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Characterizing the vaccine knowledge, attitudes, beliefs, and intentions of pregnant women in Georgia and Colorado

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ABSTRACT

Vaccine coverage for maternal vaccines is suboptimal; only about half of pregnant women received influenza and Tdap vaccines in 2018. We explored knowledge, attitudes, beliefs, intentions, and trust regarding maternal and infant vaccines among pregnant women. Between June 2017 and July 2018, we surveyed 2196 pregnant women recruited from geographically and socio-demographically diverse prenatal care practices in Georgia and Colorado (56% response rate). Fifty-six percent of pregnant women intended to receive both influenza and Tdap vaccines during pregnancy and 68% intended to vaccinate their baby with all recommended vaccines on time. Attitudinal constructs associated with intention to vaccinate include confidence in vaccine safety (ORs: 16–38) and efficacy (ORs: 4–19), perceived risk of vaccine-preventable diseases (ORs: 2–6), social norms (ORs: 4–10), and trust in sources of vaccine information. Women pregnant with their first child were less likely than women who had prior children to intend to vaccinate themselves and their children, more likely to be unsure about their intentions to receive both maternal and infant vaccines, and less likely to report feeling they had enough knowledge or information about vaccines and vaccine safety ($p < .01$). This demonstrates an opportunity for vaccine education to increase vaccine confidence and informed decision-making, especially among first-time pregnant women.

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Introduction

Vaccine coverage among children in the United States remains high[1] but varies by region.[2] However, vaccine hesitancy among parents has emerged in recent decades as a threat to this high coverage,[3,4] leading to the clustering of vaccine refusal and associated outbreaks of vaccine-preventable diseases (VPDs).[5–7] This includes the most recent outbreak of measles in the United States, in which more cases have been reported so far in 2019 than in any year since 1994.[8]

Vaccine coverage for maternal vaccines is suboptimal, with only about half of pregnant women receiving influenza and tetanus, diphtheria and acellular pertussis (Tdap) vaccines in 2018.[9] Knowledge, attitudes, and beliefs of pregnant women regarding maternal vaccines are also suboptimal, although pregnant women's attitudes and beliefs toward infant vaccines have not been as well characterized.[10–18]

Many parents primarily seek out vaccine information during and immediately after their first pregnancy.[19–22] The first pregnancy may be a "teachable moment" – a key opportunity to provide accurate information about both maternal and infant vaccinations – since one's vaccine attitudes and beliefs may not yet be fully solidified.[4,23,24] The vast majority of parents[25,26] and pregnant women[10–15] cite health-care providers as their most trusted source of vaccine information. However, many pregnant women do not receive information about infant vaccines directly from their obstetrician or midwife, instead relying on their social networks and internet searches.[18]

The objective of this study was to determine, among a sample of pregnant women from Georgia and Colorado: 1) knowledge, attitudes, and beliefs regarding maternal and infant vaccines; 2) trust in vaccine information sources; 3)

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intention to vaccinate; and 4) associations between vaccine intentions and vaccine knowledge, attitudes, beliefs, and trust.

Materials and methods

Data collection

We administered a survey within the context of a multi-level intervention that sought to increase maternal and infant immunization among first-time mothers. Pregnant women were recruited by study staff from waiting rooms of a geographically and socio-demographically diverse set of prenatal care settings in Georgia and Colorado between June 2017 and July 2018. Women were eligible for participation if they were 18–50 years old, 8–26 weeks pregnant, and had not yet received Tdap vaccine during their current pregnancy. A survey was administered immediately upon enrollment via tablets in the waiting rooms, and a $20 incentive was provided for survey completion.[27] The study was approved by the Emory University Institutional Review Board (IRB00090267).

This survey included multiple-choice questions assessing a number of prior children and intention to receive recommended maternal and infant vaccines. Also included were 58 Likert scale statements assessing latent attitudinal constructs specific to maternal and infant vaccination, such as confidence in vaccine safety and efficacy, perceived susceptibility to and severity of VPDs, descriptive (what people typically do) and injunctive (what people typically approve or disapprove) norms,[28] self-efficacy (an individual's belief in their capacity to execute behaviors necessary to produce specific performance attainments),[29] perceived knowledge, and trust in information sources (Tables 2 and 3). These constructs were chosen after reviewing other relevant behavioral models, theories, and scales,[15,30] and several survey items were dedicated to each construct. Likert scale response options were strongly agree, agree, disagree, and strongly disagree; knowledge and trust statements included a "don't know" option; and trust statements regarding pediatricians and naturopathic/chiropractic doctors included options for "I don't have a pediatrician yet" and "I don't see this type of doctor", respectively. Specific vaccine safety concern statements were automatically administered only to participants who expressed a lack of confidence in the safety of a particular vaccine using survey skip logic. Sociodemographic information such as ethnicity and level of education was collected.

