better perception of care. Findings may be translated to other patient populations who receive recurring care for chronic disease.

Keywords: mobile health, patient activation, patient-provider communication, prenatal interpersonal processes of care

1. Introduction

Mobile health (mHealth) applications shift mobile telephone technology from the lean function of text messaging¹⁻⁴ to a potentially dynamic interactive and social environment that can include verbal, vocal, and visual messages.⁵ Mobile apps enable patients to record health information collected at each appointment and to track their health. As patients interact with this information, they may become more engaged in their care. Activated patients believe their roles as patients are important, that they have the confidence and knowledge necessary to take action, and that they can enact behaviors to maintain and improve their health.⁶⁻⁸ These patients take action, ask questions of the provider, and participate in decisions about treatment.⁹⁻¹¹ They are collaborative partners with the provider in their health care.⁶

Patient activation is just one factor that affects prenatal interpersonal processes of care. Interpersonal processes of care conceptually and operationally capture three dimensions of clinical care: communication, patient-centered decision making, and interpersonal style.^{12,13} In the prenatal setting, evidence has demonstrated a limited association between interpersonal processes of care and risk of Caesarean delivery.¹³

Specifically in the context of clinic communication, physicians communicate differently with patients who they perceive to be more active in clinic interactions.¹⁴ Interventions, including educational programs,¹⁵ care coaching,¹⁶ and motivational interviewing,¹⁷ have attempted to increase physician perception of active patients with varied success. Patient activation can be increased with strategic methods.^{11,18-20}

Compared to a written recording of children's health information, mothers find e-diaries easier to use, less bothersome, and more efficient.²¹ Although pregnant mothers are increasingly using mobile applications throughout their pregnancy,^{22,23} data on the extent to which the use of

apps improve care are limited.²⁴ Research has shown that mobile apps provide a powerful alternative to traditional paper diaries in weight loss promotion;²⁵ however, little data exists in comparing apps to the traditional mode of paper as a patient education and engagement tool in the clinical setting. In a randomized study of a mobile application regarding long-acting reversible contraception, patient use of a mobile app was found to be most effective in complementing interpersonal healthcare rather than replacing provider counseling.²⁶

The following randomized controlled study was designed to test the effectiveness of a mobile application as an alternative to a spiral-notebook guide throughout prenatal care. Three hypotheses are tested.

H1: Patients who are distributed a mobile application will use the education and engagement tool more than patients who are distributed notebooks.

H2: Patients who are distributed a mobile application will develop greater patient activation than patients who are distributed notebooks.

H3: Patients who are distributed a mobile application will report better prenatal interpersonal processes of care from their prenatal provider than patients who are distributed notebooks.

2. Methods

The study was conducted at a community hospital in both the women's health and family medicine departments. In this hospital system, women are distributed a spiral notebook at their obstetric care intake appointment, which generally is scheduled for 8-10 weeks gestation. The spiral notebook is designed for two purposes: 1) patient education of what happens throughout pregnancy, and 2) patient record keeping of the patient's own pregnancy experience, including space for recording weight, blood pressure, and journaling about what they experience between

prenatal appointments. The mobile app used in this study was designed for the same two purposes and contained identical content, though through a mobile design interface (available on both Android and iOS platforms). This randomized controlled study had one intervention (mobile application) and one control (standard of care – spiral notebook) group. The study was approved by the first author's Institutional Review Board.

In each department, the obstetrics intake nurse serially screened all new obstetrics patients for inclusion criteria from October 2013 to January 2014. If patients met inclusion criteria, the nurse invited the patient to talk to a research assistant about the study (See Figure 1.). Exclusion criteria included conditions that would elevate the patient's care to complicated obstetrics care (e.g., cardiovascular disease, diabetes mellitus, renal disorder, etc.). This was intended to capture a low-risk obstetrics patient population that would follow a standard 4-week pathway of care, in which patients attend a prenatal appointment once every four weeks during pregnancy.

At consent, patients were asked if they owned a device which would support a mobile application. If patients did not own a device, the study team issued them a spiral notebook. These patients ($n = 2$) were kept in the study for measurement, but were not included in data analysis. The study used pre-assigned block randomization (each block $n = 40$) to balance the conditions throughout recruitment. Following consent and baseline measures, participants were randomized to the two conditions. Providers were blinded to patient participation in the study.

