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ORIGINAL ARTICLE

Trajectories of Digital Prenatal Service Utilization and Pregnancy Outcomes: A Multitrajectory Analysis

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Abstract

Objective: To identify trajectories of prenatal digital service utilization across pregnancy and examine their associations with pregnancy outcomes.

Patients and Methods: Data were extracted from 5409 pregnant people enrolled in Maven, a comprehensive digital platform for women's and family health, between January 1, 2020, and May 27, 2022. Multitrajectory modeling used digital service utilization data (eg, articles read, classes attended, and appointments with providers) at each trimester to identify trajectories of digital use across pregnancy. Multinomial logistic regression models tested for associations between the utilization trajectories and user-reported pregnancy education, experiences, and outcomes.

Results: Four distinct trajectories of digital service utilization were identified and labeled as follows: (1) baseline users (52% of users), (2) just-in-timers (16%), (3) learners (26%), and (4) super users (6%). Users varied across trajectories by race, perinatal support interests, mental health, and parity. Compared with baseline users, trajectories reflective of more digital health service utilization were all positively associated with self-reported influence of Maven on pregnancy education, maternity care experience, and clinical outcomes.

Conclusion: Distinct trajectories of digital health utilization emerged among pregnant individuals with differences in user characteristics and medical risks by trajectory group. Users in higher-use trajectories reported greater benefits from digital health. These findings may be used to inform gaps in existing prenatal care and help provide tailored services to reflect the unique needs of each individual pregnancy.

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Despite high costs, the United States has the highest maternal mortality rate in the developed world, suggesting inequitable access and significant gaps in health services during pregnancy.[1] The current medical model emphasizes clinical care, with less emphasis on education and support.[2] Digital health presents a promising but underexplored opportunity to supplement the gaps in routine prenatal care.[3,4] Telemedicine and mobile applications may help address current gaps in prenatal care by making pregnancy services more accessible and affordable.[4] Most studies of digital health tools during pregnancy have compared the outcomes of pregnant people who used an assigned mobile application with those of people who did not,[5] often approaching the use of a digital platform as an all-or-nothing intervention without considering the multifaceted ways in which users can engage with digital technologies.[6]

Although these studies have provided valuable insights into the utility of digital health to improve perinatal care, their methods are capturing between-group differences in digital health utilization, instead of using person-centered methods to capture within-person differences in utilization over the course of pregnancy.[7] Given the changes in both physical and mental health that occur as a pregnancy progresses,[7] there is likely within-person variation in the utilization of

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perinatal digital health services that is not yet well understood. This variation has the potential to provide insight into how pregnant people longitudinally engage with several components of digital health tools in tandem across their pregnancy.

Understanding how pregnant people engage with supplemental prenatal digital services across their pregnancy could guide further digital solutions to improve prenatal care and elucidate gaps in in-person service delivery. Maven, a comprehensive digital platform for women's and family health, provides patient education (through articles, videos, and live classes), care coordination (through a dedicated care advocate), and provider services (virtual appointments and communication with a diverse team of providers) that are intended to supplement routine prenatal care. This study seeks to understand how pregnant people avail themselves of this access across their pregnancy. The objectives of this study were to identify digital health utilization trajectories among pregnant people enrolled in Maven and to examine associations between utilization trajectories and user-reported pregnancy education, experience, and clinical outcomes.

PATIENTS AND METHODS

Study Design and Participants

This retrospective cohort study longitudinally examined digital health utilization of pregnant people who were enrolled in Maven. Maven offers a multifaceted virtual platform that includes virtual health services (eg, access to articles, videos, and live classes and virtual care appointments with providers across a variety of specialties, including mental health, nutrition, and physical therapy, among others). Data for this analysis included utilization data and user-reported data from the onboarding questionnaire (completed upon enrollment in Maven) and the postdelivery questionnaire (completed after delivery).

Data were extracted from 14,997 employer- or health plan–sponsored Maven users who enrolled in the pregnancy track or transitioned to the pregnancy track from the fertility track between January 1, 2020 and May 27, 2022 (Figure 1). We excluded users who had not yet given birth (n=3901) and users who did not complete the pregnancy onboarding and postdelivery questionnaires (n=5684), resulting in 5412 users. Of these 5412 users, 3 users did not have data on which trimester of pregnancy they enrolled in Maven, which was necessary for generating trajectories of utilization across pregnancy. Thus, a final analytic sample of 5409 participants was selected for this analysis. All users consented to the use of their deidentified data for scientific research upon creating a Maven account. This study used deidentified data only, and the protocol was designated as exempt by Western Institutional Review Board, an independent ethical review board.

Measures

User-Reported Outcomes. The study outcomes were user-reported influences of Maven on their pregnancy education, experiences, and clinical outcomes. After delivery, each user was asked "In what way(s) did Maven influence your [pregnancy] experience?" with several response options. Examples of response items included "Maven helped me manage my anxiety and/or depression" and "Maven helped me avoid a trip to ER or in-person doctor's visit." Each item was coded separately as a dichotomous variable, "yes" when users selected the item and "no" when the item was not selected. Users were asked "Did Maven help you understand the warning signs during pregnancy?," "Did something you learned through Maven influence the way you approached your maternity experience?," (dichotomous response options "yes" or "no"), and "On a scale of 1-5, how would you rate the support you received from Maven on your pregnancy journey?" (coded dichotomously as a 1 if users selected "5-excellent" and 0 if users selected 4 or less).

