Published in final edited form as:

Vaccine. 2017 March 13; 35(11): 1551–1558. doi:10.1016/j.vaccine.2017.01.037.

Evaluation of two vaccine education interventions to improve pertussis vaccination among pregnant African American women: a randomized controlled trial

Jennifer L. Kriss^a, Paula M. Frew^{b,c}, Marielysse Cortes^c, Fauzia A. Malik^c, Allison T. Chamberlain^d, Katherine Seib^c, Lisa Flowers^e, Kevin A. Ault^f, Penelope P. Howards^d, Walter A. Orenstein^g, and Saad B. Omer^{c,d,h}

^aEmory University, Department of Epidemiology and Laney Graduate School, Atlanta, GA.

^bEmory University, Rollins School of Public Health, Department of Behavioral Sciences and Health Education, and Division of Infectious Diseases, Department of Medicine, Atlanta, GA.

^cEmory University, Rollins School of Public Health, Hubert Department of Global Health, Atlanta, GA.

^dEmory University, Rollins School of Public Health, Department of Epidemiology, Atlanta, GA.

^eEmory University, School of Medicine, Department of Gynecology and Obstetrics, Atlanta, GA.

^fUniversity of Kansas Medical Center, Department of Obstetrics and Gynecology, Kansas City, KS.

^gEmory University, Emory Vaccine Center and School of Medicine, Atlanta, GA.

^hEmory University, Department of Pediatrics, Atlanta, GA.

Abstract

Background—Vaccination coverage with tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine in pregnancy or immediately postpartum has been low. Limited data exist on rigorously evaluated interventions to increase maternal vaccination, including Tdap. Tailored messaging based on the Elaboration Likelihood Model (ELM) framework has been successful in improving uptake of some public health interventions. We evaluated the effect of two ELM-based vaccine educational interventions on Tdap vaccination among pregnant African American women, a group of women who tend to have lower vaccine uptake compared with other groups.

Corresponding Author: Jennifer L. Kriss, PhD, MPH, Emory University, Rollins School of Public Health, Department of Epidemiology, Atlanta, GA, 30322, JKriss@cdc.gov.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

Trial Registration: clinicaltrials.gov Identifier: NCT01740310

Conflicts of interest.

None

Methods—We conducted a prospective randomized controlled trial to pilot test two interventions – an affective messaging video and a cognitive messaging iBook – among pregnant African American women recruited during routine prenatal care visits. We measured Tdap vaccination during the perinatal period (during pregnancy and immediately postpartum), reasons for non-vaccination, and intention to receive Tdap in the next pregnancy.

Results—Among the enrolled women (n=106), 90% completed follow-up. Tdap vaccination in the perinatal period was 18% in the control group; 50% in the iBook group (Risk Ratio [vs. control group]: 2.83; 95% CI, 1.26–6.37), and 29% in the video group (RR: 1.65; 95% CI, 0.66–4.09). From baseline to follow-up, women’s reported intention to receive Tdap during the next pregnancy improved in all three groups. Among unvaccinated women, the most common reason reported for non-vaccination was lack of a recommendation for Tdap by the woman’s physician.

Conclusions—Education interventions that provide targeted information for pregnant women in an interactive manner may be useful to improve Tdap vaccination during the perinatal period. However, larger studies including multiple ethnic groups are needed to evaluate robustness of our findings.

Keywords

Elaboration Likelihood Model; maternal immunization; pertussis; Tdap; vaccine; whooping cough

1. Introduction

Pertussis has recently reappeared in the U.S. and in many other countries.[1, 2] Infants too young to be completely vaccinated have the highest burden of pertussis-related morbidity and mortality.[3–6] Immunization with tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis (Tdap) vaccine of mothers and others with infant contact is a strategy to protect young infants from pertussis before they are fully vaccinated. In 2011, the Advisory Committee on Immunization Practices (ACIP) recommended that pregnant women who have not previously been vaccinated with Tdap receive the vaccine during the third or late second trimester, or immediately postpartum if not administered during pregnancy.[7] The ACIP currently recommends that pregnant women be vaccinated with Tdap during every pregnancy, regardless of immunization history, and women who are not vaccinated in pregnancy should be vaccinated immediately postpartum.[8]

Despite the ACIP recommendations, maternal Tdap vaccination in the U.S. remains low and there is a need for evidence-based strategies for increasing maternal Tdap coverage. However, very limited data exist on rigorously evaluated interventions to increase the coverage of maternal vaccines.[9, 10] Tailored messaging based on the Elaboration Likelihood Model (ELM) framework has been successful in improving human papillomavirus (HPV) vaccine uptake[11] and breast cancer screening,[12] and may be useful in improving pertussis vaccination among pregnant women.