Data analysis

Responses to maternal and infant vaccine intention questions were dichotomized to represent those who intended to receive influenza vaccine, those who intended to receive Tdap vaccine, and those who intended to get their baby all recommended vaccines on time (versus those who did not). Likert scale responses were dichotomized to represent those who agreed or strongly agreed versus those who did not. Pearson's chi-squared test for independence was used to assess differences in vaccine intentions by sociodemographic characteristics. McNemar's test was used to assess differences in the frequency of agreement to survey statements. All p-values were two-sided and $p < .05$ was considered statistically significant.

Simple logistic regressions were performed separately with dichotomous indicators for influenza, Tdap, and infant vaccine intentions as the dependent variables and the dichotomous indicators for other survey items as independent variables. Odds ratios (ORs) and 95% confidence intervals (95% CIs) were calculated for all logistic regressions. Confidence intervals that did not overlap the value of 1 were considered statistically significant.

Summary scores were created by encoding all Likert scale responses (1 – strongly disagree, 2 – disagree, 3 – don't know, 4 – agree, 5 – strongly agree) and combining the survey questions assessing each of the following constructs: confidence in vaccine safety (for the mother), confidence in vaccine safety (for the infant), risk perception (maternal influenza), risk perception (maternal whooping cough), risk perception (infant whooping cough), confidence in vaccine efficacy (influenza), confidence in vaccine efficacy (whooping cough), self-efficacy, social norms, perceived vaccine knowledge, trust in vaccine information (from obstetricians and pediatricians), trust in vaccine information (from naturopaths and chiropractors), and trust in vaccine information (from federal agencies and academic institutions). Three best-fit multiple logistic regression models (dependent variables: intention to receive influenza vaccine, intention to receive Tdap vaccine, intention to get their baby all recommended vaccines on time) were created by backward selection to include only those summary scores with statistical significance ($p < .05$) when adjusted for each other and selected sociodemographic characteristics.

All analysis was performed using Stata/IC 12.1 (STATA Corp., College Station, TX, USA).

Results

Study population

Of the 3904 pregnant women found to be eligible for participation after screening, 2,196 (56% response rate) agreed to participate and took the survey (Table 1). Reasons for eligible women declining study participation include being too busy to screen (18%), not being interested in the study (40%), being wary of the study (5%), and not being able to communicate or read in English (13%).

Roughly half of the participants were from each state, and 46% were first-time pregnant women. Of women who provided education information (n = 1812), 27% had a graduate (master's, doctoral, or professional) degree, and 45% had an undergraduate (associate's or bachelor's) degree. Of women who provided their ethnicity (n = 1862), 63% were white, 17% were black, and 11% were Hispanic.

Confidence in vaccine safety

Over three-quarters of pregnant women were confident that getting influenza and Tdap vaccines during pregnancy was safe both for themselves (76% for influenza, 80% for Tdap) and their unborn babies (76% for influenza, 81% for Tdap) (Table 2). Eighty-six percent of women were confident that infant vaccines were safe for their babies after birth (Table 3).

Table 1. Frequency of pregnant women intending to receive maternal and infant vaccines, stratified by sociodemographic characteristics.

