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Effect of a Best Practice Alert on Gestational Weight Gain, Health Services, and Pregnancy Outcomes

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Abstract *Objective* To examine whether an electronic medical record "best practice alert" previously shown to improve antenatal gestational weight gain patient education resulted in downstream effects on service delivery or patient health outcomes. *Methods* This study involved secondary analysis of data from an intervention to improve provider behavior surrounding gestational weight gain patient education. Data were from retrospective chart reviews of patients who received care either before (N = 333) or after (N = 268) implementation of the intervention. Pre-post comparisons and multivariable logistic regression were used to analyze downstream effects of the intervention on health outcomes and obesity-related health services while controlling for potential confounders. *Results* The intervention was associated with an increase in the proportion of prenatal patients who gained weight within Institute of Medicine guidelines, from 28 to 35 % ($p < .05$). Mean total gestational weight gain did not change, but variability decreased such that post-intervention women had weight gains closer to their gestational weight gain targets. The intervention was associated with a 94 g decrease in mean infant birth weight ($p = .03$), and an increase in the proportion of overweight and obese women screened for undiagnosed Type 2 diabetes before 20 weeks gestation, from 13 to 25 % ($p = .01$). *Conclusions for Practice* The electronic medical record can be leveraged to promote healthy gestational weight gain and early screening for undiagnosed Type 2 diabetes. Yet most patients still need additional support to achieve gestational weight gain within Institute of Medicine guidelines.

Keywords Obesity · Diabetes · Prevention · Prenatal counseling · Electronic health records

Significance

What is already known on this subject? Decision support tools in the electronic medical record have been shown to improve provider behavior surrounding gestational weight gain patient education. However, it was unknown whether interventions targeting gestational weight gain patient education could lead to measurable improvement in patients' actual gestational weight gain, uptake of recommended health services, and related health outcomes.

What this study adds? A best practice alert in the electronic medical record promotes healthy gestational weight gain and early screening for undiagnosed Type 2 diabetes.

Introduction

The Institute of Medicine (IOM) provides guidelines for gestational weight gain based on pre-gravid body mass index (BMI) and fetal number [15]. Only 30–40 % of pregnant women report discussing gestational weight gain with their providers [21, 27], and only a third of women

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gain weight within guidelines [15]. This is a significant public health problem. Inappropriate gestational weight gain increases risk for adverse maternal and child health outcomes including preterm birth [2, 23, pregnancy complications [16, 25], extreme birth weight [17, 25], maternal obesity [7, 20], pediatric obesity [19, 22, and lifelong elevated cardiovascular and metabolic risk [5, 28]. Inappropriate gestational weight gain also disproportionately affects minority and low-income women [9, 13], contributing to and perpetuating health disparities across generations [3].

We previously showed that implementing decision support tools in the electronic medical record (EMR) resulted in substantial improvement in provider behavior surrounding gestational weight gain patient education. In the previous study, we designed and implemented a best practice alert in the EMR. Based on each patient's pre-gravid body mass index (BMI), fetal number, and 2009 Institute of Medicine (IOM) guidelines, the alert provides personalized gestational weight gain goals and a template for scripted provider counseling and documentation. Retrospective chart reviews of 388 pre-intervention patients and 345 post-intervention patients were used to evaluate effectiveness. This tool improved the rate of antenatal gestational weight gain counseling that was consistent with current IOM guidelines ($p < .001$) across all provider types, including obstetricians, family practice physicians, and certified nurse midwives. [1]. Gestational weight gain patient education is correlated with patients' internalized gestational weight gain goals and actual gestational weight gain, and those who receive no patient education are more likely to gain weight outside guidelines [11, 27]. However, patient education alone usually has limited effectiveness and may be insufficient to overcome barriers to healthy gestational weight gain, especially in disadvantaged populations [6, 10].