The ELM describes two types of information processing – central and peripheral – by which individuals receive and process information. Central processing is evoked when an individual has the motivation and ability to analyze a message that is information-based and

personally relevant; central processing tends to occur for decisions that are higher-risk, and result in stronger and less modifiable behavioral changes. In contrast, peripheral processing is evoked when simplistic messages or peripheral cues (e.g., brand logos) are used; peripheral processing tends to result in behavioral changes that are more subject to change and less enduring.[13] Given that in the context of vaccination a more enduring change in attitude is required, educational messages that utilize the central route may be more appropriate. However, it is unclear how these messages can be effectively delivered. Our evaluation of communication strategies to increase maternal pertussis vaccination helps to fill the substantial evidence gap for rigorously evaluated interventions for increasing vaccine acceptance among this population.[14]

This study was designed to: 1) evaluate whether two vaccine education interventions based on the ELM framework administered during the prenatal period improved Tdap vaccination among pregnant African American women, 2) evaluate whether the interventions affect the reasons women report for non-vaccination, 3) assess women's engagement with the interventions, and 4) assess whether provider recommendation was associated with perinatal Tdap vaccination irrespective of education interventions. This study, conducted among pregnant African American women, has important implications for minority women for whom distrust, a lack of information, and fear of vaccination may result in lower vaccination rates compared with other population groups.[7, 15–17]

2. Data and methods

2.1. Study design

This study was a prospective, randomized, controlled trial designed to pilot test two ELM-based vaccine education interventions to improve maternal vaccine receipt in the perinatal period. The study population consisted of African American pregnant women in the Atlanta, Georgia metropolitan area. We selected only African American women for our study sample in order to reduce heterogeneity that would result from including women from other diverse racial and ethnic backgrounds for which an array of cultural factors may have played a role in their response to the message framing, formatting style, and content. Women were recruited into the study during routine prenatal care visits at their obstetrician-gynecologist (ob-gyn) offices. Four antenatal clinics in metropolitan Atlanta participated as enrollment sites. The clinics selected for this study served populations of pregnant women who were racially and socioeconomically diverse and represented the metropolitan Atlanta area. Relationships with these clinics were well established through previous research experiences.

2.2. Recruitment

Recruitment occurred during the 2013 influenza season (January 30–April 3, 2013); this period was chosen for recruitment because one of the study outcomes of interest was influenza vaccination (results published previously[18]). Pregnant African American women ages 18–50 years with an expected delivery date of January 30–June 30, 2013 were eligible for inclusion in the study. Women were not eligible if they had already received the influenza or Tdap vaccine during the current pregnancy.

Women were approached by trained study personnel in the waiting rooms of antenatal clinics if they appeared to be eligible for the study (based on pregnancy status, age, and race) and were asked if they would participate in an interview on women's health education. For eligible and interested participants, an informed consent document was read to the participant and written informed consent was obtained. Enrolled women completed a baseline questionnaire to assess attitudes regarding vaccination before randomization.

2.3. Randomization and interventions

A master database which provided randomization assignments was generated by non-study personnel. Randomization lists were produced separately for each of the four study sites. Participants were randomly assigned to the control group or to one of two vaccine education interventions based on the ELM central processing route: 1) an affective messaging video titled "Pregnant Pause," or 2) a cognitive messaging iBook titled "Vaccines for a Healthy Pregnancy." Both vaccine education interventions were completed on a handheld electronic tablet device and were designed to take no longer than 20 minutes, to enable patients to complete them while waiting for their prenatal appointments.

The "Pregnant Pause" video was targeted specifically to pregnant women and showed physicians providing detailed information on Tdap and influenza vaccines, the severity of pertussis and influenza, how the vaccines protect pregnant women and newborns, safety information, and the current ACIP recommendations. The interactive iBook was based on an educational tutorial developed for a previous study,[9] but modified to exclude affective testimonial videos of parents whose infants contracted influenza and pertussis. This tutorial provided information through a question-and-answer format on the topics of antenatal Tdap and influenza vaccination, vaccine safety, pertussis and influenza among pregnant women and infants, and the current ACIP recommendations for vaccination during pregnancy. Women could choose the topic(s) that most interested them and complete each tutorial section separately. The video and iBook were given to the women in the waiting room, and if not completed before the woman was called back for her appointment, the woman was allowed to take the iPad to her examination room to complete. Women randomized to the control arm received the standard CDC Vaccine Information Statements (VIS) on Tdap and influenza vaccines. These statements are paper-based, text-only, non-interactive, and do not contain information specifically targeted for pregnant women.