Utilization of digital services. Utilization of Maven services was our primary predictor variable. All utilization data were tracked automatically within Maven for each user by trimester of utilization on the basis of the user's self-reported estimated due date. Tracked data included the total number of articles read, class recordings watched, virtual classes attended live, messages sent to a care advocate, messages sent to a provider, and appointments with a provider (Supplemental Table 1, available

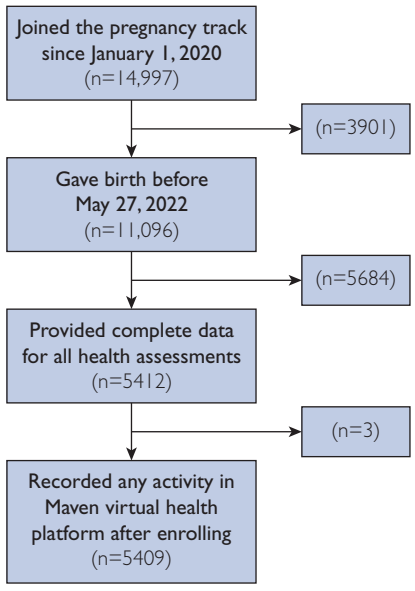

FIGURE 1. Flowchart of the participants included in the current analysis.

online at https://www.mcpdigitalhealth.org/). Users had continuous access to Maven as an employer- or health plan–sponsored health benefit and could enroll in Maven at any point during their pregnancy. We did not have data on whether a user joined Maven later in the course of their pregnancy because they did not want to engage with Maven earlier in their pregnancy or because they did not have access to Maven (ie, they were unaware that their employer provided access). Users who enrolled in their second or third trimester of pregnancy were assigned a "0" for each utilization indicator in the trimester(s) before their enrollment. We made this decision to capture the realities of how pregnant people initiate and engage with digital health technologies throughout pregnancy.

User Characteristics. We examined several user characteristics related to engagement with a digital women's and family health platform during pregnancy and self-reported pregnancy outcomes, including age, race and ethnicity, body mass index (BMI) (calculated as the weight in kilograms divided by the height in meters squared), parity, presence of chronic medical conditions, presence of pregnancy-related medical conditions, presence of mental health conditions, pregnancy-related anxiety, and desired perinatal support domains. These data were self-reported by users upon enrollment in the digital service.

Ethnicity and race were categorized into "Hispanic/Latinx" and non-Hispanic/Latinx: "white," "Asian or Pacific Islander," "Black," and "other" (composed of users who identified as multiracial or American Indian). Prepregnancy BMI was calculated using self-reported height and weight. Chronic and pregnancy medical conditions were each assessed using cumulative risk scores, calculated by adding the number of medical conditions reported by each user. The presence of mental health conditions was coded as a dichotomous variable, "yes" when users reported the presence or history of anxiety, depression, or perinatal mood disorder and "no" when users reported no history of these conditions. Pregnancy-related anxiety was assessed using a 5-item Likert scale in response to "On a scale of 1-5, how anxious are you feeling about your pregnancy?," with responses ranging from 1 ("Not at all") to 5 ("Extremely"). Pregnancy-related anxiety was coded dichotomously as "yes" when users reported that they were feeling "4-very" or "5-extremely" anxious about their pregnancy and "no" if users rated the item at 3 or lower. Upon enrollment, to identify the desired areas of perinatal support, each user was asked "Which areas are you most interested in receiving support in?" and was able to select areas of interest, including "Labor and delivery options" and "Emotional health during and after pregnancy."

Statistical Analyses

We used group-based multitrajectory modeling to identify distinctive clusters of digital health service utilization throughout pregnancy (hereinafter referred to as "utilization trajectories") within our sample and for profiling the characteristics of individuals within the clusters.[8] We constructed the model as a function of time (ie, trimester of pregnancy) to describe the utilization of digital health services in key categories: (1) articles read, (2) class recordings watched, (3) virtual classes attended live, (4) messages sent to a care advocate, (5) messages sent to a provider, and (6) appointments with a provider. Group-based multitrajectory modeling

uses maximum likelihood estimation to identify latent clusters of individuals following similar trajectories across multiple indicators of interest.[8-10] With this data-driven method, we were able to provide a nuanced interpretation regarding what it means to have "low" or "high" digital health utilization across both time (ie, trimesters of pregnancy) and indicators of interest (ie, articles read, class recordings watched, virtual classes attended live, messages sent to a care advocate, messages sent to a provider, and appointments with a provider). We performed the group-based multitrajectory modeling analysis using the Stata plug-in *traj* (StataCorp).[11] Model selection was conducted using Bayesian information criteria (BIC) comparison (where a BIC closer to 0 was indicative of a better fitting model) and subjective domain knowledge. We specified a censored normal distribution for the number of articles read during each trimester and a zero-inflated Poisson distribution for the rest of the utilization indicators (ie, recordings watched, classes attended, messages sent to a care advocate or provider, and appointments with a provider). Model output provided the number of trajectory groups that best fit the data, the trajectory for each group, and the probability that each participant belongs to a particular trajectory group.

We tested users in up to 5 trajectory groups with zero-order, linear, and quadratic specifications for each trajectory shape until we established the best-fitting model (Supplemental Tables 2-4, available online at https://www.mcpdigitalhealth.org/). To determine the best-fitting model, we relied on our subjective domain knowledge of digital health utilization during pregnancy; compared the BIC values of each model with a BIC closer to zero indicating better model fit; verified that at least 5% of the analytic sample was assigned to each trajectory group; and confirmed that each trajectory group had an average posterior probability of usership greater than 0.7, an odds of correct classification greater than 5.0, and estimated group probabilities comparable to the proportion of the sample assigned to each trajectory group.[10] Descriptive statistics were used to examine the mean and SD of each digital service indicator for each utilization trajectory during each trimester of pregnancy and to assess the differences between trajectories by user characteristics. One-way analysis of variance and chi-square or Fisher exact tests were used to assess continuous and categorical variables, respectively.