Surveys were completed at each prenatal appointment, which occur approximately every four weeks. This accounted for five data collection points, from 10-12 weeks gestation to 32 weeks gestation. All data collection was conducted with paper-and-pencil surveys in the clinic, immediately before and following each clinical appointment. At each appointment, patient weight and blood pressure were also recorded from the patient's electronic medical record.

At baseline, self-reported measures included demographics, health literacy, and patient activation. Health literacy was assessed using the self-reported Functional, Communicative, Critical Health Literacy Scale.²⁷ Patient activation was assessed with the validated, licensed patient activation measure (PAM),^{7,28-30} which uses 13 Likert-type items to create a continuous patient activation measure on a scale of 0 (not activated) to 100 (most activated). PAM was also replicated at time 5 (32 week appointment).

Use was assessed with three measures. Before each appointment, patients completed two items regarding use of the education and engagement tool. First they indicated if they had brought the mobile app/notebook to the appointment with them (yes/no). Then, they reported how frequently they had used the tool over the past month 1) to *look* for information and 2) to *record* information (never = 0, once = 1, weekly = 4, or daily = 28).

Following each appointment, patients completed five subscales of the validated Prenatal Interpersonal Processes of Care (PIPC) scale, including elicitation/responsiveness to the patient, explanations of care, empowerment, patient-centered decision making, and emotional support.¹² Responses to each item were transformed onto a 0 (negative perception) to 100 (positive perception) scale, and items are averaged to create subscales. Then subscales are averaged to calculate the overall PIPC scale. Across time points for in this study, the PIPC scale's internal reliability (Cronbach's α) ranged from .797 to .891, for an average Cronbach's α = .857.

At delivery, outcomes were recorded from the health record: gestational age, birth weight, mode of delivery (vaginal or Caesarean section), and anesthesia used (epidural, spinal, or general).

3. Results

Of the 173 patients who completed consent, 87 were assigned to the mobile condition and 86 were assigned to the notebook condition. In the mobile group, 10 women experienced miscarriage, 3 women withdrew from the study, and 2 women were elevated to high-risk care. In the notebook group, 6 women experienced miscarriage and 2 women were elevated to high-risk care. Therefore, throughout the study, 72 women participated in the mobile group and 78 women participated in the notebook group. Analysis of variance (continuous variables) and chi-square (nominal variables) tests were used to compare the intervention and control groups. (See Table 1 for sample characteristics.) No group differences were detected.

In this data analysis, only patients who remained in low-risk obstetrics care in the health system through 32 weeks are included (notebook group $n = 65$, mobile group $n = 62$). Throughout data collection, some participants did not complete every survey for the following reasons: patient arriving early for appointment (without research-assistant notification), patient declining survey after appointment due to time constraints, and clinic canceled appointments due to weather conditions. For these missing surveys, mean linear regression imputation was used on individual sub-scaled items. When comparing the two conditions among women included in data analysis, tests showed no significant group differences.

For the first hypothesis, chi-square tested condition effects on if the patient brought the tool with her to the appointment. At 10-12 weeks, there was not a significant difference between conditions. Then starting at the 16-20 week appointment and throughout the remainder of the pregnancy, patients in the mobile group were repeatedly more likely to bring the mobile app to the appointment as compared to women bringing the notebook, $\chi^2(1,119) = 9.38, p < .01$. A repeated measures analysis of variance (RM ANOVA) model tested intervention effects on the

five time-point measurements of patient use of the tool to find information about pregnancy. No significant difference was detected between the two groups. The RM ANCOVA was then repeated on patient use of the tool to record information about her pregnancy. Across all time points, the mobile group reported more frequent use than the notebook group, $F(1, 118) = 4.10$, $p > .05$, $\eta^2 = .03$. Therefore, hypothesis one is partially supported.

For the second hypothesis, an analysis of covariance (ANCOVA) tested the effect of condition on patient activation at time 5 (32 weeks pregnant), controlling for baseline patient activation. Condition had a significant association with patient activation, $F(1, 127) = 4.99$, $p > .05$, $\eta^2 = .04$. At time 5, the estimated marginal mean for patient activation in the notebook group was 74.81; the estimated marginal mean for patient activation in the mobile group was 79.88. Therefore, hypothesis two was supported: patients who were distributed the mobile application developed greater patient activation than patients who were distributed notebooks.