Study personnel recorded start and end times that participants spent on each section of the interventions, and observed the women's engagement in the intervention activities. Study personnel assigned a score of each woman's engagement in the interventions; for each section of the interventions an engagement score between 1 and 5 was given (1=very engaged, 2=engaged, 3=neither engaged nor disengaged, 4=disengaged, 5=very disengaged). Observation by study personnel was done in an unobtrusive manner to minimize the effect on participants' experiences with the interventions. Those who were randomized to one of the two interventions completed a brief post-intervention questionnaire which had been described at enrollment, and which asked about information learned, confidence in the evidence presented, and comprehension of the information. Women in the control group did not complete a post-intervention questionnaire, in order to replicate the currently used

practice in which women are provided with text-based vaccine information statements which they must read and comprehend themselves, with no formalized follow-up to ensure their understanding of the information.

2.4. Outcomes

The main outcome presented in this paper is Tdap vaccination during the perinatal period, which includes during pregnancy and immediately postpartum (vaccination after delivery and before discharge from the hospital). All perinatal vaccination measured by this study occurred after enrollment, since women who had already received the influenza or Tdap vaccine during the current pregnancy were ineligible to enroll in the study. These outcomes were assessed via self-report during a follow-up survey conducted 1–2 months (mean=47 days) after the expected delivery date. Other outcomes included intention to receive Tdap in the next pregnancy (scale of 0 [definitely will not]–10 [definitely will]) and reasons for non-vaccination with Tdap. The follow-up questionnaire also asked about health of the mother and infant, birth characteristics, Tdap and influenza vaccination during the perinatal period, recommendation by ob-gyn or nurse midwife for Tdap and influenza vaccine, reasons for vaccination or non-vaccination, perceptions and concerns about pertussis and influenza, and plans for vaccination of infants (scale 0 [definitely will not]–10 [definitely will]). Follow-up was conducted via telephone; contact attempts were also made by email or social media for women who had given consent for this type of contact. Participants received grocery store gift cards after completion of the baseline questionnaire (\$35) and the follow-up questionnaire (\$50).

2.5. Study power and sample size

Power and sample size calculations were based on ensuring adequate power for the outcome of maternal vaccination during pregnancy; in order to have 80% power to detect a 20 percentage point increase in vaccine coverage in each of the intervention arms compared with the control arm, we planned to enroll 162 women, or 54 women in each study arm. Due to smaller than expected numbers of eligible participants, the target sample size was not enrolled before the end of the 2013 influenza season recruitment period (January 30–April 3, 2013), and enrollment was not continued after the end of influenza season because one of the primary study outcomes was influenza vaccination. The smaller than planned study sample size results in limited power to detect effects.

2.6. Statistical analysis

Descriptive analyses were conducted to characterize the study population. We used chi-square tests and t-tests to test for differences in proportions and means between the randomization arms. We assessed the success of randomization with respect to maternal age, education, gravidity, health insurance, and health seeking behavior. Risk ratios (RRs) were calculated for the dichotomous study outcomes from log-binomial regression models. The outcome maternal intention to be vaccinated with Tdap in the next pregnancy (a 0–10 scale) was divided into three categories (low likelihood [0–3], medium likelihood [4–6], and high likelihood [7–10]), and polytomous logistic regression models were used to calculate odds ratios (ORs). All analyses were based on intention-to-treat and were conducted using SAS

version 9.4 (SAS Institute, Inc., Cary, NC). This study was approved by the institutional review board of Emory University.

3. Results

A total of 741 women were approached for recruitment; 224 (30%) declined eligibility screening and 392 (53%) were ineligible (Fig. 1). Out of 125 women who were screened and eligible, 106 (85%) agreed to participate and were enrolled in the study. Ninety-five (90%) of the women completed follow-up after giving birth, of which 34 were in the control group, 31 were in the video group, and 30 were in the iBook group. The remaining 11 women were lost to follow-up due to incorrect telephone numbers or inability to contact them.

Women who completed follow-up were on average 26 years of age (Table 1). The majority of respondents had less than a college degree (91%), and the average number of current children was 1.2 (SD 1.4). Most women (92%) had health insurance at the time of the survey, primarily Medicaid (88%). The mean gestational age at time of enrollment in the study was 7.3 months (range 4.6–9.1 months), calculated based on the due date reported by participants. Most women had not received an influenza vaccine in the last five years (63%) or did not know if they had (12%). Only 10% received an influenza vaccine in at least two of the last five years. More women assigned to the video arm had received an influenza vaccine at least once in the last five years (35%) compared with women assigned to the iBook arm (10%) ($p=0.008$). At baseline, women were moderately hesitant about getting vaccines that their doctor recommended during pregnancy (4.5 on a scale of 0 [not hesitant] to 10 [very hesitant]), and reported low average likelihood of getting the Tdap (3.0) or influenza (2.1) vaccine during their current pregnancy (0 [definitely will not] to 10 [definitely will] scale). In contrast, most women said they planned to vaccinate their babies with all recommended childhood vaccines (8.2).