Selected Characteristics	Total Sample, N (%)	Influenza Vaccine, N (%)	P[a]	Tdap Vaccine, N (%)	P[a]	All Infant Vaccines on Time, N (%)	P[a]
All	2196	1,381 (63)		1,426 (65)		1,495 (68)	
State							
Colorado	1099 (50)	735 (67)	**<0.01**	737 (67)	**0.04**	746 (68)	0.75
Georgia	1097 (50)	646 (59)		689 (63)		749 (69)	
Total	2196	1,381 (63)		1,426 (65)		1,495 (68)	
Education[b]							
Graduate degree	482 (27)	375 (78)	**<0.01**	369 (77)	**<0.01**	386 (80)	**<0.01**
Undergraduate degree	812 (45)	519 (64)		550 (68)		566 (70)	
No college degree	518 (29)	261 (50)		296 (57)		311 (60)	
Total	1,812	1,155 (64)		1,215 (67)		1,263 (70)	
Ethnicity							
Black/African American	312 (17)	148 (47)	**<0.01**	153 (49)	**<0.01**	172 (55)	**<0.01**
Hispanic/Latino	209 (11)	117 (56)		109 (52)		138 (66)	
White	1,175 (63)	819 (70)		879 (75)		863 (74)	
Other	166 (9)	99 (60)		97 (58)		111 (67)	
Total	1,862	1,183 (64)		1,238 (66)		1,284 (69)	
Number of prior children							
0	1015 (46)	603 (59)	**<0.01**	605 (60)	**<0.01**	633 (62)	**<0.01**
1	781 (36)	539 (69)		568 (73)		583 (75)	
2	266 (12)	168 (63)		181 (68)		193 (73)	
3	90 (4)	47 (52)		46 (51)		59 (66)	
4+	43 (2)	24 (56)		26 (60)		27 (63)	
Total	2195	1,381 (63)		1,426 (65)		1,495 (68)	

[a] *P*-value for the Pearson chi-squared proportion test at the significance level of (α) 5%; boldface indicates statistical significance ($p < 0.05$).
[b] Graduate degree includes master's, doctoral, and professional degrees; undergraduate degree includes bachelor's and associate's degrees.

Confidence in vaccine safety was higher among white women, women with older children, and women with at least a college degree than nonwhite women, first-time pregnant women, and women without a college degree, respectively.

Risk perception

Most women perceived influenza (85%) and whooping cough (76%) infections as dangerous for pregnant women (Table 2). Participants worried more about getting influenza (61%) than whooping cough (39%) while pregnant ($p < .01$). Although most women perceived whooping cough as dangerous for babies (92%), less were worried about their baby getting whooping cough (61%) ($p < .01$) (Table 3).

Confidence in vaccine efficacy

More women perceived a reduction in disease risk for themselves (69% for influenza, 75% for Tdap) than for their unborn baby (47% for influenza, 62% for Tdap) by vaccinating during pregnancy ($p < .01$); however, 73% of women perceived a reduction in their baby's risk of whooping cough from the diphtheria, tetanus, and acellular pertussis (DTaP) infant vaccine. First-time pregnant women were less likely to perceive a reduction in risk of whooping cough for themselves or their unborn baby by vaccinating during pregnancy ($p = .01$), risk of influenza for their unborn baby ($p = .01$) by vaccinating during pregnancy, and risk of whooping cough for their baby from the DTaP infant vaccine ($p < .01$).

Self-efficacy and social norms

Nearly every woman considered getting vaccines for themselves during pregnancy (98%) or for their baby after birth (96%) as being within their control. Most women thought that the majority of their friends and family would encourage them to get the vaccines recommended during pregnancy (72%) and recommended vaccines for babies (81%). First-time pregnant women were less likely to perceive that the majority of their friends and family would get recommended vaccines during pregnancy or for babies than women with prior children ($p < .01$).

Perceived knowledge

Most women thought they already had most of the important information they needed to make decisions about vaccines during pregnancy (82%) and for their babies (84%). First-time pregnant women were less likely than women with older children to report that they felt they had enough information about maternal (74% versus 90%, $p < .01$) and infant (74% versus 93%, $p < .01$) vaccines or had enough knowledge about influenza (74% versus 89%, $p < .01$), Tdap (59% versus 81%, $p < .01$) and DTaP (65% versus 87%, $p < .01$) vaccine safety to make informed vaccine decisions. A substantial portion of this difference was due to less first-time pregnant women than women with prior children strongly agreeing to having enough information about maternal (21% versus 32%) and infant (22% versus 38%) vaccines and knowing enough about influenza (23% versus 31%), Tdap (18% versus 26%), and DTaP (20% versus 33%) vaccine safety.

Trust in vaccine information sources

The vast majority of women (93%) trusted the information provided by their obstetrician or midwife about maternal and infant vaccines (Tables 2 and 3). Among those who had already seen a pediatrician, the vast majority of women trusted the information pediatricians provided about maternal (92%) and infant (94%) vaccines. Over a third of women reported not seeing naturopathic and/or chiropractic doctors; among the rest, 63–64% reported trusting vaccine information provided by naturopathic and/or chiropractic doctors. Most women trusted vaccine information provided by federal agencies such as the Centers for Disease Control and Prevention

Table 2. Frequency of agreement with maternal vaccine statements, and unadjusted odds ratios for maternal vaccine intentions.