Adjusted logistic regression models with robust SEs were used to test for associations between the identified utilization trajectories and 10 user-reported pregnancy outcomes and experiences. Each user-reported outcome was assessed in its own model. All models were adjusted for trimester of enrollment into the digital health service, user race and ethnicity, age, BMI, presence of chronic medical conditions, pregnancy conditions, and mental health conditions.

RESULTS

Sample Characteristics

Our analytic sample consisted of 5409 users who enrolled or transitioned into the digital health service during their pregnancy. Users who had not yet given birth before the start of data analysis, had not completed all health assessments, or had not been active at all in Maven were excluded from the sample (Figure 1). Demographic, health, and utilization differences between users who completed all health assessments and those who only completed the onboarding assessment are summarized in Supplemental Table 5 (available online at https://www.mcpdigitalhealth.org/). The mean age of our sample was 32.7 years (SD=4.0). Forty-three percent (n=2317) of the included users identified as non-Hispanic white, 18% (n=996) of the included users identified as non-Hispanic Asian or Pacific Islander, and 25% (n=1327) of the included users preferred not to disclose their race and ethnicity status. Most of the included users were nulliparous (had not had a prior birth) (Table 1). Upon enrollment, the included users commonly expressed interest in receiving support with postpartum recovery (n=4622, 86%), breastfeeding (n=4428, 82%), and infant care (n=4186, 78%). Fewer users indicated interest in support with prenatal nutrition (n=2811, 52%) and choosing a pregnancy provider (n=863, 16%).

Trajectories of Utilization

On the basis of statistical model fit, class size, and interpretation, the 4-group trajectory model was chosen (Supplemental Tables 2 and 3). The 4-group model performed well on all tests of model adequacy.[8,10] The average posterior probability was greater than 0.96 for each group, well above the 0.7 threshold of model acceptability; the proportion assigned to each group matched the estimated probability of group membership; and the odds of correct classification exceeded 5 for each group (Table 2).

Figure 2 and Table 3 show the mean individual utilization indicators in each of the 4 trajectory groups across all trimesters of pregnancy. Trajectory group 1 was characterized by users who read articles and attended classes increasingly throughout pregnancy, watched few class recordings, minimally attended provider appointments, and sent few messages to their care advocate or a provider (Figure 2). In trajectory group 2, there is a distinct increasing pattern seen for all utilization indicators across pregnancy. Trajectory group 3 was characterized by users who read a high number of articles (compared to the other trajectories), watched class recordings, and attend live classes, with minimal messaging or appointments with their care advocate or a provider. Compared with all other groups, the users in trajectory group 4 exhibited high utilization for each indicator of interest. On the basis of these observed trends, the 4 utilization trajectory groups were named as follows: (1) baseline users (n=2828, 52%), (2) just-in-timers (n=876, 16%), (3) learners (n=1393, 26%), and (4) super users (n=312, 6%).

Demographic and Pregnancy Characteristics Across Multitrajectory Groups

Several user characteristics differed by trajectory group (Table 1). In particular, the baseline user trajectory had a higher proportion of users who identified as non-Hispanic white, had an obese BMI, had given birth previously, and had previously undergone cesarean section. The just-in-timers had a lower proportion of users who identified as non-Hispanic white and a lower proportion of pregnancy-related anxiety. Most of the just-in-timers reported interest in support with the postpartum-related topic areas. The learners trajectory had a higher proportion of users who identified as non-Hispanic white, were nulliparous, and were interested in support with prenatal nutrition, labor and delivery options, and working during parenthood. The super-user trajectory had the highest proportion of non-Hispanic Black and Asian or Pacific Islander users. Most of the super users were nulliparous and had a normal BMI. Compared with the other trajectory groups, a higher proportion of the super users reported experiencing several medical, pregnancy, and mental health conditions. Further, a high proportion of super users reported interest in support with childcare, choosing a provider, emotional health, labor and delivery options, prenatal nutrition, and working during parenthood.

Associations Between User-Reported Pregnancy Outcomes and Multitrajectory Groups

The baseline user trajectory, characterized by users who read articles and attended classes increasingly throughout pregnancy, with minimal engagement with the other services, was used as the reference group for all regression models.

Utilization Trajectories and User-Reported Education Measures. In adjusted models, trajectories reflective of increased utilization of digital health services were positively associated with user education measures (Table 4). Compared with baseline users, classification as a just-in-timer, learner, or super user was associated with an increased likelihood of helping users learn something that influenced how they approach their maternity experience ([adjusted odds ratio (AOR)$_{\text{just-in-timer}}$, 6.71; 95% CI, 5.50-8.18], [AOR$_{\text{learner}}$, 4.53; 95% CI, 3.84- 5.33], [AOR$_{\text{super user}}$, 8.90; 95% CI, 6.16-12.86]), understand warning signs during pregnancy ([AOR$_{\text{just-in-timer}}$, 1.89; 95% CI, 1.61-2.23], [AOR$_{\text{learner}}$, 2.26; 95% CI, 1.93-2.64], [AOR$_{\text{super user}}$, 2.73; 95% CI, 2.04-3.63]), and learn medically accurate information about pregnancy and potential complications ([AOR$_{\text{just-in-timer}}$, 2.96; 95% CI, 2.52-3.49], [AOR$_{\text{learner}}$, 2.73; 95% CI, 2.36-3.16], [AOR$_{\text{super user}}$, 4.02; 95% CI, 3.07-5.26]).