There is a critical gap in the existing literature on whether interventions targeting gestational weight gain patient education lead to measurable improvements in patients' actual gestational weight gain, uptake of recommended health services, and related health outcomes. The current study aimed to fill this gap through secondary analysis of data from our previous study. Specifically, the purpose of this study was to examine whether our intervention to improve patient education resulted in subsequent effects on service delivery or patient health outcomes.

Methods

Participants

This study involved secondary analysis of data from an intervention that improved provider behavior surrounding gestational weight gain patient education [1]. The original sample contained 388 participants who received prenatal care at one of five participating clinics before implementation of the intervention, in 2011, and 345 participants who received prenatal care at the same clinics after implementation of the intervention, in 2012. The purpose of the current analysis was to study patient health outcomes and health services through the entire obstetric episode. We therefore excluded participants who miscarried or terminated their pregnancies (n = 31), moved out of the health system prior to delivery (n = 36), had no recorded pre-gravid BMI (unable to determine IOM target range of gestational weight gain, n = 59). We also excluded participants who had twins (n = 15) and two participants with total gestational weight gain greater than 35 kg (77 lbs) who were outliers and exerting undue influence on the results as measured by Cook's distance [4]. This resulted in a final analytic sample of 333 pre-intervention participants and 268 post-intervention participants.

Intervention

We designed and implemented a "best practice alert" in the EMR that provides tailored gestational weight gain goals and patient education materials based on patients' pre-gravid BMI, fetal number, and the 2009 IOM Guidelines. The alert includes an individualized template for scripted provider counseling and documentation of the patients' gestational weight gain. Additionally, the alert has a "Smart Set" the provider can access with related orders, such as medical diagnostic tests, appropriate diagnosis codes, and a prompt recommending early screening for type 2 diabetes in patients affected by obesity or overweight with a risk factor for Type II diabetes. The project was reviewed and approved as exempt by the University of Wisconsin Institutional Review Board as a quality improvement initiative. Additional details on development of the intervention and its effects on provider behavior can be found elsewhere [1].

Data Collection

The University of Wisconsin Office of Clinical Trials coordinated data abstraction. Variables abstracted from participants' EMRs included age, race/ethnicity, gravida/parity, gestational number (singleton, twin), pre-gravid weight and height, pre-gravid BMI, last recorded weight during each trimester, total gestational weight gain, pre-existing medical conditions (e.g., hypertension, diabetes), relevant pregnancy conditions (e.g., gestational hypertension/preeclampsia, gestational diabetes), gestational age at delivery, infant birth weight, and mode of delivery. Abstractors conducted a thorough search of each

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patient's EMR to identify obesity-related health services, with particular attention to the problem list, provider progress notes, prenatal education checklists, telephone encounter notes, and consults/referrals. The date, method, and lab results of each prenatal patient's first diabetes screen were recorded and gestational age at first diabetes screen was calculated based on screen date and estimated date of delivery. Total gestational weight gain was computed as the difference between the last recorded third trimester weight minus the pre-gravid weight. Total gestational weight gain was then classified as within or outside IOM guidelines [15]. Two participants were missing total gestational weight gain, so analyses for these outcomes have an effective sample size of N = 599. Births occurring prior to 37 weeks gestation were classified as preterm. Infant birth weights and gestational age were used to compute birth weight percentiles [24]. Birth weights below the 10th percentile were classified as small for gestational age and above the 90th percentile classified as large for gestational age. All provider and patient data were de-identified to maintain confidentiality. 10 % of charts were abstracted by two independent reviewers and results compared to ensure agreement. Reviewers had 100 % agreement on most variables and greater than 90 % agreement on all variables. Study data were managed using REDCap electronic data capture tools [8].

Data Analyses

Chi-square tests and *t* tests were computed to compare pre-intervention and post-intervention patients' pre-gravid demographic and clinical characteristics, receipt of health services, and health outcomes. A series of univariable and multivariable logistic regression analyses were used to estimate the relative odds of meeting IOM gestational weight gain guidelines before versus after the intervention while controlling for potential confounders available to researchers via patients' EMRs, such as maternal age, ethnicity, parity, pre-gravid BMI, gestational weight gain, and comorbid conditions.