	Agree or Strongly Agree, N (%)	Influenza, OR (95% CI)[a]	Tdap, OR (95% CI)[a]
Total (N = 2210)			
Number of Vaccine Safety Concerns Identified[b]			
Influenza vaccine concerns (0–6)			
0 (reference)	1,630 (74)	1	
1–2	134 (6)	**0.08 (0.05–0.12)**	
3–4	197 (9)	**0.02 (0.02–0.04)**	
5–6	235 (11)	**0.01 (0.00–0.02)**	
Tdap vaccine concerns (0–6)			
0 (reference)	1,739 (79)		1
1–2	106 (5)		**0.08 (0.05–0.13)**
3–4	206 (9)		**0.04 (0.03–0.06)**
5–6	145 (7)		**0.02 (0.01–0.04)**
Confidence in Vaccine Safety Statements			
I am confident that getting the flu vaccine during my pregnancy is safe for me.	1662 (76)	**37.50 (27.43–51.26)**	
I am confident that getting the flu vaccine during my pregnancy is safe for my unborn baby.	1676 (76)	**26.49 (19.86–35.34)**	
I am confident that getting the whooping cough vaccine during my pregnancy is safe for me.	1754 (80)		**28.80 (20.95–39.59)**
I am confident that getting the whooping cough vaccine during my pregnancy is safe for my unborn baby.	1771 (81)		**18.07 (13.57–24.06)**
Risk Perception Statements			
I worry that I could get the flu while I am pregnant.	998 (61)	**4.76 (3.84–5.91)**	
The flu is dangerous for pregnant women.	1401 (85)	**2.53 (1.92–3.33)**	
The flu is more dangerous for pregnant women than for women who are not pregnant.	1296 (79)	**2.17 (1.70–2.75)**	
I worry that I could get whooping cough while I am pregnant.	649 (39)		**3.57 (2.83–4.50)**
I worry that I could give whooping cough to my baby after birth.	935 (57)		**6.20 (4.96–7.76)**
Whooping cough is dangerous for pregnant women.	1256 (76)		**2.61 (2.07–3.29)**
Confidence in Vaccine Efficacy Statements			
Getting the flu vaccine will reduce my risk of getting the flu during my pregnancy.	1136 (69)	**18.74 (14.39–24.41)**	
Getting the flu vaccine while I am pregnant will reduce my unborn baby's risk of getting the flu.	774 (47)	**6.12 (4.84–7.72)**	
Whooping cough vaccine will reduce my chances of getting whooping cough.	1238 (75)		**10.92 (8.40–14.19)**
Whooping cough vaccine will reduce the chance of me giving whooping cough to my unborn baby.	1146 (70)		**7.55 (5.98–9.54)**
Getting the whooping cough vaccine while I am pregnant will reduce my unborn baby's risk of getting whooping cough.	1019 (62)		**6.40 (5.12–8.00)**
Self-Efficacy Statement			
It is in my control whether or not I get vaccines during my pregnancy.	1601 (98)	1.54 (0.83–2.87)	1.67 (0.90–3.10)
Social Norms Statements			
The majority of my friends and family would get the vaccines that are recommended during pregnancy.	1608 (73)	**7.99 (6.45–9.90)**	**6.10 (4.97–7.50)**
The majority of my friends and family would encourage me to get the vaccines that are recommended during pregnancy.	1579 (72)	**9.92 (7.99–12.32)**	**7.26 (5.91–8.93)**
Perceived Knowledge Statements			
I have most of the important information I need to make a decision about vaccines given during pregnancy.	1806 (82)	**4.13 (3.27–5.21)**	**3.88 (3.09–4.88)**
I know enough about the safety of the flu vaccine to make a decision about getting the vaccine for myself while pregnant.	1343 (82)	**4.60 (3.53–6.01)**	
I know enough about the safety of the whooping cough vaccine to make a decision about getting the vaccine for myself while pregnant.	1173 (71)		**4.50 (3.59–5.65)**
Trust in Vaccine Information Source Statements			
I trust the information provided by my obstetrician or midwife about vaccines during pregnancy.	2032 (93)	**8.62 (5.74–12.96)**	**6.70 (4.61–9.72)**
I trust the information provided by my baby's doctor about vaccines during pregnancy.[c]	1871 (92)	**8.28 (5.52–12.43)**	**6.82 (4.68–9.93)**
I trust the information provided by naturopathic and/or chiropractic doctors about vaccines during pregnancy.[c]	917 (64)	**0.65 (0.52–0.81)**	**0.72 (0.57–0.90)**
I trust the information provided by federal agencies such as the Centers for Disease Control and Prevention (CDC) about vaccines during pregnancy.	1768 (81)	**6.38 (5.04–8.07)**	**5.62 (4.47–7.07)**
I trust the information provided by scientists and doctors at universities and academic institutions about vaccines during pregnancy.	1799 (82)	**3.85 (3.07–4.84)**	**3.55 (2.83–4.45)**