TABLE 1. Participant Demographic Characteristics and Select Baseline Conditions Across Digital Health Utilization Trajectories[a]

	Total (N=5409)	Group 1: baseline users (n=2828)	Group 2: just-in-timers (n=876)	Group 3: learners (n=1393)	Group 4: super users (n=312)	*P* value
Sociodemographic characteristics						
Age (y)	32.7 (4.0)	32.8 (4.1)	32.9 (4.0)	32.4 (3.8)	32.9 (3.9)	.045
Race and ethnicity						<.0001
Non-Hispanic, white	2317 (42.8)	1304 (46.1)	310 (35.4)	604 (43.4)	99 (31.7)	
Non-Hispanic, Asian or Pacific Islander	996 (18.4)	422 (14.9)	206 (23.5)	280 (20.1)	88 (28.2)	
Non-Hispanic, Black	238 (4.4)	117 (4.1)	44 (5.0)	61 (4.4)	16 (5.1)	
Non-Hispanic, American Indian or multiracial	120 (2.2)	64 (2.3)	18 (2.1)	32 (3.2)	6 (1.9)	
Hispanic	411 (7.6)	211 (7.5)	72 (8.2)	115 (8.3)	13 (4.2)	
I prefer not to say	1327 (24.5)	710 (25.1)	226 (25.8)	301 (21.6)	90 (28.9)	
Nulliparous	4028 (74.5)	1862 (65.8)	708 (80.8)	1190 (85.4)	268 (85.9)	<.0001
Body mass index classification (kg/m^2)						<.0001
Underweight (<18.5)	174 (3.2)	79 (2.8)	34 (3.9)	48 (3.5)	13 (4.2)	
Normal (18.5 to <25.0)	2963 (54.8)	1455 (51.5)	499 (57.0)	816 (58.6)	193 (61.9)	
Overweight (25.0 to <30.0)	1433 (26.5)	788 (27.9)	224 (25.6)	347 (24.9)	74 (23.7)	
Obese (≥30.0)	839 (15.5)	506 (17.9)	119 (13.6)	182 (13.1)	32 (10.3)	
Chronic medical conditions						
Heart disease	24 (0.4)	11 (0.4)	3 (0.3)	8 (0.6)	2 (0.6)	.64
Diabetes (type 1 or type 2)	68 (1.3)	43 (1.5)	10 (1.1)	12 (0.9)	3 (1.0)	.33
High blood pressure	184 (3.4)	113 (4.0)	26 (3.0)	41 (2.9)	4 (1.3)	.03
Blood disorder	55 (1.0)	28 (1.0)	10 (1.1)	14 (1.0)	3 (1.0)	.98
APLA[b]/thrombophilia	28 (0.5)	20 (0.7)	0 (0.0)	7 (0.5)	1 (0.3)	.04
Kidney disease	13 (0.2)	8 (0.3)	3 (0.3)	1 (0.1)	1 (0.3)	.36
Thyroid disease	435 (8.0)	203 (7.2)	95 (10.8)	100 (7.2)	37 (11.9)	<.0001
Autoimmune disease	164 (3.0)	79 (2.8)	21 (2.4)	49 (3.5)	15 (4.8)	.10
Pregnancy-related medical conditions						
Cholestasis in pregnancy	81 (1.5)	45 (1.6)	9 (1.0)	17 (1.2)	10 (3.2)	.04
Gestational diabetes	581 (10.7)	296 (10.5)	112 (12.8)	128 (9.2)	45 (14.4)	.01
Intrauterine growth restriction	147 (2.7)	69 (2.4)	31 (3.5)	36 (2.6)	11 (3.5)	.27
High blood pressure	686 (12.7)	357 (12.6)	117 (13.4)	170 (12.2)	42 (13.5)	.84
Preeclampsia	305 (5.6)	156 (5.5)	47 (5.4)	84 (6.0)	18 (5.8)	.89
Previous cesarean	414 (7.7)	282 (10.0)	60 (6.9)	55 (4.0)	17 (5.5)	<.0001
Mental health conditions						
Pregnancy-related anxiety	611 (11.3)	302 (10.7)	83 (9.5)	169 (12.1)	57 (18.3)	<.0001
Anxiety	1255 (23.2)	642 (22.7)	202 (23.1)	317 (22.8)	94 (30.1)	.03
Depression	660 (12.2)	357 (12.6)	118 (13.5)	138 (9.9)	47 (15.1)	.01
Perinatal mood disorder	85 (1.6)	37 (1.3)	16 (1.8)	21 (1.5)	10 (3.2)	.07
User-selected perinatal areas of interest[c]						
Breastfeeding	4428 (82.0)	2261 (80.2)	777 (88.7)	1142 (82.0)	248 (79.5)	<.0001
Childcare	22,679 (49.6)	1253 (44.4)	478 (54.6)	768 (55.2)	180 (57.7)	<.0001
Choosing a provider	863 (16.0)	289 (10.3)	131 (15.0)	346 (24.9)	97 (31.1)	<.0001
Emotional health	3855 (71.4)	1911 (67.8)	639 (73.0)	1040 (74.7)	265 (84.9)	<.0001
Infant care	4186 (77.5)	2066 (73.3)	746 (85.2)	1120 (80.5)	254 (81.4)	<.0001
Labor and delivery options	3348 (62.0)	1424 (50.5)	627 (71.6)	1055 (75.8)	242 (77.6)	<.0001
Postpartum recovery	4622 (85.6)	2369 (84.0)	784 (89.5)	1197 (86.0)	272 (87.2)	<.0001
Prenatal nutrition	2811 (52.1)	1182 (41.9)	418 (47.7)	972 (69.8)	239 (76.6)	<.0001
Working during parenthood	3539 (65.5)	1751 (62.1)	567 (64.7)	989 (71.1)	232 (74.4)	<.0001

[a]Data are presented as n (%) or mean (SD). Data are displayed for members who enrolled in Maven Clinic and gave birth between January 1, 2020, and May 27, 2022.
[b]To identify the desired areas of perinatal support, each user was asked the following question: "which areas are you most interested in receiving support in?"
[c]APLA, antiphospholipid antibody.