Results

Sample Characteristics

Demographic and clinical characteristics of the sample are presented in Table 1. Nearly half of patients (47.4 %) were primiparous. Most patients (73.2 %) were White, with a mean age of 30.4 years (SD = 4.9). Just over half the study sample (53.9 %) started pregnancy normal weight, while most of remaining women were either overweight (22.6 %) or obese (20.1 %) based on pre-gravid BMI. Fewer than 5 % had documented pre-gravid medical conditions, i.e. diabetes, hypertension, cardiovascular disease, renal disease, sleep apnea, lupus, representing a relatively low-risk prenatal cohort. There were no significant differences between the pre-intervention and post-intervention samples on any patient characteristic we examined.

Obesity-Related Health Services

As shown in Table 2, obesity-related health services were relatively rare, both before and after the intervention. There was no significant change in the rate of referrals for dietary/nutrition counseling when calculated for entire sample of prenatal patients (4.8 % pre-intervention vs. 4.5 % post-intervention). However, homogeneity tests indicated that the pattern of pre-post differences varied across patient subgroups, $p = .02$. Specifically, dietary referrals for underweight, normal weight, and overweight patients remained statistically unchanged (and infrequent), whereas dietary referrals for obese patients increased. The intervention was also associated with an increase in the proportion of overweight and obese patients who received early screening (before 20 weeks gestation) for undiagnosed diabetes (12.7 % pre-intervention vs. 25.4 % post-intervention). Tests for homogeneity of the effect showed that the increase was consistent across overweight and obese patient subgroups. Additional screens did not yield any cases of previously undiagnosed type 2 diabetes or prediabetes, but this result is limited by providers' use of inappropriate screening tests. We found that many providers ordered 1 h 50 g glucose tolerance tests prior to 20 weeks gestation, which is the most commonly used test to screen for gestational diabetes but is not validated for diagnosing pre-existing adult type 2 diabetes. This use of inappropriate early diabetes screening tests was in spite of an EMR trigger within the best-practice alert recommending use of fasting plasma glucose and/or hemoglobin A1C for early diabetes screenings, as well as links to the appropriate orders within the associated smart set.

Health Outcomes

The intervention was associated with an increase in the proportion of patients who met Institute of Medicine guidelines for target gestational weight gain (27.5 % pre-intervention vs. 35.1 % post-intervention, $p = .05$, see Table 3). This increase was achieved via small decreases in both the proportion of women gaining insufficient weight (26.3 % pre-intervention vs. 21.6 % post-intervention) and excess weight (46.2 % pre-intervention vs. 43.3 % post-intervention). We tested whether this effect differed for women who began pregnancy at different BMI categories (underweight vs. overweight, etc.), but homogeneity tests

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Table 1 Sample Characteristics

Characteristic	Pre-intervention (n = 333)	Post-intervention (n = 268)	*p* value
Maternal age at delivery, years			
<20	6 (1.8)	5 (1.9)	.33
20–24	30 (9.0)	29 (10.8)	
25–29	94 (28.2)	82 (30.6)	
30–34	142 (42.6)	97 (36.2)	
35–39	54 (16.2)	42 (15.7)	
40+	7 (2.1)	13 (4.9)	
Maternal race[a]			
White, non-hispanic	256 (79.0)	184 (81.1)	.91
Black, non-hispanic	18 (5.6)	10 (4.4)	
Hispanic	17 (5.2)	9 (4.0)	
Asian	30 (9.3)	22 (9.7)	
American Indian/Pacific Islander	3 (0.9)	2 (0.9)	
Parity			
Primiparous	150 (45.0)	135 (50.4)	.19
Multiparous	183 (55.0)	133 (49.6)	
Pre-gravid BMI class			
Underweight	14 (4.2)	6 (2.2)	.52
Normal weight	182 (54.7)	142 (53.0)	
Overweight	73 (21.9)	63 (23.5)	
Obese	64 (19.2)	57 (21.3)	
Pre-existing medical conditions			
Diabetes (Type 1 or Type 2)	0 (0.0)	1 (0.4)	.27
Chronic hypertension	10 (3.0)	8 (3.0)	.99
Renal disease	2 (0.6)	3 (1.1)	.49
Cardiovascular disease	2 (0.6)	5 (1.9)	.15
Lupus	0 (0.0)	2 (0.7)	.11
Sleep apnea	0 (0.0)	0 (0.0)	.99
None of the above	320 (96.1)	252 (94.0)	.24