For the third hypothesis, a repeated measures analysis of variance (RM ANOVA) model tested intervention effects on five time-point measurements of prenatal interpersonal processes of care (PIPC). Condition had only a marginal effect on PIPC, $F(1, 123) = 2.75$, $p = .10$, $\eta^2 = .02$. Across all time points, the mobile group rated PIPC higher than the notebook group (See Figure 2.) However, this difference was not statistically different. To interpret this finding, the RM ANOVA was replicated on the subscales of PIPC. The effect was significant for emotional support, $F(1, 119) = 4.19$, $p = .04$; and was moderate for explanation, $F(1, 119) = 3.17$, $p = .08$. No effect was detected for the other three subscales. Therefore, hypothesis three was not statistically supported only marginally supported: patients who were distributed the mobile application reported better prenatal interpersonal processes of care from their prenatal provider than patients who were distributed notebooks.

Though not hypothesized, intervention effects were tested on blood-pressure control and weight gain throughout the pregnancy. Intervention effects were also tested on delivery outcomes: gestational age, birth weight, delivery mode, anesthesia delivery. No difference was detected by any biometrics.

4. Discussion and conclusion

4.1 Discussion

In this longitudinal test over six months of use, patients who were given a mobile app for prenatal education and engagement used the app to record information about their pregnancy more frequently and became more activated and reported that providers gave more emotional support and better explained in-clinic procedures than patients who were given a spiral notebook for the same purpose. These two effects demonstrate a longitudinal benefit of mobile apps that can outpace the utility of spiral notebooks as a patient aid. Though no difference was detected on biometrics, patient activation is a factor that can influence lifelong health outcomes.

Additionally, no significant difference was detected on prenatal interpersonal processes of care; however, the mobile group consistently rated their care higher. One potential explanation of this mobile app effect is the symbol-carrying capacity patients ascribe to communication tools.^{31,32} Specifically in this case, patients may perceive that when their health system develops a mobile app specific to their care, they are receiving better health care. This interpretation draws from the finding that pregnant mothers who received the app rated their perception of interpersonal processes of care higher than those who had received the spiral notebook, immediately at their next appointment and then through their 32-week appointment. This perception may prompt patient activation and then a virtuous cycle of greater use, perception of

better care, and higher activation. This explanation also reinforces that this study looked at how mobile apps can enhance patient care, not replace it.

Findings are limited by the design, which focused on low-risk obstetrics patients. Differences detected here may not exist among high-risk obstetrics patients who are faced with the need to document greater health challenges throughout pregnancy. Findings are also limited by the number of participants who completed surveys through 32 weeks pregnancy. We did not include women in the data analysis who left the healthcare system at some point during pregnancy. The two primary reasons for leaving the system were elevation of prenatal care to high-risk obstetrics care or moving to a new location for work. Generalizability is also limited by the single-site design. The women who participated in this study reflected the local population, and that population was primarily white highly educated, and married. Future research is needed to replicate this study in different populations as health care systems move forward with mobile app development to improve patient education and engagement.

4.2 Conclusion

A mobile application successfully activated a patient population in which self-management is a critical factor. Findings may be translated to other patient populations who receive recurring care for chronic disease.

4.3 Practice implications

This study shows that particularly for women mobile apps can prompt greater use and result in more activated patients and better perception of care. Specific groups who may benefit are young women with endocrine disorders or rheumatologic disorders. The translation of mobile apps to other patient populations must include study of those populations' media use to assess the appropriate mode.