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Utilization Trajectories and User-Reported Experience Measures. In adjusted models, trajectories reflective of increased utilization of digital health services were positively associated with user experience measures (Table 4). Compared with baseline users, classification as a just-in-timer, learner, or super user was associated with an increased likelihood of providing users with excellent support through their pregnancy journey ([$AOR_{just\text{-}in\text{-}timer}$, 4.05; 95% CI, 3.43-4.79], [$AOR_{learner}$, 2.68; 95% CI, 2.29-3.13], [$AOR_{super\ user}$, 8.10; 95% CI, 6.23-10.54), help when they are in the hospital during labor and delivery ([$AOR_{just\text{-}in\text{-}timer}$, 2.95; 95% CI, 2.31-3.75], [$AOR_{learner}$, 2.44; 95% CI, 1.93-3.10], [$AOR_{super\ user}$, 4.04; 95% CI, 2.88-5.68]), and support that influenced their birth plan or delivery method preference ([$AOR_{just\text{-}in\text{-}timer}$, 5.20; 95% CI, 4.31-6.28], [$AOR_{learner}$, 2.80; 95% CI, 2.32-3.37], [$AOR_{super\ user}$, 5.67; 95% CI, 4.33-7.44]).

Utilization Trajectories and User-Reported Clinical Outcome Measures. In adjusted models, trajectories reflective of increased utilization of digital health services were positively associated with user perinatal outcomes (Table 4). Compared with baseline users, classification as a just-in-timer, learner, or super user was associated with an increased likelihood that users report that Maven helped them avoid a trip to the emergency room or an in-person doctors visit ([$AOR_{just\text{-}in\text{-}timer}$, 2.98; 95% CI, 2.07-4.29], [$AOR_{learner}$, 2.58; 95% CI, 1.86-3.58], [$AOR_{super\ user}$, 6.46; 95% CI, 4.32-9.67), manage anxiety and/or depression ([$AOR_{just\text{-}in\text{-}timer}$, 2.72; 95% CI, 2.12-3.48], [$AOR_{learner}$, 1.91; 95% CI, 1.52-2.40], [$AOR_{super\ user}$, 5.79; 95% CI, 4.29-7.81]), influence their choice of delivery method ([$AOR_{just\text{-}in\text{-}timer}$, 4.50; 95% CI, 3.15-6.43], [$AOR_{learner}$, 3.20; 95% CI, 2.21-4.63.], [$AOR_{super\ user}$, 6.20; 95% CI, 3.93-9.79]), and with breastfeeding ([$AOR_{just\text{-}in\text{-}timer}$, 2.19; 95% CI, 1.81-2.66], [$AOR_{learner}$, 2.14; 95% CI, 1.79-2.57], [$AOR_{super\ user}$, 3.15; 95% CI, 2.39-4.16]).

TABLE 2. Model fit Criterion of Digital Health Utilization Trajectories[a]

Multitrajectory groups	n	Group average posterior probability	Weighted odds of correct classification	Total group probability
1	2828	0.98	38.63	0.52
2	876	0.96	118.49	0.16
3	1393	0.96	74.50	0.26
4	312	0.99	1334.82	0.06

[a]An average posterior probability of >0.7, odds of correct classification of >5.0, and ≥5% of analytic sample in each trajectory indicate good model fit.

DISCUSSION

This study identified 4 distinct digital prenatal health platform utilization trajectories among the included users: (1) baseline user, (2) just-in-timer, (3) learner, and (4) super user. Utilization trajectories differ by user demographic and pregnancy characteristics, providing insight into how user characteristics may influence digital resource use. Overall, trajectories characterized by more use were associated with positive user-reported outcomes for all included measures, even after adjusting for confounders. The results suggest that during pregnancy, distinct trajectories of digital health utilization emerge, and these trajectories may contribute to self-reports of Maven's influence on pregnancy and postpartum outcomes.

The use of perinatal digital health services and mobile applications continues to increase,[12-14] and pregnant people have reported using digital tools to access educational information, track health indicators, and monitor perinatal development.[15] Previous studies have found mixed associations between the utilization of perinatal digital health tools and perinatal outcomes[6,15]; however, these studies have narrowly examined only individual exposure measures (ie, mobile application use [yes/no]) in relation to perinatal outcomes and not comprehensive delivery of multiple digital services.[16,17] In our analysis, we found that combinations of particular digital health components utilized with varying intensity over time contribute to positive self-reports of Maven's influence on pregnancy outcomes.

