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ORIGINAL ARTICLE

Two decades of interventions in New York State to reduce maternal mortality a systematic review

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Objective To perform a systematic review of interventions to reduce maternal mortality in New York.

Study design We conducted a systematic review of literature published between 2000 and January 2019 reporting interventions to reduce maternal mortality in New York using PubMed and search terms: pregnancy-related death or maternal mortality OR maternal death AND New York. Eight hundred and ninety-three articles were reviewed by title, content, and focus on New York interventions or policies. Ten met inclusion criteria. A second review of the Safe Motherhood Initiative (SMI) identified an additional six articles.

Results Nine articles described hospital-based initiatives; one described a community-based initiative. No prospective randomized controlled trials in a nonsimulated setting were identified. Several articles described SMI bundles; one tested simulated checklist implementation. Three presented results of bundle implementation but did not significantly impact measured maternal mortality and/or morbidity. The single community-based initiative provided doulas to low-income women, yielding significantly lower rates of preterm birth and low birthweight, but no difference in cesarean deliveries compared to other women in the community.

Conclusion Current hospital-based interventions have not reduced maternal mortality in New York. The single community-based intervention identified reduced adverse birth outcomes. Continued concern about maternal mortality in New York suggests community-based approaches should be considered to affect change in conjunction with longer term hospital-based interventions.

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Community-based; interventions; maternal death; maternal mortality; Safe Motherhood Initiative

Introduction

On the global stage, the United States has a remarkably high burden of maternal mortality, or pregnancy-related deaths, among economically similar nations [1]. A pregnancy-related death has been defined by the Centers for Disease Control and Prevention as a woman s death while pregnant or within one year of being pregnant for any reason related to the pregnancy [2]. In the most recent global report in 2015, the United States placed 46th among all countries ranked [1]. From 2011 to 2015, the US maternal mortality ratio was 20.7 deaths per 100 000 live births [3], and recently published data from 2013 to 2017 suggests the US maternal mortality ratio from that period was 29.6 [4]. When US maternal mortality is viewed state by state, New York maternal mortality remains in the bottom half of all 50 states, ranking 30th (lower ranking indicates higher mortality) from 2011 to 2015 [3] and 23rd from 2013 to 2017 [4]. Between 2012 and 2016, the state had a maternal mortality rate of 19.2 per 100,000 live births [5]; other values suggest it was 20.6 between 2011 and 2015 [3] and 25.5 from 2013 to 2017 [4]. The leading causes of pregnancy-related death in New York between 2012 and 2013 included embolism (29), hemorrhage (17.7), infection (14.5), and cardiomyopathy (11.3) [6]. In New York, most (66.1) pregnancy-related deaths between 2012 and 2013 involved cesarean deliveries, and 9.7 of pregnancy-related deaths occurred before delivery [6].

There are significant racial and regional disparities in pregnancy-related deaths in New York. In one review, the statewide maternal mortality ratio for black non-Hispanic women was four times greater than that of white women [7]; other studies similarly showed that black women died of pregnancy-related causes at higher rates [8], and that black race can be considered a risk factor for maternal mortality [9]. In addition, Hispanic ethnicity has been considered a risk factor [9]. These racial and ethnic variables may be the strongest risk factors for maternal death [9]. Such disparities

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are heightened in New York City where black women are 12 times more likely than white women to suffer a pregnancy-related death [10]. Causes of mortality also differ along racial lines: more black women died from embolism, while more white women died from hemorrhage [6]. Among New York City boroughs, the Bronx sees the greatest burden of pregnancy-related deaths. From 2014-2016, the rate was 30.0 deaths per 100,00 live births [11].