[a]Odds ratio (95% Confidence interval) for intention to receive influenza or Tdap vaccine by agreement with survey statement; boldface indicates statistical significance ($p < 0.05$).
[b]Specific safety concerns were only obtained from those who did not agree that the vaccine in question was safe.
[c]Removed those who stated they had not yet seen this type of provider from this analysis.
OR, Odds ratio

(CDC) (81%) and by scientists and doctors at universities and academic institutions (82%).

Intentions to vaccinate

Sixty-three percent of pregnant women intended to receive influenza vaccine, and 65% intended to receive Tdap vaccine (Table 1). Fifty-six percent of women intended to receive both maternal vaccines, 15% intended to receive neither vaccine, and 13% were unsure. First-time pregnant women were more likely to be uncertain about maternal vaccines compared to women with prior children (8% vs. 19%, $p < .01$).

Sixty-eight percent of women intended their baby to receive all recommended vaccines on time (Table 1).

Twelve percent of women intended their baby to receive all recommended infant vaccines but intended to spread out the vaccine schedule past the recommended ages. Five percent of women intended their baby to receive only some vaccines on time, and 3% intended their baby to receive only some vaccines spread out past the recommended ages. Two percent intended their baby to receive no vaccines, and 9% were still unsure. Fourteen percent of first-time pregnant women versus 4% with prior children had uncertain infant vaccine intentions ($p < .01$).

Associations between vaccine intentions and vaccine knowledge, attitudes, beliefs, and trust

Maternal vaccines

Confidence in maternal vaccine safety and efficacy, perceived risk of maternal VPDs, perceived pro-maternal vaccine norms, high-perceived maternal vaccine knowledge, and trust in maternal vaccine information from obstetricians and midwives, pediatricians, the CDC, and universities were all positively associated with intention to receive maternal vaccines (Table 2). Trust in maternal vaccine information from naturopathic and/or chiropractic doctors was negatively associated with intention to receive influenza vaccine.

The attitudinal constructs significantly associated with intention to receive influenza vaccine after multivariate adjustment (Table 4) were education (adjusted odds ratio: 1.98, 95% Confidence interval: 1.37–2.85), state (Colorado vs Georgia) (aOR: 1.44; 95% CI: 1.01–2.05), number of influenza vaccine safety concerns (aOR: 0.56; 95% CI: 0.46–0.68), confidence in vaccine safety for the mother (aOR: 1.30; 95% CI: 1.12–1.52) and efficacy of the influenza vaccine (aOR: 1.60; 95% CI: 1.42–-1.81), perceived risk of influenza (aOR: 1.22; 95% CI: 1.12–1.33), and pro-vaccine social norms (aOR: 1.11; 95% CI: 1.04–1.18).

The attitudinal constructs significantly associated with intention to receive Tdap vaccine after multivariate adjustment (Table 4) were having prior children (aOR: 1.44; 95% CI: 1.06–1.97), black (aOR: 0.60; 95% CI: 0.40–0.92), and Hispanic (aOR: 0.59; 95% CI: 0.35–0.99) versus white race/ethnicity, number of Tdap vaccine safety concerns (aOR: 0.70; 95% CI: 0.60–0.83), confidence in vaccine safety for the mother (aOR: 1.31; 95% CI: 1.15–1.48) and efficacy of the Tdap vaccine (aOR: 1.14; 95% CI: 1.06–1.24), perceived risk of whooping cough (aOR: 1.24; 95% CI: 1.16–1.32), and pro-vaccine social norms (aOR: 1.11; 95% CI: 1.04–1.18).

Infant vaccines

Confidence that vaccines for babies after birth are safe and efficacious, perceived risk of infant VPDs, perceived pro-infant vaccine norms, high perceived infant vaccine knowledge, and trust in infant vaccine information from obstetricians and midwives, pediatricians, the CDC, and universities were all positively associated with intention to receive all infant vaccines on time (Table 3). Agreement with the statement: "I believe it is better for my baby to develop their own immunity by getting sick rather than by getting a vaccine" corresponded with 74% lower odds of intention to receive all infant vaccines on time.