Data are n (%). *p* values are reported from χ^2 tests

[a] Maternal race classifications are listed for participants whose race/ethnicity were documented in the EMR. Race was unspecified in the electronic medical records of 50 patients (8.3 %)

revealed that this effect was consistent across patient subgroups. In other words, the proportion of women meeting guidelines increased across all pre-gravid BMI categories.

Notably, the intervention was not associated with a change in the mean amount of total gestational weight gain. Rather, Levene's test for equality of variance showed that the intervention was associated with a decrease in variability ($p = .04$), such that post-intervention patients across all pre-gravid BMI categories had weight gains closer to their gestational weight gain targets compared to pre-intervention patients. This is illustrated in Fig. 1. The intervention was also associated with a modest but statistically significant decrease in mean infant birth weight, by 94 g, from 3476 (SD = 520) to 3382 g (SD = 554), $p = .03$. This change in mean birth weight did not result in a corresponding change in the proportion of infants classified as small for gestational age (weight below the 10th percentile for gestational age) or large for gestational age (weight above the 90th percentile for gestational age). There also were no differences between the pre-intervention and post-intervention samples on other health outcomes we examined, including incident gestational diabetes, gestational hypertension, gestational age at delivery, number of preterm births, or mode of delivery.

Next, we conducted a series of logistic regression analyses to explore whether the pre versus post intervention differences in the proportion of women meeting gestational weight gain guidelines might be explained by some confounding variable. These results are displayed in Table 4. The first column in Table 4 shows the independent, univariable relationships between the intervention effect (i.e. pre vs. post), maternal demographic factors (i.e.

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Table 2 Obesity-related health services, by time period

Outcome	Pre-intervention (n = 333)	Post-intervention (n = 268)	*p* value
Dietary/nutrition referral			
All BMI classes, combined	16 (4.8)	12 (4.5)	.85
Underweight	0 (0.0)	0 (0.0)	
Normal weight	4 (2.2)	0 (0.0)	
Overweight	4 (5.5)	0 (0.0)	
Obese	8 (12.5)	12 (21.1)	
Diabetes screen before 20 weeks gestation			
Overweight and obese, combined	17 (12.7)	30 (25.4)	.01
Overweight	7 (9.7)	13 (21.3)	
Obese	10 (16.1)	17 (29.8)	
Early diabetes screening yielded positive screen for undiagnosed type 2 diabetes[a]	0 (0.0)	0 (0.0)	.99
Early diabetes screening yielded positive screen for prediabetes[a]	0 (0.0)	0 (0.0)	.99

Data are n (%). *p* values are reported from χ^2 tests

[a] Positive screens are reported based on random plasma glucose, fasting plasma glucose, and hemoglobin A1C tests. As noted in the text, many providers ordered 1 h 50 g glucose tolerance tests prior to 20 weeks, for which there are no standard cutoffs for diagnosing diabetes or prediabetes

age, race/ethnicity), pre-pregnancy clinical factors (i.e., parity, pre-pregnancy BMI, pre-existing conditions), and pregnancy factors (i.e., preterm birth, gestational diabetes, gestational hypertension) on the odds of gaining weight within guidelines. The subsequent columns in Table 4 show the results of multivariable logistic regression analyses in which we modeled the intervention effect while controlling for maternal demographic factors (Model 1), maternal demographic and pre-pregnancy clinical factors (Model 2), and finally maternal demographics, pre-pregnancy clinical factors and pregnancy factors, i.e. fully adjusted (Model 3). As seen in the table, the intervention effect remained significant through all the models, suggesting that the pre-intervention versus post-intervention increase in the proportion of women meeting gestational weight gain guidelines could not be explained by any of the other factors in the model. Across models, even controlling for potential confounds, post-intervention patients had approximately 50 % greater odds of gaining weight within the current GWG guidelines than pre-intervention patients did.

