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Hospital Adoption of Electronic Decision Support Tools for Preeclampsia Management

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Background: Electronic health record (EHR)–based clinical decision support tools can improve the use of evidence-based clinical guidelines for preeclampsia management that can reduce maternal mortality and morbidity. No study has investigated the organizational capabilities that enable hospitals to use EHR-based decision support tools to manage preeclampsia. **Objective:** To examine the association of organizational capabilities and hospital adoption of EHR-based decision support tools for preeclampsia management. **Methods:** Cross-sectional analyses of hospitals providing obstetric care in 2017. In total, 739 hospitals responded to the 2017-2018 National Survey of Healthcare Organizations and Systems (NSHOS) and were linked to the 2017 American Hospital Association (AHA) Annual Survey Database and the Area Health Resources File (AHRF). A total of 425 hospitals providing obstetric care across 49 states were included in the analysis. The main outcome was whether a hospital adopted EHR-based clinical decision support tools for preeclampsia management. Hospital organizational capabilities assessed as predictors include EHR functions, adoption of evidence-based clinical treatments, use of quality improvement methods, and dissemination processes to share best patient care practices. Logistic regression estimated the association of hospital organizational capabilities and hospital adoption of EHR-based decision support tools to manage preeclampsia, controlling for hospital structural and patient sociodemographic characteristics. **Results:** Two-thirds of the hospitals (68%) adopted EHR-based decision support tools for preeclampsia, and slightly more than half (56%) of hospitals had a single EHR system. Multivariable regression results indicate that hospitals with a single EHR system were more likely to adopt EHR-based decision support tools for preeclampsia (17.4 percentage points; 95% CI, 1.9 to 33.0; $P < .05$) than hospitals with a mixture of EHR and paper-based systems. Compared with hospitals having multiple EHRs, on average, hospitals having a single EHR were also more likely to adopt the tools by 9.3 percentage points, but the difference was not statistically significant (95% CI, −1.3 to 19.9). Hospitals with more processes to aid dissemination of best patient care practices were also more likely to adopt EHR-based decision-support tools for preeclampsia (0.4 percentage points; 95% CI, 0.1 to 0.6, for every 1-unit increase in dissemination processes; $P < .01$). **Conclusion:** Standardized EHRs and policies to disseminate evidence are foundational hospital capabilities that can help advance the use of EHR-based decision support tools for preeclampsia management in the approximately one-third of US hospitals that still do not use them.

Key words: clinical decision support, health information technology, hospitals, preeclampsia

The United States has the worst maternal mortality rate compared with similarly wealthy countries.[1,2] Preeclampsia is a leading cause of maternal mortality, a significant contributor to maternal morbidity in the country, and poses a significant cost burden to mothers and infants.[3,4] Affecting 1 to 2 of every 25 pregnancies, preeclampsia is a condition in which a woman suddenly develops high blood pressure and proteinuria

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during pregnancy, typically after 20 weeks of gestation, or during the postpartum period.[5,6] Women with preeclampsia can develop eclampsia, the onset of seizures, which may lead to coma or death. Furthermore, they have a higher risk of preterm birth, having low-birth-weight babies, a recurrence of preeclampsia in subsequent births, and future cardiovascular problems.[5-8] However, preeclampsia and eclampsia are among the most preventable causes of maternal death.[9] Early detection, medication treatment, and delivery management are essential to reduce risks of pregnancy complications and adverse maternal and birth outcomes.[10-12]

The American College of Obstetricians and Gynecologists recommended that the adoption of standardized, evidence-based clinical guidelines for the management of preeclampsia may reduce adverse maternal outcomes.[13-15] The use of guidelines for the management of women admitted to hospitals with preeclampsia was associated with a reduction in the incidence of adverse maternal outcomes (ie, maternal death or 1 or more of common severe maternal morbidities) from 5.1% to 0.7%.[15] A review of cases of maternal death from preeclampsia in California revealed that the implementation of standardized policies and protocols to manage severe hypertension, prevent seizures, and respond to obstetric emergencies is among the key quality improvement opportunities.[16] One implementation strategy to improve the use of evidence-based clinical guidelines is adopting clinical decision support tools. Clinical decision support tools provide clinicians, staff, and patients with medical knowledge to support health care decisions and have been widely used across health care settings including maternal health.