The attitudinal constructs significantly associated with intention to receive influenza vaccine after multivariate adjustment (Table 4) were: having prior children (aOR: 1.50; 95% CI: 1.10–2.05), number of infant DTaP vaccine safety concerns (aOR: 0.64; 95% CI: 0.51–0.81), confidence in vaccine safety for the infant (aOR: 1.28; 95% CI: 1.18–1.40), and trust in vaccine information from obstetricians and pediatricians (aOR: 1.19; 95% CI: 1.11–1.28), naturopaths and chiropractors (aOR: 0.88; 95% CI: 0.81–0.95), and federal agencies and academic institutions (aOR: 1.11; 95% CI: 1.03–1.19).

Discussion

In this study of pregnant women from Georgia and Colorado, we describe suboptimal vaccine knowledge, attitudes, beliefs, and intentions regarding maternal and infant vaccines; high levels of trust in obstetric and pediatric doctors as vaccine information sources; and associations between vaccine intentions and confidence in vaccine safety and efficacy, perceived risk of VPDs, pro-vaccine social norms, and trust in sources of vaccine information.

Over half of the pregnant women in our sample intended to receive all recommended maternal vaccines, aligning with recent national data.[9] Over two-thirds intended for their baby to receive all recommended infant vaccines on time, which was also consistent with recent national data.[3] However, a substantial proportion of pregnant woman did not intend to vaccinate themselves or their children according to the recommended immunization schedule.

Most attitudinal constructs assessed were associated with vaccine intention. Confidence in vaccine safety and efficacy showed the strongest individual associations with intention to receive maternal influenza and Tdap vaccines, whereas confidence in vaccine safety and trust in vaccine information from obstetricians and pediatricians showed the strongest individual associations with intention to receive infant vaccines. Significant predictors of maternal vaccine intentions after adjustment for other constructs and sociodemographic characteristics included confidence in vaccine safety and efficacy for the mother, perceived risk of maternal VPDs, and pro-vaccine social norms. This aligns with the findings of previous prospective cohort studies.[15–17] Since maternal vaccine acceptance is known to be influenced by the perceived risk of maternal VPDs,[31] educational interventions focusing on this while reinforcing maternal vaccine safety and efficacy may be best suited to impact maternal vaccine intention and coverage. Significant predictors of infant vaccine intentions after adjustment for other constructs and sociodemographic characteristics included confidence in vaccine safety and trust in vaccine information from doctors, federal agencies, and academic institutions. Educational interventions reinforcing infant vaccine safety and the trustworthiness of reputable sources of vaccine information may be best suited to impact infant vaccine intention and coverage.

Women pregnant with their first child were less likely to intend to vaccinate themselves and their children and were more likely to be unsure about both maternal and infant vaccines than women who had prior children. First-time pregnant women were also less likely to perceive having enough information to make informed maternal and infant vaccine decisions. This supports the idea that during

Table 3. Frequency of agreement with infant vaccine statements, and unadjusted odds ratios for infant vaccine intentions.