Discussion

Our findings suggest that an intervention which is effective at improving provider behavior surrounding gestational weight gain patient education via an EMR "best practice alert" had positive subsequent effects on target gestational weight gain, utilization of obesity-related health services, and select patient health outcomes. The intervention was associated with a significant increase in the proportion of prenatal patients who gained weight within IOM guidelines. Although the intervention was not associated with an overall change in mean total gestational weight gain, variability decreased such that post-intervention patients consistently had weight gains closer to IOM targets compared to pre-intervention patients. This pattern of results was consistent across all pre-gravid BMI categories. The intervention was associated with a modest decrease in mean infant birth weight, and an increase in the proportion of overweight and obese women screened for undiagnosed Type 2 diabetes prior to 20 weeks gestation. The intervention was not associated with changes in other health outcomes, such as the proportion of preterm deliveries, modes of delivery, incident gestational diabetes or gestational hypertension, or the proportion of small for gestational age or large for gestational age neonates.

The intervention was innovative as it leveraged the EMR to promote adherence to clinical practice guidelines surrounding gestational weight gain patient education. The best practice alert helps clinicians follow complex IOM guidelines and provide gestational weight gain goals that are appropriately tailored to each patient's medical information. These results align with similar findings from EMR interventions in other areas in showing that interventions like this one have potential to improve both prenatal care practice and patient outcomes ([18]; [26]). This EMR intervention removes barriers that providers traditionally face when counseling patients about gestational weight

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Table 3 Health outcomes, by time period

Outcome	Pre-intervention (n = 333)	Post-intervention (n = 268)	*p* value
Gestational weight gain (%)			
Within guidelines	91 (27.5)	94 (35.1)	.05
Outside guidelines	240 (72.5)	174 (64.9)	
Gestational weight gain (kg)			
All BMI classes, combined	13.61 ± 6.14	13.55 ± 5.34	.89
Underweight	14.84 ± 5.97	13.28 ± 6.41	
Normal weight	14.35 ± 5.54	14.29 ± 4.14	
Overweight	14.11 ± 6.39	13.82 ± 5.82	
Obese	10.64 ± 6.75	11.43 ± 6.74	
Pregnancy complications (%)			
Gestational diabetes	24 (7.2)	13 (4.9)	.23
Pregnancy-induced hypertension	22 (6.6)	16 (6.0)	.75
Mode of delivery (%)			
Spontaneous vaginal	215 (64.6)	181 (67.5)	.24
Caesarean section	89 (26.7)	72 (26.9)	
Forceps/vacuum	19 (5.7)	13 (4.9)	
Vaginal birth after caesarean	10 (3.0)	2 (0.7)	
Gestational age at delivery, weeks	39.09 ± 1.48	38.93 ± 1.56	.18
Pre-term (%)	14 (4.2)	17 (6.3)	.24
Infant birth weight (g)	3475.54 ± 520.14	3382.19 ± 554.14	.03
Size for gestational age (%)[a]			
Small for gestational age	25 (7.5)	25 (9.4)	.66
Average for gestational age	268 (80.5)	211 (79.6)	
Large for gestational age	40 (12.0)	29 (10.9)	

Data are mean ± SD or n (%). *p* values are reported from *t* tests (for continuous variables) or χ^2 tests (for categorical variables)