Other patient factors also influence maternal outcomes, particularly obesity. Obese patients have a higher likelihood of experiencing maternal mortality [8,9], near misses [9], and other poor outcomes [12]. Between 2012 and 2013 in New York, half of the women who died of embolism, infection, and cardiomyopathy were obese (35.5) or overweight (12.9) [6]. For context, 19.4 of all live births in New York during these years were to obese women, suggesting that maternal mortality disproportionately affects obese women [6]. Severe maternal morbidity, as well, generally more greatly affects women with obese BMIs. From 2008 to 2012, among black women in New York, 421.1 obese (BMI $\geq$ 30.0) women per 10,000 deliveries faced severe maternal morbidity, compared to 370.1 per 10,000 who were overweight (BMI 25.0–29.9) [13]. Between 2013 and 2014, rates of severe maternal morbidity in New York were highest among obese women (345.5 per 10,000 deliveries for obesity class I, 388.9 per 10,000 for obesity class II, and 476.1 per 100,000 for obesity class III) compared to overweight women (283.8 per 10,000 deliveries) [14].

Within New York, the major hospital-based initiative designed to combat this alarming trend is the Safe Motherhood Initiative (SMI). The SMI is a New York hospital-based effort to reduce maternal mortality and morbidity through standardized clinical protocols, or "bundles," on three leading causes of maternal death: hemorrhage, severe hypertension (HTN), and venous thromboembolism (VTE) [15]. In 2013, ACOG District II began enrolling 117 obstetric hospitals statewide to participate in this program [15]. In contrast, similarly systematic community-based initiatives seemed absent. In light of our continued concern about maternal mortality in New York, we sought to examine the hospital- and community-based interventions currently described and evaluated in the published peer-reviewed literature.

Materials and methods

ources

We conducted a systematic review of literature published between 2000 and 2019 that reported interventions directed at reducing maternal mortality in New York.

To obtain published scholarly articles, we searched PubMed using the following search terms: (((pregnancy-related death) OR maternal mortality) OR maternal death) AND New York. The search term "pregnancy-related mortality" was not used. Results were limited to include articles published from 1 January 2000 to 31 January 2019. The search was performed by two authors independently of each other (S.J.R. and I.C.), and discrepancies between searches about inclusion and elimination were discussed.

A second PubMed search was conducted to obtain all articles related to the SMI. To do this, we searched PubMed using the following search terms: "Safe Motherhood Initiative." Results were also limited to include articles published from 1 January 2000 to 31 January 2019.

tudy selection

Eight hundred and ninety-three articles were initially included or excluded by the relevance of their titles and then by title and content. Articles relevant to maternal health, maternal death, pregnancy-related death, policy changes, hemorrhage, and thromboembolism were included. Articles discussing HTN were not specifically included, but articles discussing HTN related to maternal mortality were included as they related to pregnancy-related death and policy changes. Only articles discussing New York or New York City were included. In addition, only articles discussing policy or interventions were included. Articles discussing policy were included to gauge the range of approaches to maternal mortality in New York even if they had not yet produced results.

A second PubMed search was conducted by using the SMI as the sole search term, yielding 70 articles. Articles were sorted by title and then content. Articles discussing SMI checklists and bundles were included. Articles that appeared in both the initial PubMed search on maternal mortality and the second PubMed search on SMI were noted to be included in both searches. Some articles described interventions rather than their outcomes; these were still included so that the breadth of interventions could be evaluated. For example, eight articles described SMI bundles and interventions and did not evaluate outcome data, and these were included.

Each included article was assessed for study type, hospital or community-based, the intervention implemented, outcome measure(s), results, and authors

conclusions. If applicable, a meta-analysis of studies with similar interventions and outcome measures was to be performed.

A search of clinicaltrials.gov was performed using the search terms "pregnancy-related death," "maternal mortality," and "maternal death" in New York.

Results

The process and results of the first PubMed search are shown in Figure 1. The initial PubMed literature search yielded 893 results, and the final yield was 10 included studies. The process and results of the second PubMed search for the SMI studies are shown in Figure 2. The second search yielded an additional six studies. Therefore, the final analysis was on 16 studies and the results are included in Table 1.