Enabled by the widespread use of electronic health records (EHRs), hospitals are increasingly adopting EHR-based decision support tools, including embedded order sets (ie, collections of clinical orders or steps for a given condition/clinical situation),[17,18] to assist clinicians with treatment decision making.[19] Clinical decision support tools have previously been found to improve screening for maternal depression in pediatric clinics[20] and adherence to a neonatal resuscitation program algorithm.[21] Yet, no national information currently exists about the extent of hospital adoption of EHR-based decision support tools for obstetrical care. Effective decision support tools for preeclampsia management, including embedded order sets, could assist providers with standard diagnostic criteria, valid recommendations for response to maternal early warning criteria, and standardized checklists for evidence-based management, which can ultimately improve maternal and birth outcomes.[13,15,22,23]

To our knowledge, no study has investigated hospital adoption of EHR-based decision support tools for preeclampsia, and as a result, the organizational capabilities that enable hospitals to integrate these tools into routine care are poorly understood. Technical capabilities (eg, a single, functional EHR system), processes to identify best patient care practices, resources to implement them, and structures for evidence dissemination could enable hospital adoption and implementation of EHR-based decision support tools for preeclampsia management.[24,25] In a national sample, we examine the extent to which technical capabilities and organizational processes are associated with hospital adoption of EHR-based decision support for preeclampsia management.

METHODS

Data and sample

We analyzed the hospital version of the National Survey of Healthcare Organizations and Systems (NSHOS).[26] The NSHOS collected information on organizational structures, leadership, technical capabilities, and organizational processes from a nationally representative sample of critical access and general acute care hospitals between June 2017 and August 2018. In total, 1628 hospitals were sampled, 757 hospitals responded (46.5% response rate), and 739 hospitals were included in the final sample after exclusion of ineligible responses. The NSHOS hospital data were linked to the American Hospital Association (AHA) Annual Survey Database of the fiscal year 2017 and the Area Health Resources File 2019-2020 Release[27] to obtain information on hospital structural characteristics and patient demographic characteristics. Hospitals without responses to the 2017 AHA Annual Survey ($n = 91$) and NSHOS responses from hospital subunits within a hospital organization ($n = 46$) were excluded because AHA survey data are not available for subunits. We then excluded 6 hospitals without an EHR system or information on their EHR systems. Because we focus on preeclampsia management, 171 hospitals that did not provide obstetric care were excluded. The final analytic sample included 425 hospitals with some form of EHR system across 49 states that completed the 2 surveys (see the Supplemental Appendix available at: http://links.lww.com/QMH/A59 Figure for sample flow diagram). We also conducted a comparison of respondents and nonrespondents with the NSHOS and the AHA survey to examine potential sources of nonresponse bias.

Measures

Outcome variable

The survey assessed whether or not hospitals were using "EHR-based clinical decision support tools for preeclampsia, including embedded order sets, to improve adherence to evidence-based care for pregnant women." This is a binary variable indicating whether a hospital reported using EHR-based decision support tools for preeclampsia.

Main explanatory variables

Hospital organizational capabilities were the main explanatory variables, including EHR functions, barriers to the adoption of evidence-based clinical treatments in general, use of quality improvement methods, and organizational processes to disseminate best patient care practices.

Hospitals were classified into 3 groups based on their responses to a series of questions about EHR functions: (1) a single EHR system across hospital and any owned/managed physician practices; (2) multiple EHRs; or (3) a mixture of EHR and paper-based systems. A binary indicator of whether a hospital's EHR was interoperable with the EHRs at the primary care practices that patients used was also included.

To assess hospital barriers to the use of evidence-based clinical treatments, we calculated a 6-question composite that included responses about the following barriers: "Lack of a process for identifying beneficial innovations"; "Lack of a process for disseminating information about innovations"; "Not enough time to implement"; "Insufficient financial resources to implement"; "Lack the necessary knowledge/expertise to implement"; and "Lack of incentives to implement." Each question used a 3-point response scale (ie, major barrier, minor barrier, and not a barrier). We assigned a point value of 100 for "major barrier," 50 for "minor barrier," and 0 for "not a barrier" for each item and calculated a composite scale using the unweighted average of all items (range, 0-100; internal consistency reliability $\alpha = .82$).