References

1. Strandbygaard U, Thomsen SF, Backer V. A daily SMS reminder increases adherence to asthma treatment: a three-month follow-up study. *Resp Med*. 2010;104:166-71.
2. Holtz B, Whitten P. Managing asthma with mobile phones: a feasibility study. *Telemed J E Health*. 2009;15:907-9.
3. Franklin VL, Greene A, Waller A, Greene SA, Pagliari C. Patients' engagement with "Sweet Talk" - a text messaging support system for young people with diabetes. *J Med Internet Res*. 2008;10:e20.
4. Leong KC, Chen WS, Leong KW, et al. The use of text messaging to improve attendance in primary care: a randomized controlled trial. *Fam Pract*. 2006;23:699-705.
5. Whittaker R, Maddison R, McRobbie H, et al. A multimedia mobile phone-based youth smoking cessation intervention: findings from content development and piloting studies. *J Med Internet Res*. 2008;10.
6. Hibbard JH, Mahoney ER, Stock R, Tusler M. Do increases in patient activation result in improved self-management behaviors? *Health Serv Res*. 2007;42:1443-63.
7. Hibbard JH, Stockard J, Mahoney ER, Tusler M. Development of the Patient Activation Measure (PAM): conceptualizing and measuring activation in patients and consumers. *Health Serv Res*. 2004;39:1005-26.
8. Williams SS, Heller A. Patient activation among Medicare beneficiaries: Segmentation to promote informed health care decision making. *Int J Pharm Health Marketing*. 2007;1:199-213.
9. Cortes DE, Mulvaney-Day N, Fortuna L, Reinfeld S, Alegria M. Patient-Provider Communication: Understanding the Role of Patient Activation for Latinos in Mental Health Treatment. *Health Educ Beh*. 2009;36:138-54.
10. Griffin SJ, Kinmonth A-L, Veltman MWM, Gillard S, Grant J, Stewart M. Effect on health-related outcomes of interventions to alter the interaction between patients and practitioners: a systematic review of trials. *Ann Fam Med*. 2004;2:595-608.
11. Deen D, Lu W-H, Rothstein D, Santana L, Gold MR. Asking questions: the effect of a brief intervention in community health centers on patient activation. *Patient Educ Couns*. 2011;84:257-60.
12. Wong ST, Korenbrot CC, Stewart AL. Consumer assessment of the quality of interpersonal processes of prenatal care among ethnically diverse low-income women: development of a new measure. *Women Health Iss*. 2004;14:118-29.
13. Hessol NA, Odouli R, Escobar GJ, Stewart AL, Fuentes-Afflick E. Interpersonal processes of care and cesarean delivery in two health care settings. *Amer J Pub Health*. 2012;102:1722-8.
14. Street RL, Gordon H, Haidet P. Physicians' communication and perceptions of patients: Is it how they look, how they talk, or is it just the doctor? *Soc Sci Med*. 2007;65:586-8.
15. Li T, Wu HM, Wang F, et al. Education programmes for people with diabetic kidney disease. *Cochrane Database Sys Rev*. 2011.
16. Lin W-C, Chien H-L, Willis G, et al. The effect of a telephone-based health coaching disease management program on Medicaid members with chronic conditions. *Med Care*. 2012;50:91-8.
17. Linden A, Butterworth SW, Prochaska JO. Motivational interviewing-based health coaching as a chronic care intervention. *J Eval Clin Prac*. 2010;16:166-74.

18. Deen D, Lu WH, Weintraub MR, Maranda MJ, Elshafey S, Gold MR. The impact of different modalities for activating patients in a community health center setting. *Patient Educ Couns.* 2012;89:178-83.
19. Lu W-H, Deen D, Rothstein D, Santana L, Gold MR. Activating community health center patients in developing question-formulation skills: A qualitative study. *Health Educ Beh.* 2011;38:637-45.
20. Ledford CJ, Ledford CC, Childress MA. Extending Physician ReACH: influencing patient activation and behavior through multichannel physician communication. *Patient Educ Couns.* 2013;91:72-8.
21. Lam J, Barr RG, Catherine N, et al. Electronic and paper diary recording of infant and caregiver behaviors. *J Dev Behav Pediatr.* 2010;31:685-93.
22. Robinson F, Jones C. Women's engagement with mobile device applications in pregnancy and childbirth. *Prac midwife.* Jan 2014;17:23-5.
23. Fleming SE, Vandermause R, Shaw M. First-time mothers preparing for birthing in an electronic world: internet and mobile phone technology. *J Reprod Inf Psych.* 2014;1-14.
24. Agarwal S, Labrique A. Newborn health on the line: the potential mHealth applications. *JAMA.* 2014;312:229-30.
25. Turner-McGrievy GM, Beets MW, Moore JB, Kaczynski AT, Barr-Anderson DJ, Tate DF. Comparison of traditional versus mobile app self-monitoring of physical activity and dietary intake among overweight adults participating in an mHealth weight loss program. *J American Med Informatics Assoc.* 2013;20:513-8.
26. Sridhar A, Chen A, Forbes ER, Glik D. Mobile application for information on reversible contraception: a randomized controlled trial. *American J Obs Gyn.* 2015; 212: 774.
27. Ishikawa H, Takeuchi T, Yano E. Measuring Functional, Communicative, and Critical Health Literacy Among Diabetic Patients. *Diab Care.* 2008;31:874-9.
28. Hibbard JH, Mahoney ER, Stockard J, Tusler M. Development and Testing of a Short Form of the Patient Activation Measure. *Health Serv Res.* 2005;40:1918-30.
29. Greene J, Hibbard JH. Why does patient activation matter? An examination of the relationships between patient activation and health-related outcomes. *J Gen Intern Med.* 2012;27:520-6.
30. Greene J, Hibbard JH, Sacks R, Overton V. When seeing the same physician, highly activated patients have better care experiences than less activated patients. *Health Aff.* 2013;32:1299-305.
31. Sitkin S, Sutcliffe KM, Barrios-Choplin JR. A dual-capacity model of communication media choice in organizations. *Human Commun Res.* 1992;18:563-98.
32. Ledford CJW. Changing Channels: A Theory-Based Guide to Selecting Traditional, New, and Social Media in Strategic Social Marketing. *Social Mark Q.* 2012;18:175-86.