	Agree or Strongly Agree, N (%)[a]	All Infant Vaccines on Time, OR (95% CI)[a]
Total (N = 2203)		
Number of Infant Vaccine Safety Concerns Identified (0–4)[b]		
0 (reference)	1,904 (87)	1
1–2	93 (4)	**0.11 (0.07–0.18)**
3–4	199 (9)	**0.02 (0.01–0.04)**
Confidence in Vaccine Safety Statements		
I am confident that vaccines are safe for my baby after birth.	1886 (86)	**16.66 (12.08–22.98)**
Risk Perception Statements		
I worry that my baby could get whooping cough after birth.	1010 (61)	**2.53 (2.05–3.13)**
Whooping cough is dangerous for babies.	1519 (92)	**2.39 (1.66–3.44)**
Whooping cough is more dangerous for babies than older children or adults.	1417 (86)	**2.46 (1.86–3.26)**
Confidence in Vaccine Efficacy Statements		
Getting the whooping cough vaccine for my baby after birth will reduce my baby's chances of getting whooping cough.	1198 (73)	**4.41 (3.50–5.55)**
I believe it is better for my baby to develop their own immunity by getting sick rather than by getting a vaccine.	473 (29)	**0.26 (0.21–0.32)**
Self-Efficacy Statement		
It is in my control whether or not my baby gets his/her vaccines.	1581 (96)	1.52 (0.90–2.55)
Social Norms Statements		
The majority of my friends and family would get all of the vaccines recommended for their babies after birth.	1789 (82)	**4.75 (3.78–5.97)**
The majority of my friends and family would encourage me to get all of the vaccines recommended for my baby after birth.	1769 (81)	**5.81 (4.63–7.30)**
Perceived Knowledge Statements		
I have most of the important information I need to make a decision about vaccines for my baby after birth.	1843 (84)	**4.40 (3.46–5.58)**
I know enough about the safety of the whooping cough vaccine to make a decision about getting the vaccine for my baby after birth.	1682 (77)	**3.13 (2.55–3.84)**
Trust in Vaccine Information Source Statements		
I trust the information provided by my obstetrician or midwife about vaccines for babies after birth.	2034 (93)	**15.22 (9.68–23.94)**
I trust the information provided by my baby's doctor about vaccines for babies after birth.[c]	1868 (94)	**26.84 (14.67–49.11)**
I trust the information provided by naturopathic and/or chiropractic doctors about vaccines for babies after birth.[c]	863 (63)	0.87 (0.69–1.09)
I trust the information provided by federal agencies such as the Centers for Disease Control and Prevention (CDC) about vaccines for babies after birth.	1775 (81)	**7.30 (5.77–9.23)**
I trust the information provided by scientists and doctors at universities and academic institutions about vaccines for babies after birth.	1806 (82)	**4.68 (3.72–5.90)**

[a] Odds ratio (95% Confidence interval) for intention to get their baby all vaccines on time by agreement with survey statement; boldface indicates statistical significance ($p < 0.05$).
[b] Specific safety concerns were only obtained from those who did not agree that the vaccine in question was safe.
[c] Removed those who stated they had not yet seen this type of provider from this analysis.
OR, Odds ratio

a woman's first pregnancy, there is a "teachable moment" due to vaccine attitudes and beliefs not being as solidified at this point as they are after having a child.[4] Among these first-time pregnant women, 19% reported being unsure about their decision to get maternal vaccines, 14% reported being unsure about their decision to get infant vaccines, and 26% reported not having enough information about maternal and infant vaccines. This indicates the need for more educational interventions before pregnancy as well.

The majority of women were confident in the safety of both maternal and infant vaccines. However, 20–24% were not confident in the safety of maternal vaccines, and 14% were not confident in the safety of infant vaccines. Women recognized the severity of influenza and whooping cough much more frequently than they did their or their baby's own susceptibility to the disease. Women were also more likely to perceive the efficacy of maternal vaccines in protecting themselves from the disease than protecting their unborn babies. Whooping cough in particular (due to its severity in infancy and the crucial protection provided by maternal antibodies during an otherwise vulnerable time) demonstrates a common gap in knowledge and an opportunity for obstetricians and midwives to educate their patients on the purpose and importance of Tdap vaccination in pregnancy. The vast majority of women trusted the vaccine information provided by both their obstetric provider and their baby's doctor, which supports current literature.[11–15] However, some obstetric providers feel they are inadequately trained regarding vaccinations,[32] demonstrating the need for better training of prenatal care providers to make the most of this opportunity for vaccine education during pregnancy.

There are several limitations of this paper. First, these data are not nationally generalizable. Although the study sites were chosen to capture as wide a range of demographics and vaccine hesitancy as possible, the sample consists solely of pregnant women from two states who were eligible and willing to participate in a study that included multiple surveys throughout and after their pregnancy, which led to a low response rate. Since the survey was in English, women who were unable to communicate or read in English were ineligible to participate, which excludes an important segment of the population from our analysis; further study would benefit from translation to other languages such as Spanish. Compared to CDC data on the demographics of U.S. births in 2016,[33] our study population contained a higher proportion of women with at least bachelor's degrees (71% vs 32%) and of non-Hispanic white women (69% vs 59% in Colorado and 57% vs 45%

Table 4. Adjusted odds ratios of pregnant women intending to receive vaccines by significantly associated attitudinal constructs.