Hospitals that use quality improvement methods such as Lean, Six Sigma, or Robust Performance Improvement are more likely to adopt evidence-based innovations.[28-30] We constructed a dichotomous variable indicating hospital use of any of these quality improvement methods.

The NSHOS also assessed organizational processes to disseminate best patient care practices in hospitals, including regular staff meetings, regular listserv e-mails/newsletters, department representatives or champions, an electronic database of practice or system-endorsed guidelines, and performance improvement events. Respondents were asked whether their hospital used (Yes vs No) each of the processes "on a routine basis to disseminate best patient care practices." We summed the dissemination approaches used by hospitals and transformed the total to construct a composite scale (range, 0-100; $\alpha = .61$).

Covariates

Structural characteristics

We were interested in the association of organizational capabilities and hospital adoption of EHR-based decision support for preeclampsia, net of hospital structural characteristics. We controlled for obstetric care levels, whether a hospital had a neonatal intensive care unit, hospital ownership, hospital participation in a network, accreditation by The Joint Commission, health system membership, and whether it was a teaching hospital.

Demographic characteristics

To account for demographic characteristics of patient populations served by hospitals, we controlled for hospital birth volume during the fiscal year 2017; US Census region (ie, Northeast, Midwest, South, and West); hospital rurality based on the zip code where each hospital was located and the Rural-Urban Commuting Area codes (RUCAs) categorized as urban, large-rural, and small-rural[31]; and the proportion of the patient population below census poverty level using zip codes where the hospitals were located. We also controlled for proportions of racial/ethnic groups at county level, that is, Hispanic, Black, Asian, and American Indian & Alaska Native/Native Hawaiian & Other Pacific Islander (AIAN/NHPI), to account for racial/ethnic composition differences.

Statistical analyses

We utilized a multivariable logistic regression model to estimate the association of organization capabilities and hospital adoption of EHR-based decision support tools for preeclampsia, controlling for hospital structural and area-level patient demographic characteristics. Robust standard errors were used to account for heteroscedasticity of the logit model. Marginal effects were computed to estimate the differences in predicted probabilities of hospital adoption of the tools by each main explanatory variable.

We conducted robustness checks for our final multivariable model specifications, including calculating collinearity and model overfit diagnostics. We computed the variance inflation factor (VIF) for each independent variable to determine whether multicollinearity was present (overall VIF >2.0). Data analyses were conducted using Stata software, version 16.1,[32] between March and June 2020.

RESULTS

Descriptive analyses

Descriptive characteristics of our sample of hospitals are summarized in Table 1. Two-thirds of the hospitals (68%) reported using EHR-based decision support tools for preeclampsia. Adoption of the tools did not differ for hospitals by obstetric care level, ownership, network participation, rurality, birth volume, racial/ethnic composition, or patient poverty levels (Table 1). Nonrespondent hospitals to the NSHOS and the AHA survey were either similar to respondent hospitals or different from the respondents for characteristics that were not significantly associated with adoption of the tools (see Supplemental Appendix Tables 1 and 2 available at: http://links.lww.com/QMH/A59).

Hospitals using EHR-based decision support tools for preeclampsia were more likely to have a single EHR system than hospitals not using the tools (60% vs 47%; $P < .05$). Interoperability between hospital EHR and EHRs at primary care practices was similar for adopters and nonadopters of decision support tools for preeclampsia (54% vs 50%; $P = .45$). Adopter hospitals were slightly more likely to use at least one quality improvement method than nonadopter hospitals (78% vs 69%; $P = .06$). Adopter hospitals reported slightly fewer barriers to using evidence-based clinical treatments (48.3 vs 53.5; $P = .05$) and more processes to disseminate best patient care practices (87.6 vs 79.4; $P < .001$) than nonadopter hospitals.