More than a quarter of users were grouped into the learner trajectory, in which they predominantly utilized articles, live classes, and class recordings and not care support or provider services. It is possible that learners had few clinical concerns, had robust in-person care services, or saw Maven as a complement

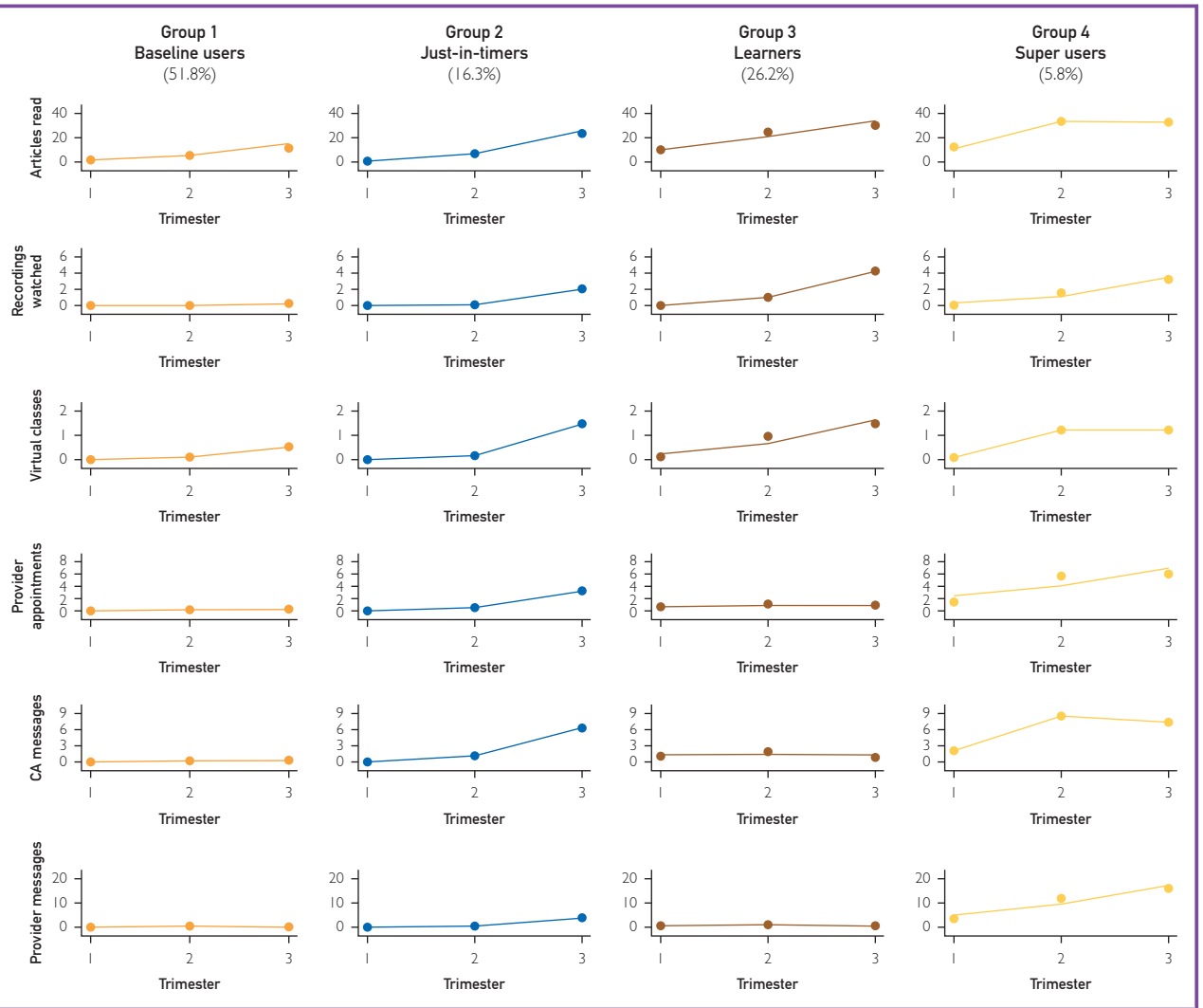

FIGURE 2. Digital health multi trajectory profiles across pregnancy. CA, care advocate.

to their in-person prenatal care. Regardless of their reasons for seeking education, these activities have documented benefits, including reduced maternal stress and increased self-efficacy.[18] Therefore, despite lack of interpersonal engagement, users in the learner trajectory may yield additional benefits from increased antenatal knowledge.

Our findings also suggest that high overall use was associated with higher likelihood of reporting that Maven contributed to better management of mental health. Users in the super-user trajectory were more likely to report an interest in emotional health support and had a higher prevalence of depression and general and pregnancy-related anxiety. Previous studies of pregnant people's experiences with perinatal anxiety have found that negative experiences within the healthcare system, poor perceived quality of available services, and feelings of shame and embarrassment inhibit the ability to connect to peers.[19-21] Our results suggest that digital health platforms may mitigate these issues by providing increased psychosocial support through access to mental health providers and education materials without having to visit an in-person clinic. Super users also reported that the services provided helped to manage their anxiety and depression during pregnancy. Given the established associations among mental health disorders, increased

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TABLE 3. Digital Health Utilization per Trimester Presented by Utilization Trajectories[a]