Overall, 32% of respondents reported receiving Tdap vaccine during the perinatal period (Fig. 2A), including 6% ($n=6$) vaccinated during pregnancy, and an additional 25% ($n=24$) vaccinated in the immediate postpartum period. No women reported that they were vaccinated with Tdap both during pregnancy and immediately postpartum.

In the control group, 18% of women were vaccinated with Tdap in the perinatal period – 6% during pregnancy and 12% immediately postpartum. In the iBook group, 50% of women were vaccinated with Tdap in the perinatal period (Risk Ratio [for comparison with control group]: 2.83; 95% CI, 1.26–6.37); 7% received the vaccine during pregnancy (RR not calculated due to $n<5$) and 43% received it in the postpartum period (RR: 3.71; 95% CI, 1.37–10.09) (Fig. 2A, Supplementary Table 1). In the video group, 29% were vaccinated with Tdap in the perinatal period (RR: 1.65; 95% CI, 0.66–4.09); 6% received Tdap during pregnancy (RR not calculated due to $n<5$) and 23% received it in the postpartum period (RR: 1.93; 95% CI, 0.63–5.92).

At baseline, women reported their average likelihood of getting Tdap during the current pregnancy as 3.0 (SD 3.4) on a 0 [definitely will not]–10 [definitely will] scale (Table 1). When asked again at follow-up, the average likelihood of getting Tdap during the next

pregnancy was 6.3 (SD 3.6). From baseline to follow-up, women's reported intention to receive Tdap vaccine improved in all three arms of the study (Fig. 2B, Supplementary Table 1).

Participant engagement in the intervention, as measured by the observing interviewer, was higher in the video group (88% very engaged or engaged) than in the iBook group (56% very engaged or engaged) (Fig. 3, Supplementary Table 2). More women in the video group said they felt they could relate to the educational material compared with women in the iBook group (68% vs. 37%, $p=0.02$), and they were more likely to believe that there was evidence to support the vaccine information presented (77% vs. 50% said the producers of the video and iBook, respectively, could provide evidence to support vaccine claims, $p=0.03$). The video was also easier to understand, with 97% saying they clearly understood it, compared with 77% of iBook users ($p=0.02$).

Among women who reported that they did not receive Tdap during pregnancy, the two most frequent reasons were not receiving a recommendation for Tdap from their doctor (48%) and not knowing about Tdap (44%) (Table 2). Other reasons given were unsure what Tdap was for (25%), did not think they were at risk for tetanus, diphtheria, or pertussis (19%), and do not generally take vaccines (14%). A smaller percentage of women in the iBook group reported that they were unsure what Tdap was for (15%, compared with 28% in the control group and 31% in the video group), but differences were not statistically significant.

Among women who recalled their ob-gyn or nurse midwife recommending Tdap during pregnancy, 67% received the vaccine in the perinatal period, compared with 18% among those who did not recall receiving a Tdap recommendation (Table 3). In adjusted models, recalling receipt of a Tdap recommendation from an ob-gyn or nurse midwife was associated with increased likelihood to be vaccinated (practice-adjusted model: aRR: 3.45; 95% CI, 1.88–6.34; intervention-adjusted model: aRR: 3.32; 95% CI, 1.85–5.98; models could not adjust for both covariates due to non-convergence). Cell sizes were too small to analyze Tdap vaccination during pregnancy only.

4. Discussion and conclusions

This is the first prospective randomized controlled trial to comparatively assess the effect of ELM-based education interventions on maternal vaccine uptake. A small number of women in this study were vaccinated with Tdap during their pregnancy; most women who received Tdap sometime in the perinatal period received it immediately postpartum, which is not consistent with the current primary recommendations for Tdap during pregnancy. The iBook – a high-involvement cognitive messaging intervention – was associated with Tdap vaccination immediately postpartum that was more than three times that of women in the control group. However, sample sizes were too small to allow for analysis of improvement in vaccination during pregnancy, which was the primary intent of the iBook. Women in the video group – a high-involvement affective messaging education intervention – had a 65% (but not statistically significant) increase in Tdap vaccination during the perinatal period, also driven by vaccination immediately postpartum. Previous research on the use of entertainment-education has found mixed results on its effectiveness in completely

transforming behavior.[19–22] Although the iBook used in our study could be tailored to each woman's needs through her independent choice of which topic(s) to view and spend time on, in our study women were less engaged with the iBook than with the video, and study participants rated the iBook as less relatable and more difficult to understand than the video. However, of the two education interventions, the iBook was associated with higher Tdap uptake in the perinatal period. The video was designed to evoke an emotional response with its affective entertainment-education storyline, and this approach demonstrated a modest but non-significant improvement in Tdap vaccination during the perinatal period, despite women seeming to be more engaged with it.