All but one of the articles found were hospital-based; one was community-based. The hospital-based initiatives range from theoretical to practical. One describes the history and overall progress of the SMI [16]. Two describe challenges and victories in SMI implementation [17,18]. Two initiatives put in place at a single hospital suggest that implementing certain techniques can reduce morbidity and mortality from major obstetric hemorrhage; these techniques include instituting an obstetric rapid response team, transfusion protocol, uterine balloon tamponade, and change in culture including education and escalation [19,20]. One describes a study evaluating the effect of an integrated healthcare system on postpartum outcomes [21]. This ongoing study met inclusion criteria because it relates to a maternal health intervention in New York. None of the studies were randomized controlled trials outside a simulated setting.

The Major Hospital-based intervention is the SMI, launched in 2001 and relaunched in 2013. Several articles described SMI bundles [22–26]. One found that implementation of a checklist in a simulated scenario did not result in the outcome of higher completion of critical steps [27]. Three articles presented results of implementation of each SMI bundle. All three were observational and retrospective. For the VTE bundle, Friedman et al. [28] found that hospitals that used the SMI bundle more frequently used pharmacologic prophylaxis in cesarean sections, but that there was no difference in risk of VTE based on SMI adoption. For the severe HTN bundle, Simpson et al. [29] found no significant differences in antihypertensive administration based on bundle implementation, but there was a nonsignificant decrease in time to treatment in hospitals that had implemented the bundle. Finally, for the obstetric hemorrhage bundle, Goffman et al. [30] found that the rate of hemorrhage morbidity did not change, but that transfusion morbidity decreased initially; hemorrhage morbidity did not change based on bundle implementation. None of the studies showed any effect on maternal mortality.

The single community-based initiative appearing in the literature under these search parameters discusses the by My Side Birth Support Program run by New York City Department of Health and Mental Hygiene s Healthy Start Brooklyn [31]. This study met inclusion criteria because it was relevant to maternal health and described an intervention in New York. This program provides doula resources before, during, and after childbirth for non-Hispanic black women who qualify for the Women, Infants, and Children nutrition program and live in certain neighborhoods of Brooklyn. Between the years 2010 and 2015, participants in the program showed lower rates of preterm birth (6.3 compared to 12.4 , .001) and low birthweight (6.5 compared to 11.1 , .001), but no difference in cesarean sections (33.5 compared to 36.9 , 0.122) compared to program nonparticipants. Additionally, participants in the program gave positive feedback. The study was observational, and not a randomized controlled trial. No interventional clinical trials were found.

Discussion and conclusions

This review identified 16 published papers about interventions designed to address outcomes contributing to or associated with maternal mortality in New York in the past 20 years. Only one published study discussed a community-based intervention, examining the effect of doula use in the community to prevent adverse pregnancy outcomes. The remaining 15 published studies described hospital-based interventions. Six of these presented data about outcomes of interventions outside of simulations; two of these six assessed interventions in the same hospital. There were no randomized trials in a nonsimulated setting and no studies that showed any effect on maternal mortality. This study examined New York alone and did not compare New York to other states; generalizability to other states or to the United States remains a limitation of this study.

Twelve of these published studies described and evaluated the SMI, the major hospital-based initiative in New York. Hospital-based programs have had success outside of New York; the California Maternal Quality Care Collaborative has reduced the state s