Table 2 includes descriptive information for the main independent variables that assessed barriers to hospital adoption of evidence-based clinical treatments and the organizational processes to disseminate best patient care practices. Hospitals adopting EHR-based

Table 1. Descriptive Statistics: Hospital Characteristics by Availability of EHR-Based Decision Support Tools for Preeclampsia Management

Hospital Characteristics	All (N = 425), n (%)	With Preeclampsia EHR-Based Decision Support Tools (n = 288), n (%)	Without Preeclampsia EHR-Based Decision Support Tools (n = 137), n (%)
Organizational capabilities			
EHR system			
Single EHR	239 (56.2)	174 (60.4)*	65 (47.4)
Multiple EHRs	142 (33.4)	89 (30.9)	53 (38.7)
Mixture of EHR and paper-based systems	44 (10.4)	25 (8.7)	19 (13.9)
EHR connected to primary care practices	222 (52.2)	154 (53.5)	68 (49.6)
Barriers to the adoption of evidence-based clinical treatments, mean (SD)	50.0 (25.6)	48.3 (24.9)	53.5 (26.8)
Any quality improvement method	319 (75.1)	224 (77.8)	95 (69.3)
Dissemination of best patient care practices, mean (SD)	84.9 (20.5)	87.6 (19.2)**	79.4 (22.0)
Structural characteristics			
Obstetric unit care level			
Uncomplicated maternity and newborn cases	157 (36.9)	98 (34.0)	59 (43.1)
All uncomplicated and most complicated cases	144 (33.9)	101 (35.1)	43 (31.4)
All serious illnesses and abnormalities	124 (29.2)	89 (30.9)	35 (25.5)
Neonatal intensive care unit	172 (40.5)	124 (43.1)	48 (35.0)
Participate in network	246 (57.9)	168 (58.3)	78 (56.9)
Health system member	329 (77.4)	228 (79.2)	101 (73.7)
Ownership			
Public	58 (13.7)	34 (11.8)	24 (17.5)
Private, nonprofit	348 (81.9)	240 (83.3)	108 (78.8)
Private, for-profit	19 (4.4)	14 (4.9)	5 (3.7)
Joint Commission accreditation	310 (72.9)	206 (71.5)	104 (75.9)
Teaching hospital	257 (60.5)	181 (62.9)	76 (55.5)
Demographic characteristics			
Birth volume, mean (SD)	1577 (1743)	1685 (1733)	1353 (1749)
US Census Region			
Northeast	68 (16.0)	43 (14.9)	25 (18.2)
Midwest	145 (34.1)	106 (36.8)	39 (28.5)
South	128 (30.1)	84 (29.2)	44 (32.1)
West	84 (19.8)	55 (19.1)	29 (21.2)
Race/ethnicity			
% Hispanic	12.6 (13.5)	12.8 (13.8)	12.4 (12.9)
% Black	10.4 (11.8)	10.6 (11.5)	10.0 (12.4)
% Asian	4.3 (5.7)	4.2 (5.1)	4.4 (6.9)
% AIAN/NHPI	1.4 (2.4)	1.3 (2.4)	1.4 (2.4)
Rurality			
Urban	281 (66.1)	199 (69.1)	82 (59.9)
Large-rural	84 (19.8)	51 (17.7)	33 (24.1)
Small-rural	60 (14.1)	38 (13.2)	22 (16.1)
Percentage of population below census poverty level			
<10%	104 (25.4)	75 (27.4)	29 (21.5)
10%-20%	205 (50.1)	131 (47.8)	74 (54.8)
20%-30%	66 (16.1)	44 (16.0)	22 (16.3)
>30%	34 (8.4)	24 (8.8)	10 (7.4)

Abbreviations: AIAN/NHPI, American Indian & Alaska Native/Native Hawaiian & Other Pacific Islander; EHR, electronic health record.
Chi-square test/t-test significant levels: *$P < .05$, **$P < .001$.

Table 2. Descriptive Statistics for Main Independent Variables: Barriers to the Adoption of Evidence-Based Clinical Treatments and Dissemination of Best Patient Care Practices