Research has been limited on methods to improve Tdap vaccination during pregnancy. An intervention package including an iBook-based interactive tutorial, provider-to-patient talking points, and materials including posters, brochures, and lapel buttons, was tested in obstetric practices in Georgia and was not found to significantly improve pregnant women's vaccination with Tdap [9] or to significantly change women's attitudes and beliefs toward receiving Tdap vaccine during pregnancy [23]. These studies evaluating interventions to improve perinatal Tdap vaccination have been conducted in limited geographic areas, and more geographically diverse research is needed. Given the differing findings related to the effect of educational interventions on perinatal Tdap vaccination in our study and others, future research should investigate what specific factors motivate women in different racial and socioeconomic strata to receive a Tdap vaccination during pregnancy.

In our study, women's reported intention to receive Tdap in the next pregnancy improved in all three arms from baseline to follow-up, which may be because of involvement in the study itself resulting in greater awareness of Tdap. However, this study did not follow women to their next pregnancy to determine whether intent to be vaccinated in the future translated into actual vaccination. We found that the two most frequent barriers to vaccination were lack of physician recommendation and lack of knowledge about Tdap. Even when women were provided with tailored information on Tdap, it appears that some women did not process the information or remember the messages that were presented. Following a vaccination campaign in England, women who decided not to get vaccinated gave similar reasons regarding feeling uninformed, lack of provider recommendation and encouragement, and uncertainties about risks.[24] We found that medical provider recommendation of Tdap vaccination was strongly associated with increased receipt of Tdap during the perinatal period, which Chamberlain et al. similarly found [9]. Physician recommendation and offer of vaccine have been associated with improved coverage for many vaccines, including influenza and pneumococcal vaccination of high-risk adults,[25] influenza vaccination of older adults,[26] HPV vaccination of adolescents,[27] and influenza vaccination of women during pregnancy.[28]

This study has several limitations. It was designed as a pilot study, and therefore has a small sample size and limited power to detect effects. The target sample size was calculated based on ensuring adequate power for the outcome of influenza vaccination during pregnancy, which is more common in the population than Tdap vaccination. Also, because of smaller than expected numbers of eligible participants resulting in slower recruitment before the end of the 2013 influenza season, the target sample size was not reached. Thus, this study is

underpowered for detecting differences in Tdap outcomes, and we were unable to model Tdap vaccination during pregnancy due to small cell sizes. Second, vaccination and provider recommendation were based only on self-report, and may be subject to poor recall. We did not validate vaccination or provider recommendation using medical records or a vaccine registry. Women were asked about vaccination on average 1.5 months after delivery, and misclassification of Tdap vaccination status is a possibility. It is also possible that women confused Tdap with influenza vaccine, since both are recommended during pregnancy. Additionally, women may not have accurately reported whether their provider recommended Tdap; they may have forgotten that they received a recommendation, or inaccurately reported a postpartum recommendation as a recommendation received during pregnancy. Third, we do not have information on the delivery hospital of each woman and Tdap vaccination policies there, so we cannot control for this potentially important source of confounding. Fourth, all analyses were conducted based on intention-to-treat, but it is possible that some of the women who were randomized to the education interventions did not have time to complete the entire activity while waiting for their prenatal appointment. If women were unable to complete either of the interventions, they may have missed important messages or failed to process the information, which would result in biased estimates of effect. We did not collect information on the number of women who were unable to complete the interventions in the available time. Fifth, the population included in this study was limited to African American women in a southeastern metropolitan area. Therefore, findings may not be generalizable to non-African American populations or to populations outside of the target geographic area.

In conclusion, in this randomized controlled trial, most women who reported receiving Tdap in the perinatal period received it immediately postpartum. Only a small number were vaccinated during pregnancy and in accordance with the current recommendations. Provider recommendation for Tdap vaccination was associated with increased likelihood of vaccination in the perinatal period, but health care providers may not be providing adequate information to all women, resulting in overall sub-optimal Tdap vaccination of pregnant women. This study suggests that education interventions that provide targeted information for pregnant women in an interactive manner may be useful in improving Tdap vaccination in the perinatal period, but larger studies among more heterogeneous populations are needed.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We would like to thank all study participants and study sites for their involvement in this study. We also thank Emory University Rollins School of Public Health graduate research assistants Amy Baugher, Eileen Curran, Jaime Hamil, Samir Hussaini, Heather March, Rosalie Robateau, Diane Saint-Victor, Mariam Siddiqui, and Georgia Tech graduate research assistant Rebekah St. Clair for their assistance in developing study materials, recruiting and interviewing participants, and/or managing data. We would like to thank the following for their participation in the "Pregnant Pause" video: Chris Aschenbrenner, John Brunet, Mark Conde, Matthew Cone, Vincent Fenimore, Vicki Freimuth, Susan Gerbensky-Klammer, Brooke Montgomery, Tequilla Pryor, Laura Riley, Eve Shapiro, and Sheena Simmons. We also wish to thank Dr. Lisa Flowers of Emory University School of Medicine and Grady Memorial Hospital; Dr. Michael Lindsay, Carole West, Shirley Marshall, and Chadrick Anderson of Grady Memorial Hospital; and Dr. Robert Bednarczyk of Emory University Rollins School of Public Health.