Attitudinal Constructs and Sociodemographic Characteristics Associated with Intention to Vaccinate[a]	aOR (95% CI)[b]
Intention to Receive Influenza Vaccine[c]	
Sociodemographic Characteristics	
Having at least a college degree	**1.98 (1.37–2.85)**
Prior children	1.24 (0.88–1.74)
State (Colorado vs Georgia)	**1.44 (1.01–2.05)**
Ethnicity	
White (reference)	
Black	0.89 (0.55–1.44)
Hispanic	0.75 (0.43–1.30)
Other	0.97 (0.52–1.79)
Attitudinal Constructs	
Number of specific vaccine safety concerns (influenza vaccine)	**0.56 (0.46–0.68)**
Confidence in vaccine safety (for the mother)	**1.30 (1.12–1.52)**
Confidence in vaccine efficacy (influenza)	**1.60 (1.42–1.81)**
Perceived risk (maternal influenza)	**1.22 (1.12–1.33)**
Pro-vaccine social norms	**1.11 (1.04–1.18)**
Intention to Receive Tdap Vaccine[d]	
Sociodemographic Characteristics	
Having at least a college degree	1.17 (0.83–1.64)
Prior children	**1.44 (1.06–1.97)**
State (Colorado vs Georgia)	0.94 (0.68–1.31)
Ethnicity	
White (reference)	
Black	**0.60 (0.40–0.92)**
Hispanic	**0.59 (0.35–0.99)**
Other	0.73 (0.43–1.24)
Attitudinal Constructs	
Number of specific vaccine safety concerns (Tdap vaccine)	**0.70 (0.60–0.83)**
Confidence in vaccine safety (for the mother)	**1.31 (1.15–1.48)**
Confidence in vaccine efficacy (whooping cough)	**1.14 (1.06–1.24)**
Perceived risk (maternal whooping cough)	**1.24 (1.16–1.32)**
Pro-vaccine social norms	**1.08 (1.02–1.15)**
Intention to Get All Infant Vaccines on Time[e]	
Sociodemographic Characteristics	
Having at least a college degree	1.13 (0.81–1.58)
Prior children	**1.50 (1.10–2.05)**
State (Colorado vs Georgia)	0.82 (0.60–1.14)
Ethnicity	
White (reference)	
Black	0.82 (0.54–1.26)
Hispanic	1.41 (0.86–2.31)
Other	1.53 (0.88–2.68)
Attitudinal Constructs	
Number of specific vaccine safety concerns (infant DTaP vaccine)	**0.64 (0.51–0.81)**
Confidence in vaccine safety (for the infant)	**1.28 (1.18–1.40)**
Trust in vaccine information (from obstetricians and pediatricians [f])	**1.19 (1.11–1.28)**
Trust in vaccine information (from naturopaths and chiropractors [f])	**0.88 (0.81–0.95)**
Trust in vaccine information (from federal agencies and academic institutions)	**1.11 (1.03–1.19)**

[a]Variables representing attitudinal construct summary scores chosen for best-fit multiple logistic regression (MLR) model using backward stepwise selection at the significance level of $p < 0.05$; sociodemographic characteristics included in all models regardless of significance.
[b]Adjusted odds ratio (95% Confidence interval) for intention to vaccinate by attitudinal construct summary score or sociodemographic characteristic; boldface indicates statistical significance ($p < 0.05$).
[c]Model fit information: Akaike information criterion (AIC) = 914; Bayesian information criterion (BIC) = 977.
[d]Model fit information: AIC = 1063; BIC = 1125.
[e]Model fit information: AIC = 1049; BIC = 1110.
[f]Removed those who stated they had not yet seen this type of provider from this analysis.
aOR, Adjusted odds ratio
CI, Confidence interval
DTaP, Diphtheria, tetanus, and pertussis
MLR, Multiple logistic regression
Tdap, Tetanus, diphtheria, and pertussis
AIC, Akaike information criterion
BIC, Bayesian information criterion

in Georgia). In addition, some women in the sample did not complete the survey and thus questions near the end of the survey had slightly lower response rates than questions toward the beginning. Despite these limitations, this paper provides useful insight into vaccine intentions, attitudes, and beliefs of current U.S. pregnant women. More surveys of vaccine intentions, attitudes, and beliefs among all age groups and demographics are needed, especially nationally representative, standardized surveys administered regularly over time.

Conclusions

A sample of pregnant women from Georgia and Colorado demonstrated suboptimal maternal vaccine knowledge and

intentions. First-time pregnant women were substantially less certain in their vaccine knowledge and intentions than women with prior children, demonstrating the opportunity for vaccine education to increase vaccine confidence and informed decision-making at this stage of life, especially coming from highly trusted sources of vaccine information for pregnant women such as obstetricians and gynecologists. Such educational interventions should be individually tailored and focus on the risk of VPDs while reinforcing confidence in vaccine safety and efficacy and the trustworthiness of reputable sources of vaccine information.

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