Hospital Characteristics	All (N = 425), Mean (SD)	With Preeclampsia EHR-Based Decision Support Tools (n = 288), Mean (SD)	Without Preeclampsia EHR-Based Decision Support Tools (n = 137), Mean (SD)
Barriers to the adoption of evidence-based clinical treatments			
Overall	**50.0 (25.6)**	**48.3 (24.9)**	**53.5 (26.8)**
Lack of a process to identify beneficial innovations	42.0 (34.9)	39.4 (33.3)*	47.4 (37.7)
Lack of a process for dissemination information about innovations	45.7 (33.5)	44.0 (32.8)	49.3 (34.8)
Not enough time to implement innovations	56.0 (35.1)	54.4 (35.0)	59.2 (35.1)
Insufficient financial resources to implement innovations	66.4 (34.9)	65.5 (34.5)	68.2 (35.8)
Lack the necessary knowledge/expertise to implement	41.6 (35.3)	39.6 (34.8)	46.0 (36.0)
Lack of incentives to implement	48.0 (36.5)	46.7 (36.1)	50.7 (37.1)
Dissemination of best patient care practices			
Overall	**84.9 (20.5)**	**87.6 (19.2)*****	**79.4 (22.0)**
Regular staff meetings	96.9 (17.2)	96.9 (17.4)	97.1 (16.9)
Regular listserv e-mails/newsletters	80.2 (39.9)	84.4 (36.4)**	71.5 (45.3)
Departmental representatives or champions	93.9 (24.0)	95.5 (20.8)	90.5 (29.4)
An electronic database of practice or system-endorsed guidelines	74.4 (43.7)	78.5 (41.2)**	65.7 (47.6)
Performance improvement events	79.3 (40.6)	82.6 (37.9)*	72.3 (44.9)

Abbreviation: EHR, electronic health record.
T-test significant levels: $^{*}P < .05$, $^{**}P < .01$, $^{***}P < .001$.

decision support tools for preeclampsia were less likely to lack a process to identify beneficial innovations (39.4 vs 47.4; $P < .05$) and more likely to use regular listserv e-mails or newsletters (84.4 vs 71.5; $P < .01$), an electronic database of practice or system-endorsed guidelines (78.5 vs 65.7; $P < .01$), and performance improvement events (82.6 vs 72.3; $P < .05$) as means to disseminate best patient care practices than nonadopting hospitals.

Multivariable regression analyses

Multivariable regression model results (Table 3) indicate that hospitals with a single EHR system ($\beta = .89$; $P = .03$) and more processes in place to disseminate best patient care practices ($\beta = .02$; $P = .005$) were more likely to use EHR-based decision support tools for preeclampsia. Private for-profit hospitals were more likely to adopt the tools than public hospitals ($\beta = 1.35$; $P = .04$). On average, hospitals with a single EHR system were more likely to adopt the tools by 17.4 percentage points (95% CI, 1.9 to 33.0) than those with a mixture of EHR and paper-based systems. Compared with hospitals having multiple EHRs, on average, hospitals having a single EHR were also more likely to adopt the tools by 9.3 percentage points but the difference was not statistically significant (95% CI, −1.3 to 19.9). For every unit increase in the score of having processes to disseminate best patient care practices, the probability of using EHR-based decision support tools for preeclampsia increased by 0.4 of a percentage point (95% CI, 0.1 to 0.6). Interoperability of hospital and primary care practices' EHRs, use of quality improvement methods, and barriers to the adoption of evidence-based clinical treatments were not associated with hospital adoption of the tools.

DISCUSSION

Approximately two-thirds of US hospitals use EHR-based decision support tools to aid preeclampsia management, and the hospital organizational capabilities most strongly associated with adoption of these tools are having a single EHR system and more processes in place to disseminate best patient care practices, including regular staff meetings, regular listserv e-mails/newsletters, department representatives or champions, an electronic database of practice or system-endorsed guidelines, and performance improvement events. Having a single EHR system may facilitate the modification of the EHR to integrate decision support tools into workflows compared with having multiple EHRs or a mixture of EHR and paper-based systems. Furthermore, hospitals with a single EHR system may be more likely to have robust, centralized training programs for clinicians and staff to implement evidence-based practices. For example, some hospital systems with robust EHR capabilities also have programs for academic detailing of physicians on evidence-based practices.[33-35] Private for-profit hospitals were more likely to adopt EHR-based decision support tools

Table 3. Multivariable Logistic Regression Results: Predictors of Use of EHR-Based Decision Support Tools for Preeclampsia Management