References

1. Centers for Disease Control and Prevention. [Accessed December 24, 2015] Pertussis (whooping cough). Fast facts. 2015. Available at <http://www.cdc.gov/pertussis/fast-facts.html>
2. Crowcroft NS, Stein C, Duclos P, Birmingham M. How best to estimate the global burden of pertussis? *Lancet Infect Dis*. 2003; 3:413–8. [PubMed: 12837346]
3. Cortese MM, Baughman AL, Zhang R, Srivastava PU, Wallace GS. Pertussis hospitalizations among infants in the United States, 1993 to 2004. *Pediatrics*. 2008; 121:484–92. [PubMed: 18310196]
4. Haberling DL, Holman RC, Paddock CD, Murphy TV. Infant and maternal risk factors for pertussis-related infant mortality in the United States, 1999 to 2004. *The Pediatric infectious disease journal*. 2009; 28:194–8. [PubMed: 19209089]
5. Heininger U, Klich K, Stehr K, Cherry JD. Clinical findings in *Bordetella pertussis* infections: results of a prospective multicenter surveillance study. *Pediatrics*. 1997; 100:E10.
6. Vitek CR, Pascual FB, Baughman AL, Murphy TV. Increase in deaths from pertussis among young infants in the United States in the 1990s. *The Pediatric infectious disease journal*. 2003; 22:628–34. [PubMed: 12867839]
7. Centers for Disease Control and Prevention. Updated recommendations for use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine (Tdap) in pregnant women and persons who have or anticipate having close contact with an infant aged <12 months -- Advisory Committee on Immunization Practices (ACIP), 2011. *MMWR Morb Mortal Wkly Rep*. 2011; 60:1424–6. [PubMed: 22012116]
8. Centers for Disease Control and Prevention. Updated recommendations for use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine (Tdap) in pregnant women--Advisory Committee on Immunization Practices (ACIP). *MMWR Morb Mortal Wkly Rep*. 2012; 62:131–5.
9. Chamberlain AT, Seib K, Ault KA, Rosenberg ES, Frew PM, Cortés M, et al. Improving influenza and Tdap vaccination during pregnancy: A cluster-randomized trial of a multi-component antenatal vaccine promotion package in late influenza season. *Vaccine*. 2015; 33:3571–9. [PubMed: 26044495]
10. Wong VW, Lok KY, Tarrant M. Interventions to increase the uptake of seasonal influenza vaccination among pregnant women: A systematic review. *Vaccine*. 2016; 34:20–32. [PubMed: 26602267]
11. Baxter CE, Barata PC. The paradox of HPV vaccines: how to reach sexually inexperienced women for protection against a sexually transmitted infection. *Women's health issues : official publication of the Jacobs Institute of Women's Health*. 2011; 21:239–45.
12. Kirby SD, Ureda JR, Rose RL, Hussey J. Peripheral cues and involvement level: influences on acceptance of a mammography message. *Journal of health communication*. 1998; 3:119–35. [PubMed: 10977249]
13. Petty, R., Cacioppo, J. *Communication and Persuasion: Central and Peripheral Routes to Attitude Change*. New York, NY: Springer-Verlag; 1986.
14. Sadaf A, Richards JL, Glanz J, Salmon DA, Omer SB. A systematic review of interventions for reducing parental vaccine refusal and vaccine hesitancy. *Vaccine*. 2013; 31:4293–304. [PubMed: 23859839]
15. Centers for Disease Control and Prevention. Influenza and pneumococcal vaccination levels among persons aged ≥ 65 years--United States, 2001. *MMWR Morb Mortal Wkly Rep*. 2002; 51:1019–24. [PubMed: 12458918]
16. Lees KA, Wortley PM, Coughlin SS. Comparison of racial/ethnic disparities in adult immunization and cancer screening. *American journal of preventive medicine*. 2005; 29:404–11. [PubMed: 16376703]
17. Henninger M, Crane B, Naleway A. Trends in influenza vaccine coverage in pregnant women, 2008 to 2012. *The Permanente journal*. 2013; 17:31–6.
18. Frew PM, Kriss JL, Chamberlain AT, Malik F, Chung Y, Cortés M, et al. A randomized trial of maternal influenza immunization decision-making: A test of persuasive messaging models. *Hum Vaccin Immunother*. 2016 Aug 2.12:1989–96. [PubMed: 27322154]