	Whole sample (N=5409)	Group 1: baseline users (n=2828)	Group 2: just-in-timers (n=876)	Group 3: learners (n=1393)	Group 4: super users (n=312)	*P* value
Trimester 1						
Articles read	4.0 (11.4)	1.5 (5.2)	0.4 (2.8)	9.9 (16.7)	11.9 (20.8)	<.001
Recordings watched	0.02 (0.3)	0.0 (0.7)	0.0 (0.0)	0.1 (0.4)	0.1 (0.5)	<.001
Virtual classes	0.03 (0.3)	0.0 (0.1)	0.0 (0.0)	0.1 (0.5)	0.1 (0.4)	<.001
Provider appointments	0.2 (1.0)	0.0 (0.2)	0.0 (0.2)	0.5 (1.1)	1.5 (2.9)	<.001
Care advocate text messages	0.5 (1.7)	0.1 (0.4)	0.0 (0.3)	1.1 (2.4)	2.1 (4.2)	<.001
Provider text messages	0.4 (2.3)	0.0 (0.1)	0.0 (0.1)	0.6 (1.8)	3.5 (7.9)	<.001
Trimester 2						
Articles read	12.3 (19.8)	5.6 (9.8)	6.2 (10.6)	25.3 (25.8)	33.2 (30.6)	<.001
Recordings watched	0.04 (1.5)	0.1 (0.3)	0.1 (0.5)	1.1 (2.3)	1.6 (3.2)	<.001
Virtual classes	0.4 (1.1)	0.1 (0.5)	0.1 (0.5)	1.0 (1.7)	1.2 (1.9)	<.001
Provider appointments	0.7 (2.6)	0.1 (0.4)	0.4 (1.0)	1.0 (1.4)	5.8 (8.6)	<.001
Care advocate text messages	1.4 (3.3)	0.3 (0.8)	1.2 (2.3)	2.0 (3.0)	8.6 (8.0)	<.001
Provider text messages	1.0 (4.8)	0.0 (0.3)	0.2 (0.8)	1.0 (1.8)	12.1 (15.7)	<.001
Trimester 3						
Articles read	19.4 (21.3)	11.3 (13.3)	23.8 (21.9)	30.2 (25.3)	32.2 (26.5)	<.001
Recordings watched	1.8 (3.8)	0.3 (0.7)	2.1 (3.3)	4.3 (5.8)	3.3 (4.5)	<.001
Virtual classes	1.0 (1.6)	0.5 (1.1)	1.5 (2.0)	1.5 (1.8)	1.2 (1.7)	<.001
Provider appointments	1.2 (2.7)	0.2 (0.6)	3.3 (3.0)	0.8 (1.3)	6.1 (6.9)	<.001
Care advocate text messages	1.9 (3.9)	0.4 (0.9)	6.4 (5.0)	0.9 (1.8)	7.5 (7.9)	<.001
Provider text messages	1.7 (6.3)	0.1 (0.3)	3.8 (4.6)	0.4 (1.1)	15.9 (19.3)	<.001

[a]Data are presented as n (%) or mean (SD). Data are displayed for members who enrolled in Maven Clinic and gave birth between January 1, 2020 and May 27, 2022.

pregnancy complications, and worse birth outcomes,[22,23] the ability to improve the experience of mental health during pregnancy may result in unforeseen benefits for both the birthing person and infant during and beyond pregnancy.

More than 15% of users had low utilization of all available services within Maven until their third trimester of pregnancy. Given the proximity of birth as the third trimester progresses, the just-in-timer trajectory may reflect reliance on supplemental services, such as Maven, to prepare for labor and delivery. Our study also found that more than half of the users were in the baseline trajectory. This trajectory may reflect individuals with more experience during pregnancy or individuals with fewer pregnancy-related questions and concerns, thus yielding lower utilization. Notably, users in this trajectory were more likely to be parous, which aligns with current research noting that individuals with prior births were less likely to use pregnancy-related mobile applications.[14]

After adjusting for relevant maternal and household characteristics, just-in-timers, learners, and super users were associated with an improvement in all 10 user-reported measures of education, experience, and sense of the role of Maven in improving outcomes when compared with baseline users. Together, these findings suggest that digital platforms are effective in supporting pregnant people throughout their pregnancies, including by increasing their sense that using Maven contributed to better clinical outcomes. Despite the rising costs of routine prenatal care, pregnant people are often left unsatisfied with their care and pregnancy-related knowledge,[2] and clinical outcomes have suffered.[1] Digital health platforms enable users to take an active role in their prenatal care because users can select appropriate resources for their circumstances to enhance their own experience and well-being. Within our analysis, multiple utilization trajectories were associated with positive experience outcomes. Therefore, it appears that providing a platform in which

TABLE 4. Adjusted Associations Between Digital Health Utilization Trajectories and User-Reported Education, Experience, and Clinical Outcome Measures[a]

	Education measures					
	Something I learned through Maven influenced the way I approached my maternity experience		Maven helped me understand warning signs during pregnancy		Maven helped me learn medically accurate information about pregnancy and/or complications	
	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Trajectory group						
Baseline users	1.00 (reference)	–	1.00 (reference)	–	1.00 (reference)	–
Just-in-timers	6.71 (5.50-8.18)	<.0001	1.89 (1.61, 2.23)	<.0001	2.96 (2.52-3.49)	<.0001
Learners	4.53 (3.84-5.33)	<.0001	2.26 (1.93, 2.64)	<.0001	2.73 (2.36-3.16)	<.0001
Super users	8.90 (6.16-12.86)	<.0001	2.73 (2.04-3.63)	<.0001	4.02 (3.07-5.26)	<.0001
	Experience measures					
	I experienced excellent support from Maven through my pregnancy journey		Maven helped me when I was in the hospital during labor and delivery		Maven influenced my birth plan or delivery method preference	
	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Trajectory group						
Baseline users	1.00 (reference)	–	1.00 (reference)	–	1.00 (reference)	–
Just-in-timers	4.05 (3.43-4.79)	<.0001	2.95 (2.31-3.75)	<.0001	5.20 (4.31-6.28)	<.0001
Learners	2.68 (2.29-3.13)	<.0001	2.44 (1.93-3.10)	<.0001	2.80 (2.32-3.37)	<.0001
Super users	8.10 (6.23-10.54)	<.0001	4.04 (2.88-5.68)	<.0001	5.67 (4.33-7.44)	<.0001
	Clinical outcome measures					
	Maven helped me avoid a trip to the ER or an in-person doctors visit		Maven helped me manage anxiety and/or depression		Maven influenced my choice of delivery method		Maven helped me with breastfeeding	
	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value	Adjusted odds ratio (95% CI)	*P* value
Trajectory group								
Baseline users	1.00 (reference)	–	1.00 (reference)	–	1.00 (reference)	–	1.00 (reference)	–
Just-in-timers	2.98 (2.07-4.29)	<.0001	2.72 (2.12-3.48)	<.0001	4.50 (3.15-6.43)	<.0001	2.19 (1.81-2.66)	<.0001
Learners	2.58 (1.86-3.58)	<.0001	1.91 (1.52-2.40)	<.0001	3.20 (2.21-4.63)	<.0001	2.14 (1.79-2.57)	<.0001
Super users	6.46 (4.32-9.67)	<.0001	5.79 (4.29-7.81)	<.0001	6.20 (3.93-9.79)	<.0001	3.15 (2.39-4.16)	<.0001