Table 1. Sample characteristics by condition as randomized and as included in study results

		Overall (N = 150)	Randomized		Included in present analysis	
			Notebook (N = 78)	Mobile app (N = 72)	Notebook (N = 65)	Mobile app (N = 62)
Age		28.91 (sd 5.03)	29.12 (sd 5.00)	28.69 (sd 5.10)	29.37 (sd 4.83)	29.29 (sd 4.80)
Ethnicity	Asian/Pacific islander	8 (5.6%)	7 (9%)	1 (1.4%)	5 (7.7%)	1 (1.6%)
	Black/African-American	14 (9.7%)	10 (12.8%)	5 (6.9%)	8 (12.3%)	5 (8.1%)
	Caucasian/white	100 (69.4%)	48 (61.5%)	55 (76.4%)	39 (60%)	47 (75.8%)
	Hispanic	15 (10.4%)	9 (11.5%)	7 (9.7%)	9 (13.8%)	6 (9.7%)
	Native American/Alaskan native	1 (.7%)	0	1 (1.4%)	0	1 (1.6%)
	Choose not to respond	1 (.7%)	0	2 (2.8%)	0	1 (1.6%)
	Multi-answer	5 (3.5%)	4 (5.1%)	1 (1.4%)	4 (4.9%)	1 (1.6%)
Marital status	Single	6 (4.2%)	5 (6.4%)	2 (2.8%)	5 (7.7%)	1 (1.6%)
	Married	133 (92.4%)	70 (89.7%)	68 (94.4%)	58 (89.2%)	59 (95.2%)
	Divorced	4 (2.8%)	3 (3.8%)	1 (1.4%)	2 (3.1%)	1 (1.6%)
	Other	1 (.7%)	0	1 (1.4%)	0	1 (1.6%)
Education	Less than high school	1 (.7%)	1 (1.3%)	0	1 (1.5%)	0
	High school	8 (5.6%)	5 (6.4%)	5 (6.9%)	4 (6.2%)	2 (3.2%)

Some college	43 (29.9%)	25 (32.1%)	20 (27.8%)	20 (30.8%)	17 (27.4%)
Bachelor's degree	58 (40.3%)	28 (35.9%)	31 (43.1%)	26 (21.5%)	27 (43.5%)
Post bachelor's degree	34 (23.6%)	19 (24.4%)	16 (22.2%)	14 (21.5%)	16 (25.8%)
Gravida	2.11 (sd 1.09)	1.97 (.98)	2.25 (1.18)	2.05 (1.01)	2.27 (1.16)
Health literacy	4.17 (sd .42)	4.18 (.41)	4.15 (.44)	4.17 (.42)	4.15 (.43)

Figure 1. CONSORT flow diagram

The following figure illustrates recruitment, allocation, and follow up for each condition.

Figure 2. Comparison of traditional notebook and mobile app groups on the Prenatal Interpersonal Processes of Care (PIPC)

Patients who had received the mobile app reported better interpersonal processes of care than patients who had received the spiral notebook. The difference was not significantly different.