[a] Infant birth weights and gestational age were used to compute birth weight percentiles [24]. Birth weights below the 10th percentile were classified as small for gestational age and above the 90th percentile classified as large for gestational age

gain [12], i.e. it automatically calculates appropriate gestational weight gain goals for each unique patient based on pre-gravid BMI, fetal number, and IOM guidelines, it provides scripted messages to facilitate patient education and documentation, it provides prompts to counsel patients and screen early for Type 2 diabetes when warranted, and it changes organizational culture to make gestational weight gain patient education a normative part of prenatal care. Given that the use of EMRs is now widespread [14], and yet just 30–40 % of pregnant women report discussing gestational weight gain with their providers [21, 27], replication of these findings in other health systems and with other patient populations is needed. When integrated into a broader set of intervention strategies, this type of EMR intervention has potential to promote best practices for healthy gestational weight gain and management of overweight and obesity risk in pregnancy.

These findings fill a critical gap in the existing scientific literature by clarifying that interventions to improve gestational weight gain patient education have the potential to increase the proportion of women who gain weight within guidelines and to improve related health outcomes. This is consistent with previous research that gestational weight gain patient education is correlated with patients' gestational weight gain goals and actual gestational weight gain [11, 27]. It goes beyond previous findings to show that interventions to improve patient education can increase the proportion of patients who meet IOM guidelines and bring total gestational weight gain closer to IOM targets regardless of pre-gravid BMI. However, with a majority of patients still gaining outside guidelines, it is also clear that improved patient education is only part of the solution. Further research should examine which patients are most likely to benefit from interventions like this one while also seeking to identify which patients are most in need of additional supports.

Our finding that the intervention was associated with a decrease in infant birth weight, without a corresponding increase in the proportion of small for gestational age babies, is also promising. As Kim and colleagues showed,

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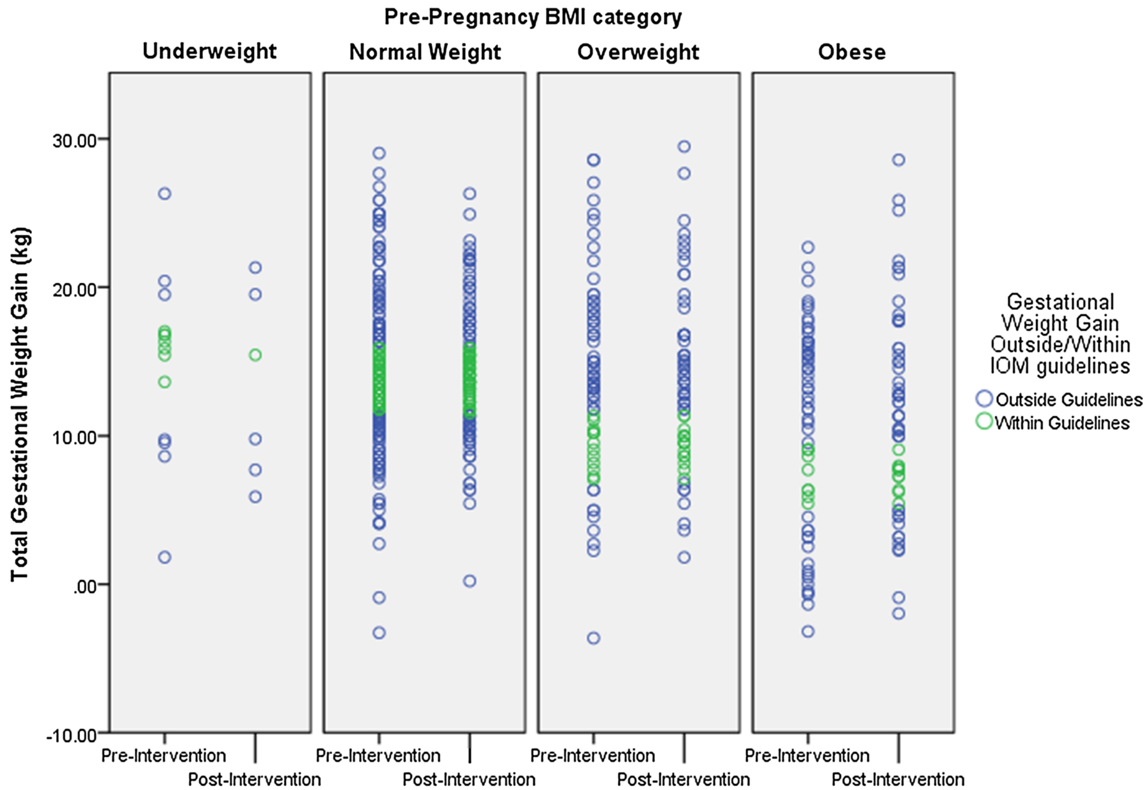