[a]ER, emergency room. All models were adjusted for trimester of enrollment into the digital health service, user race and ethnicity, age, body mass index, presence of chronic medical conditions, pregnancy conditions, and mental health conditions.

pregnant individuals can tailor care to their needs may be especially beneficial for improving maternal experience.

To our knowledge, this study was the first to use multitrajectory modeling to evaluate longitudinal utilization of a digital health platform throughout pregnancy. Additional strengths of this study include a large sample size from a national cohort and detailed data on digital utilization and user-reported outcomes. Despite its strengths, this study has important limitations. First, users were unable to access any of the resources within Maven until they officially enrolled, which could have been at any point during their pregnancy. Of the 5409 users, 1418 (26.2%) enrolled in the first trimester, 2323 (43.0%) enrolled in the second trimester, and 1668 (30.8%) enrolled in the third trimester, so the increasing use observed across groups may in part be due to enrollment in second and third trimesters. Although our approach demonstrates how pregnant people initiate and engage with digital health technologies throughout their pregnancies, this approach does not highlight how long-term users (ie, those who enrolled in the first trimester) may independently contribute to trajectories.

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However, when we limited our sample to only users who enrolled in the first trimester, we saw consistent trajectories (data not shown). Second, users who did not complete all health assessment surveys were excluded from this analysis. The trajectories presented here may not be representative of those users. Third, all users had access to a smartphone device and were commercially insured, and most users who chose to report their race and ethnicity identified as white and non-Hispanic, potentially limiting the generalizability of these findings. Fourth, we did not collect data related to the gestational age when pregnancy-related conditions were diagnosed. In addition to the positive association between utilization and user-reported pregnancy outcomes, it is possible that digital health utilization contributed to more clinical outcomes, including symptom recognition and early diagnosis of pregnancy-related conditions (ie, preeclampsia or gestational diabetes). Although we were unable to assess some clinical outcomes, our patient-reported outcomes on mental health management and avoiding emergency room/in-person visits provide important preliminary data to suggest Maven's clinical benefit. Fifth, all users in our sample had access to the digital health platform. Without a true control group, we were unable to assess how any utilization of Maven was associated with our pregnancy outcomes, compared with a group who did not have access. Sixth, we did not collect data on individual expectations at enrollment in Maven. It is possible that individuals who anticipated receiving more pregnancy support through Maven would have higher utilization and be more likely to respond positively to the user-reported pregnancy outcomes we assessed. Finally, all outcome measures were collected via self-report, which may have led to shared method variance. However, research suggests that self-reported pregnancy experience and outcome measures are reliable and especially valuable when evaluating digital health services.[24,25]

CONCLUSION

Our findings suggest that multitrajectory modeling provides a nuanced approach to understanding how utilization of digital health services through mobile applications might influence health outcomes, particularly in pregnancy. The present study identified 4 trajectory groups with distinct digital health utilization. Multiple utilization trajectories were associated with positive health outcomes, indicating that pregnant individuals are especially suited to determine which aspects of digital health will address their specific needs. Our results indicate that digital health tools, such as Maven, may provide a viable, patient-centered approach to enhance and optimize current prenatal care. Utilization trajectories create the potential for digital health products to better align with member preferences and learning styles, ultimately creating a more personalized member experience. On the basis of our findings, digital health services should aim to provide a variety of services (eg, patient-provider interactions) and tools (eg, educational materials) to their members. Additionally, digital services and tools should be made available across the pregnancy journey to ensure that pregnant people have access at the right time. Diversification of digital health services will support individualized care by permitting users to self-select and use the services that reflect their unique needs. Future digital health research in this area should seek to identify the most impactful utilization trajectories to incentivize optimally effective user interaction with digital health services.

POTENTIAL COMPETING INTERESTS

Drs Jahnke, Henrich, Moss, and Shah and authors Rubin-Miller and Challa hold positions at Maven Clinic and have equity in Maven Clinic, and Dr Peahl and author Brinson are paid consultants for Maven Clinic. Maven Clinic was involved in study design, data management, data analysis, and writing of the manuscript.

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All authors had access to the datasets and take responsibility for the integrity of the analysis. Author Brinson and Dr Jahnke conceptualized and designed the study. Author Challa was responsible for data acquisition. Authors Brinson and Rubin-Miller and Drs Jahnke, Henrich, Peahl, and Shah played a role in data interpretation. Authors Brinson and Rubin-Miller and Drs Jahnke and Peahl prepared

the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at https://www.mcpdigitalhealth.org/. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **AOR**, adjusted odds ratio; **BIC**, Bayesian information criteria; **BMI**, body mass index

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