19. Glik D, Nowak G, Valente T, Sapsis K, Martin C. Youth performing arts entertainment-education for HIV/AIDS prevention and health promotion: practice and research. *Journal of health communication*. 2002; 7:39–57. [PubMed: 11878569]
20. Jones R, Hoover DR, Lacroix LJ. A randomized controlled trial of soap opera videos streamed to smartphones to reduce risk of sexually transmitted human immunodeficiency virus (HIV) in young urban African American women. *Nurs Outlook*. 2013; 61:205–15. [PubMed: 23743482]
21. Mohammed S. Personal communication networks and the effects of an entertainment-education radio soap opera in Tanzania. *Journal of health communication*. 2001; 6:137–54. [PubMed: 11405078]
22. Vaughan PW, Rogers EM, Singhal A, Swalehe RM. Entertainment-education and HIV/AIDS prevention: a field experiment in Tanzania. *Journal of health communication*. 2000; (5 Suppl):81–100. [PubMed: 11010359]
23. Chamberlain AT, Seib K, Ault KA, Rosenberg ES, Frew PM, Cortes M, et al. Impact of a multi-component antenatal vaccine promotion package on improving knowledge, attitudes and beliefs about influenza and Tdap vaccination during pregnancy. *Hum Vaccin Immunother*. 2016 Aug 2.12:2017–24. [PubMed: 27082036]
24. Donaldson B, Jain P, Holder BS, Lindsay B, Regan L, Kampmann B. What determines uptake of pertussis vaccine in pregnancy? A cross sectional survey in an ethnically diverse population of pregnant women in London. *Vaccine*. 2015; 33:5822–8. [PubMed: 26409139]
25. Nichol KL, MacDonald R, Hauge M. Factors associated with influenza and pneumococcal vaccination behavior among high-risk adults. *J Gen Intern Med*. 1996; 11:673–7. [PubMed: 9120653]
26. Zimmerman RK, Santibanez TA, Janosky JE, Fine MJ, Raymund M, Wilson SA, et al. What affects influenza vaccination rates among older patients? An analysis from inner-city, suburban, rural, and Veterans Affairs practices. *Am J Med*. 2003; 114:31–8. [PubMed: 12543287]
27. Guerry SL, De Rosa CJ, Markowitz LE, Walker S, Liddon N, Kerndt PR, et al. Human papillomavirus vaccine initiation among adolescent girls in high-risk communities. *Vaccine*. 2011; 29:2235–41. [PubMed: 21288799]
28. Ding H, Black CL, Ball S, Donahue S, Izrael D, Williams WW, et al. Influenza vaccination coverage among pregnant women--United States, 2013–14 influenza season. *MMWR Morb Mortal Wkly Rep*. 2014; 63:816–21. [PubMed: 25233283]

Fig. 1.
Participant enrollment in the study.

* Note: individuals could be ineligible for more than one reason.

(A) Maternal receipt of Tdap vaccine during perinatal period **(B) Mother's intention to be vaccinated with Tdap in next pregnancy (scale 0-10)** **Fig. 2.**

Associations^a between vaccine education interventions and (A) self-reported Tdap vaccination in the perinatal period or immediately postpartum and (B) intention to be vaccinated with Tdap in the next pregnancy.

^a Unadjusted models.

^b 95% confidence interval.

^c Perinatal period combines during pregnancy and immediately postpartum.

^d Postpartum vaccination refers to vaccine administered while in the hospital after delivering baby. These models exclude women who already received Tdap during pregnancy.

^e Ref=control group.

Fig. 3.

Engagement with interventions, among pregnant women in the two intervention arms (n=61).

*p<0.05.

^a Engagement was based on observation by study personnel; average engagement was calculated for the iBook using engagement scores for the 5 chapters.

^b Based on respondent answers on post-intervention questionnaire.

Table 1

Demographic characteristics and health-seeking behavior at baseline of pregnant women who completed follow-up.

	Total group (n=95)	Control group (n=34)	Video group (n=31)	iBook group (n=30)	p- value
Demographics					
Maternal age, years ^a	26.1 (5.5)	25.3 (6.0)	25.8 (5.1)	27.4 (5.1)	
Education					
Less than high school	12 (13)	5 (15)	4 (13)	3 (10)	0.93
High school graduate/GED	45 (47)	17 (50)	15 (48)	13 (43)	
Vocational or associates	29 (31)	9 (26)	10 (32)	10 (33)	
Bachelor degree or higher	9 (9)	3 (9)	2 (6)	4 (13)	
Number of children ^{a,b}	1.2 (1.4)	1.0 (1.3)	1.5 (1.5)	1.2 (1.4)	
Currently insured	87 (92)	31 (91)	30 (97)	26 (87)	0.11
Practice					
Urban 1	39 (41)	14 (41)	14 (45)	11 (37)	0.73
Urban 2	5 (5)	3 (9)	1 (3)	1 (3)	
Suburban 1	18 (19)	8 (24)	4 (13)	6 (20)	
Suburban 2	33 (35)	9 (26)	12 (39)	12 (40)	
Gestational age, months ^c	7.3 (4.6–9.1)	7.3 (4.6–9.1)	7.0 (5.1–8.4)	7.5 (4.8–9.0)	
Health-Seeking Behavior					
Considers ob-gyn as primary care doctor ^d	74 (80)	27 (79)	25 (83)	22 (76)	0.74
Number of times been treated by a health care provider in past year					
0	38 (40)	12 (35)	14 (45)	12 (40)	0.71
1–4	49 (52)	20 (59)	15 (48)	14 (47)	
5 or more	6 (6)	1 (3)	2 (6)	3 (10)	
Don't know	2 (2)	1 (3)	0 (0)	1 (3)	
How many seasonal influenza vaccines received in past 5 years					
5 (every year)	1 (1)	0 (0)	0 (0)	1 (3)	0.14
2–4	9 (9)	4 (12)	5 (16)	0 (0)	