	Use of Preeclampsia EHR-Based Decision Support Tools		
Hospital Characteristics	**Coefficients (SE)[a]**	**Marginal Effects (95% CI),[b] Percentage Points**	***P***
Organizational capabilities			
EHR system			
(Ref group: Single EHR)			
Mixture of EHR and paper-based systems	− 0.875 (0.406)	− 17.42 (−32.98 to −1.87)	.03
Multiple EHRs	− 0.467 (0.275)	− 9.31 (−19.88 to 1.26)	.09
EHR connected to primary care practices	− 0.323 (0.258)	− 6.43 (−16.41 to 3.54)	.21
Barriers to the adoption of evidence-based clinical treatments	− 0.009 (0.005)	− 0.18 (−0.37 to 0.02)	.08
Any quality improvement method	0.230 (0.309)	4.58 (−7.47 to 16.63)	.46
Dissemination of best patient care practices	0.019 (0.007)	0.37 (0.12 to 0.63)	.005
Structural characteristics			
Obstetric unit care level			
(Ref group: Uncomplicated maternity and newborn cases)			
All uncomplicated and most complicated cases	− 0.073 (0.301)	− 1.44 (−13.18 to 10.29)	.81
All serious illnesses and abnormalities	− 0.258 (0.379)	− 5.15 (−19.91 to 9.62)	.50
Neonatal intensive care unit	0.207 (0.349)	4.12 (−9.52 to 17.75)	.55
Participate in network	− 0.043 (0.247)	− 0.85 (−10.47 to 8.77)	.86
Health system member	0.055 (0.313)	1.09 (−11.13 to 13.32)	.86
Ownership			
(Ref group: Public)			
Private, nonprofit	0.363 (0.369)	7.24 (−7.10 to 21.58)	.33
Private, for profit	1.348 (0.665)	26.85 (1.25 to 52.46)	.04
Joint Commission Accreditation	− 0.661 (0.298)	− 13.17 (−24.60 to −1.74)	.03
Teaching hospital	− 0.097 (0.291)	− 1.92 (−13.30 to 9.45)	.74
Demographic characteristics			
Birth volume, mean (SD)	0.0001 (0.0001)	0.001 (−0.003 to 0.006)	.60
US Census Region			
(Ref group: Northeast)			
Midwest	0.602 (0.375)	11.98 (−2.46 to 26.43)	.11
South	− 0.213 (0.397)	− 4.24 (−19.73 to 11.24)	.59
West	− 0.190 (0.437)	− 3.77 (−20.80 to 13.25)	.66
Race/ethnicity			
% Hispanic	0.005 (0.009)	0.09 (−0.27 to 0.46)	.62
% Black	− 0.009 (0.013)	− 0.18 (−0.69 to 0.34)	.51
% Asian	− 0.022 (0.026)	− 0.44 (−1.46 to 0.57)	.39
% AIAN/NHPI	0.026 (0.049)	0.51 (−1.38 to 2.41)	.60
Rurality			
(Ref group: Urban)			
Large-rural	− 0.520 (0.4040)	− 10.35 (−26.08 to 5.37)	.20
Small-rural	− 0.458 (0.474)	− 9.13 (−27.60 to 9.35)	.33
Percentage of population below census poverty level by zip code			
(Ref group: <10%)			
10%-20%	− 0.139 (0.299)	− 2.78 (−14.44 to 8.89)	.64
20%-30%	0.239 (0.395)	4.76 (−10.63 to 20.16)	.55
>30%	0.270 (0.515)	5.37 (−14.70 to 25.44)	.60

Abbreviations: AIAN/NHPI, American Indian & Alaska Native/Native Hawaiian & Other Pacific Islander; EHR, electronic health record.

[a]Standard errors are in parentheses.

[b]95% CI of marginal effects are in parentheses. Marginal effects indicate changes in probability of the adoption of EHR-based decision support tools for preeclampsia in terms of percentage points.

for preeclampsia management than public hospitals, which suggests that hospital resources and access to capital support the adoption and use of electronic decision support tools. Incentive programs to promote EHR standardization within hospitals may simplify and standardize clinician and staff training for using evidence-based guidelines, decision support tools, and documentation of clinical information.

More evidence dissemination processes were also associated with hospital use of EHR-based decision support tools for preeclampsia management. Previous research suggests that processes to disseminate guidelines on the management of hypertension in pregnancy are important to promote adoption of guidelines.[36] Staff engagement in improving care delivery has also been shown to aid the implementation of evidence-based practices.[29] Therefore, policies supporting evidence dissemination with staff engagement in the processes may support adoption of EHR-based decision support tools for preeclampsia.