Fig. 1 Distribution of total gestational weight gain, by pre-pregnancy body mass index and time period

excess gestational weight gain is responsible for the greatest share of attributable risk for large for gestational age babies, even more so than gestational diabetes [17]. Thus, an intervention that produces even small or modest gains in reducing excess gestational weight gain and decreasing average birth weight could have a significant impact at the population level.

While our intervention approach holds promise, our findings also inspire caution. Interventions like this one can have downstream consequences on health service delivery in ways that are not always predictable or intended. Although we saw an increase in early screening for diabetes in obese and overweight women with risk factors, many obstetric providers ordered the wrong test, obtaining a 1-h 50 g glucose tolerance test prior to 20 weeks, which is not validated for this purpose and was not recommended in the EMR intervention. Follow-up education and modifications to the EMR alert will need to ensure that providers use appropriate early testing.

Limitations

These findings should be considered in light of some limitations, which suggest questions for further research. First, although we have referred to the 'intervention effect' as shorthand for pre-post differences throughout the paper, our use of a pre-post design without a control group precludes us from concluding that the observed changes were a direct result of the intervention. The fact that the pre-post difference remained robust after statistically controlling for over a dozen potential confounders, with no attenuation of effect, improves confidence that the pre-post differences are due the intervention and not some other factor. Nonetheless, there remains the possibility of unmeasured confounding, and replication and further research is needed. For example, we were only able to control for confounders available in patients' medical charts, which lack information on factors like patient education and socioeconomic status. Second, although information about women's pre-pregnancy heights, weights and BMIs were abstracted from patient's electronic health records, we know from previous work with providers in this health system that pre-pregnancy weights represent a mix of measured weights at ambulatory visits preceding the pregnancy, measured weights at obstetrical intake visits occurring in the first trimester, and self-reported weights. This heterogeneity of data sources and the inclusion of self-reported weights in patients' medical charts introduces some chance of information bias. A third limitation of this study is the racial homogeneity of its sample. Further research with larger, more diverse samples will be needed to examine

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Table 4 Regression of the intervention effect and perinatal risk factors on odds of attaining gestational weight gain within Institute of Medicine guidelines