	Total (n=95)	Control group (n=34)	Video group (n=31)	iBook group (n=30)	p- value
Demographics	n (%)	n (%)	n (%)	n (%)	
1	14 (15)	6 (18)	6 (19)	2 (7)	
0	60 (63)	21 (62)	16 (52)	23 (77)	
Don't know	11 (12)	3 (9)	4 (13)	4 (13)	
Likelihood of getting: ^{a,e}					
Tdap vaccine during current pregnancy	3.0 (3.4)	2.8 (3.6)	3.2 (3.1)	2.9 (3.6)	0.85
Influenza vaccine during current pregnancy	2.1 (2.8)	1.8 (2.8)	2.6 (2.9)	1.9 (2.9)	0.88
Baby vaccinated with all recommended childhood vaccines	8.2 (2.9)	8.3 (2.7)	8.0 (3.2)	8.2 (2.9)	0.90
Hesitancy about getting vaccines doctor recommends during pregnancy ^{a,f}	4.5 (3.1)	4.8 (3.2)	4.7 (3.1)	3.8 (3.1)	0.22

GED=General Educational Development test.

^aMean (standard deviation).

^bNot including current pregnancy.

^cAt time of enrollment in study. Mean (range).

^d1 respondent in Video group and 1 respondent in iBook group answered 'don't know', not shown here.

^eScale: 0=definitely will not, 10=definitely will.

^fScale: 0=not hesitant, 10=very hesitant.

Associations between vaccine education interventions and women's reported reasons for non-vaccination with Tdap, among women who did not receive Tdap during pregnancy (n=84^a).

Table 2

	Control group		Video group^b		iBook group^b	
	n (%)	n (%)	Risk ratio (95% CI)	p-value	Risk ratio (95% CI)	p-value
Not recommended by doctor	15 (47)	10 (38)	0.82 (0.45–1.51)	0.53	1.23 (0.75–2.02)	0.41
Didn't know about Tdap	14 (44)	11 (42)	0.97 (0.53–1.76)	0.91	1.05 (0.60–1.87)	0.86
Unsure what Tdap was for	9 (28)	8 (31)	1.09 (0.49–2.43)	0.83	---	---
Didn't think was at risk for tetanus, diphtheria, or pertussis	5 (16)	5 (19)	1.23 (0.40–3.80)	0.72	1.48 (0.51–4.30)	0.47
Doesn't take vaccines	5 (16)	5 (19)	1.23 (0.40–3.80)	0.72	---	---

^a84 women did not receive Tdap during pregnancy and were asked what their reasons were; 5 did not know if they had received Tdap during pregnancy.

^bReferent is control group.

Note: RRs not shown when n<5.

Table 3

Associations between recommendation of Tdap by ob-gyn or nurse midwife and reported Tdap vaccination in the perinatal period.

Ob-gyn or nurse midwife recommended Tdap during pregnancy ^a					
	n (%)	Unadjusted risk ratio ^b (95% CI)	p-value	Adjusted ^c risk ratio (95% CI)	Adjusted ^d risk ratio (95% CI) p-value
Tdap vaccine administered during perinatal period	18 (67)	3.78 (2.12–6.74)	<0.001	3.45 (1.88–6.34)	3.32 (1.85–5.98) <0.001
During pregnancy	4 (15)	---	---	---	---
Immediately postpartum ^e	14 (56)	4.02 (2.08–7.76)	<0.001	2.92 (1.52–5.61)	3.20 (1.63–6.28) <0.001

^a According to self-report by the pregnant women.

^b Ref=ob-gyn or nurse midwife did not recommend Tdap during pregnancy.

^c Adjusted for practice.

^d Adjusted for intervention arm.

^e Postpartum vaccination refers to vaccine administered while in the hospital after delivering baby. These models exclude women who already received Tdap during pregnancy.
Note: RRs not shown when n<5.