Interoperability of hospital and primary care practices' EHRs and use of quality improvement methods were not associated with hospital adoption of EHR-based decision support tools for preeclampsia. Interoperability of hospital and primary care practices' EHRs may enable comprehensive data for reliable risk prediction for preeclampsia, but interoperability may not influence hospital decisions to adopt the tools in the first place. Using quality improvement methods may be helpful for identifying and implementing evidence-based practices, but evidence of their effectiveness on the adoption of decision support tools and in influencing organizational culture is mixed.[30,37]

Taken together, our results suggest that EHR standardization and hospital use of specific evidence dissemination processes are foundational capabilities to improve for approximately one-third of the hospitals that still do not use EHR-based decision support tools for preeclampsia management. For these late adopter hospitals, it is essential to improve their capability to integrate clinical guidelines into EHR systems and to disseminate evidence-based processes within their organizations. For example, the Meaningful Use program led by the Centers for Medicare & Medicaid Services and the Office of the National Coordinator for Health Information Technology (Health IT) provided incentive payments to eligible hospitals for adopting and demonstrating meaningful use of EHR systems, which promotes venture capital investments in Health IT that can support decision support tools in priority clinical areas.[38] With the change to Promoting Interoperability Program in 2018 and a shift of focus to interoperability of health care data,[39] continued incentives may further promote EHR standardization and dissemination of EHR-based decision support tools. Future research should assess the implementation costs of EHR-based decision support tools to improve the business case for late adopter hospitals to use these tools.

Although no published evidence exists about the specific impact of EHR-based decision support tools for preeclampsia management specifically, clinical decision support tools for chronic conditions and other maternal and neonatal conditions are effective in increasing the use of evidence-based clinical guidelines and can potentially improve health outcomes.[20,21,40,41] Given the strong recommendation by the American College of Obstetricians and Gynecologists of having standardized clinical guidelines for detection and management of preeclampsia,[13] future research should examine the effectiveness of hospital adoption of EHR-based decision support for preeclampsia on maternal and birth outcomes.

There are disparities in morbidity and mortality associated with hypertensive disorders of pregnancy by race/ethnicity.[42-44] Evidence indicates that Black and Hispanic women have a higher risk of preeclampsia than White women,[44] and Black women with preeclampsia are 3 times more likely to die from the condition than are White women.[42] County-level race/ethnicity composition was not associated with hospital adoption of EHR-based decision support tools for managing preeclampsia. These national results provide reassurance that hospitals serving Black and Hispanic populations are not consistently late adopters of this important decision support technology. Given the importance of preeclampsia identification and management for Black and Latino women, future research should examine the extent to which EHR decision support can be used to reduce disparities in maternal and birth outcomes.

Our study results should be interpreted with some limitations in mind. First, we focus on the adoption of any EHR-based decision support tools for preeclampsia and are unable to assess the content of tools or the extent of their implementation, which may vary across hospital sites within a hospital organization. Second, the NSHOS is a single informant survey; however the individuals selected were sampled for their knowledge of hospital organizational processes and encouraged to consult with others in the organization when completing the survey. Third, we were not able to control for important patient case mix and hospital characteristics in our multivariable analyses such as safety net status, payer mix, or race/ethnicity of patients because no data were available to assess these variables. Following previous studies,[45-47] we controlled for hospital structural factors and patients' demographic characteristics based on hospital zip code to account for potential confounders. Finally, we could not establish causal relationships between use of EHR-based decision support tools and adherence to evidence-based clinical guidelines for preeclampsia management and ultimately improved health outcomes; future research should clarify these relationships. Despite these limitations, the study provides the first national assessment of EHR-based decision support tools for preeclampsia management, which support clinician adherence to evidence-based care for a major contributor to preventable maternal mortality.

CONCLUSIONS

Hospitals with a single EHR system and organizational processes to support evidence dissemination are more likely to adopt EHR-based decision support tools to manage preeclampsia, a significant contributor to maternal morbidity and mortality. Establishing hospital processes to disseminate best patient care practices and standardizing EHR systems within hospital organizations may improve the adoption of electronic decision support tools and other innovations in patient care delivery. To advance evidence about the effectiveness of EHR decision support tools for preeclampsia management, tool content and quality should be examined, as well as how differences in hospital implementation of the tools differentially impact maternal and birth outcomes.

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