Predictors of weight gain within guidelines	Unadjusted associations OR (95 % CI)	Model 1 OR (95 % CI)	Model 2 OR (95 % CI)	Model 3 OR (95 % CI)
Intervention effect				
Pre	Ref	Ref	Ref	Ref
Post	**1.43 (1.01–2.02)**	1.44 (0.99–2.07)	**1.55 (1.06–2.26)**	**1.52 (1.04–2.24)**
Pre-Post *p* value	.046	.054	.025	.031
Sample Size	599	599	599	599
Nagelkerke adjusted R^2	.009	.063	.132	.145
Maternal age				
<20	0.82 (0.21–3.18)	0.94 (0.24–3.75)	0.79 (0.19–3.31)	0.82 (0.19–3.44)
20–24	0.76 (0.40–1.46)	0.76 (0.39–1.50)	0.79 (0.39–1.59)	0.83 (0.41–1.68)
25–29	0.90 (0.59–1.38)	0.81 (0.52–1.25)	0.80 (0.51–1.27)	0.81 (0.51–1.30)
30–34	Ref	Ref	Ref	Ref
35–39	1.20 (0.73–1.98)	1.16 (0.69–1.93)	1.18 (0.69–2.02)	1.11 (0.64–1.90)
40+	1.18 (0.45–3.07)	1.07 (0.40–2.85)	1.09 (0.39–3.03)	1.10 (0.39–3.06)
Race/ethnicity				
White, non-hispanic	Ref	Ref	Ref	Ref
Black, non-hispanic	0.43 (0.15–1.26)	0.48 (0.16–1.43)	0.70 (0.22–2.16)	0.68 (0.22–2.14)
Hispanic	1.71 (0.75–3.92)	1.76 (0.76–4.04)	1.94 (0.81–4.63)	1.78 (0.75–4.23)
Asian	**3.24 (1.80–5.82)**	**3.41 (1.88–6.18)**	**3.09 (1.67–5.71)**	**2.88 (1.54–5.36)**
American Indian	0.64 (0.07–5.80)	0.60 (0.07–5.53)	0.86 (0.09–8.63)	0.86 (0.09–8.65)
Other/unspecified	1.45 (0.78–2.67)	1.25 (0.66–2.37)	1.34 (0.69–2.58)	1.34 (0.69–2.59)
Parity				
Primiparous	Ref		Ref	Ref
Multiparous	1.07 (0.75–1.51)		1.12 (0.76–1.65)	1.14 (0.77–1.68)
Pre-gravid BMI				
Underweight	1.00 (0.40–2.50)		0.95 (0.36–2.52)	0.99 (0.37–2.63)
Normal weight	Ref		Ref	Ref
Overweight	**0.39 (0.24–0.63)**		**0.37 (0.23–0.60)**	**0.38 (0.23–0.62)**
Obese	**0.28 (0.16–0.48)**		**0.29 (0.16–0.51)**	**0.29 (0.16–0.53)**
Pre-existing hypertension				
No	Ref		Ref	Ref
Yes	0.63 (0.21–1.95)		1.17 (0.34–4.08)	1.31 (0.34–4.95)
Pre-existing CVD				
No	Ref		Ref	Ref
Yes	0.89 (0.17–4.65)		1.02 (0.18–5.86)	1.15 (0.19–6.79)
Pre-term birth				
No	Ref			Ref
Yes (<37 weeks)	1.66 (0.80–3.47)			1.76 (0.79–3.95)
Gestational diabetes				
No	Ref			Ref
Yes	1.13 (0.55–2.31)			1.28 (0.56–2.94)
Gestational hypertension				
No	Ref			Ref
Yes	**0.25 (0.09–0.71)**			0.34 (0.11–1.04)

Model 1: pre-post difference, adjusted for maternal demographics; Model 2: pre-post difference, adjusted for maternal demographics and pre-gravid clinical factors; Model 3: pre-post differences, fully adjusted; Bold typeface denotes significant differences at $p < .05$

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whether these findings generalize across racial/ethnic and socioeconomic groups.

This study focuses on a low-risk prenatal population in a single health care system, but our findings about the potential of health information technology to improve prenatal care delivery and patient health outcomes can inform care delivery in a variety of practice settings. The use of electronic medical records is now widespread and extends beyond academic medical centers to many community health centers [14].

Conclusion

The need to identify and disseminate evidence-based approaches to promote healthy gestational weight gain is urgent, given that: a significant proportion of women enter pregnancy overweight or obese, only a third of women attain gestational weight gain within recommendations, even fewer minority and low-income women do so, and inappropriate gestational weight gain leads to serious, lifelong health problems for mother and child. Our findings show that an EMR intervention to improve patient education about gestational weight gain can effectively improve the proportion of women who achieve healthy gestational weight gain based on IOM guidelines and improve early screening for diabetes. While provider and patient education are important first steps, ongoing efforts are needed to develop comprehensive, more effective gestational weight gain interventions.

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Compliance with Ethical Standards

Conflict of interests The authors have nothing to disclose.

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