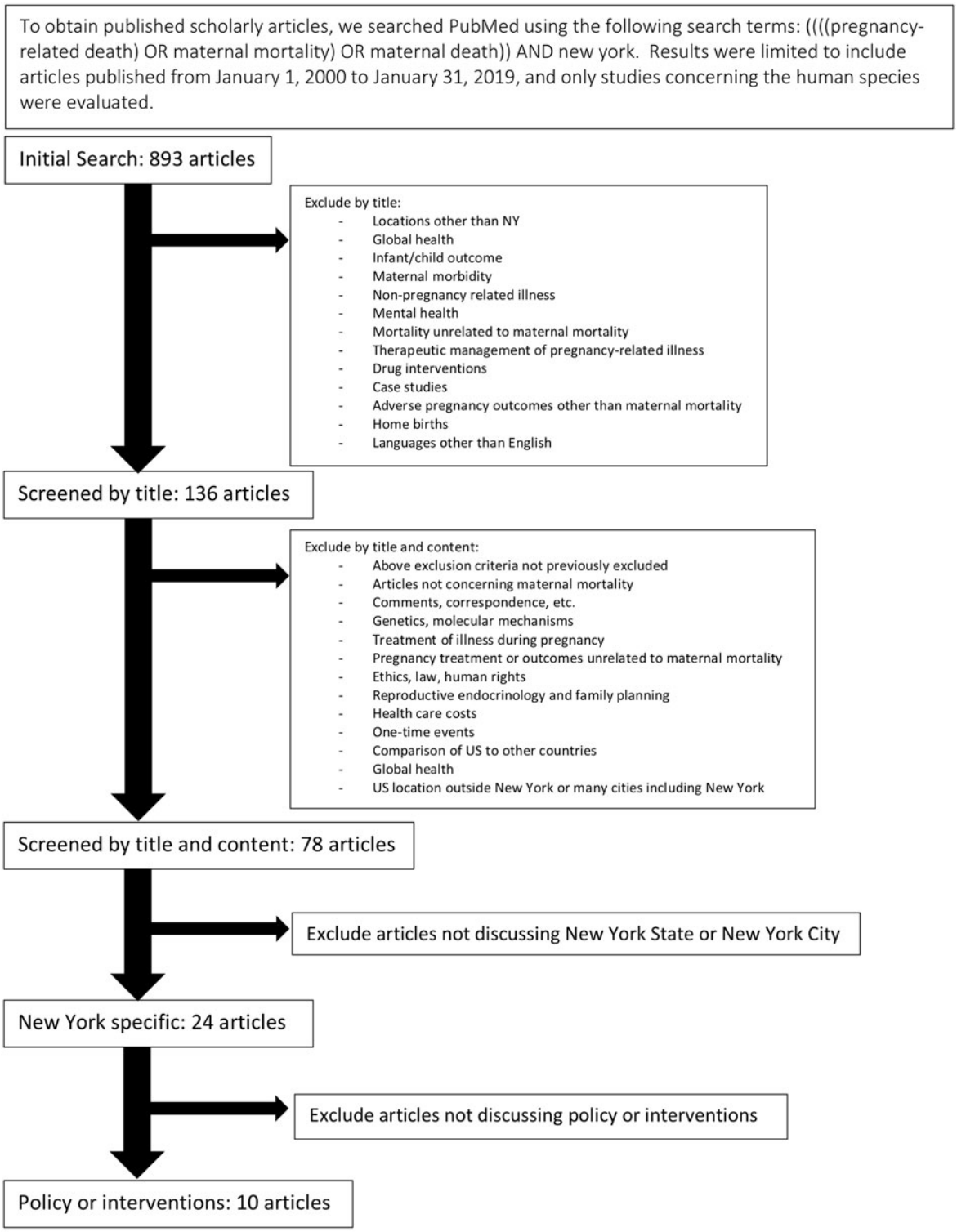

Figure 1 Flowchart outlining methods of study acquisition.

maternal mortality by half in a few years (from 13.1 per 100,000 live births in 2005–2009 to 7.0 in 2011–2013) through increased reporting, quality assessment, and interventions [32]. In addition, studies evaluating interventions within a single hospital have shown promising results [19,20]. Unfortunately, the SMI thus far has shown limited results. The SMI has reported that hospitals using the VTE bundle used pharmacologic prophylaxis more frequently, but bundle implementation did not decrease maternal

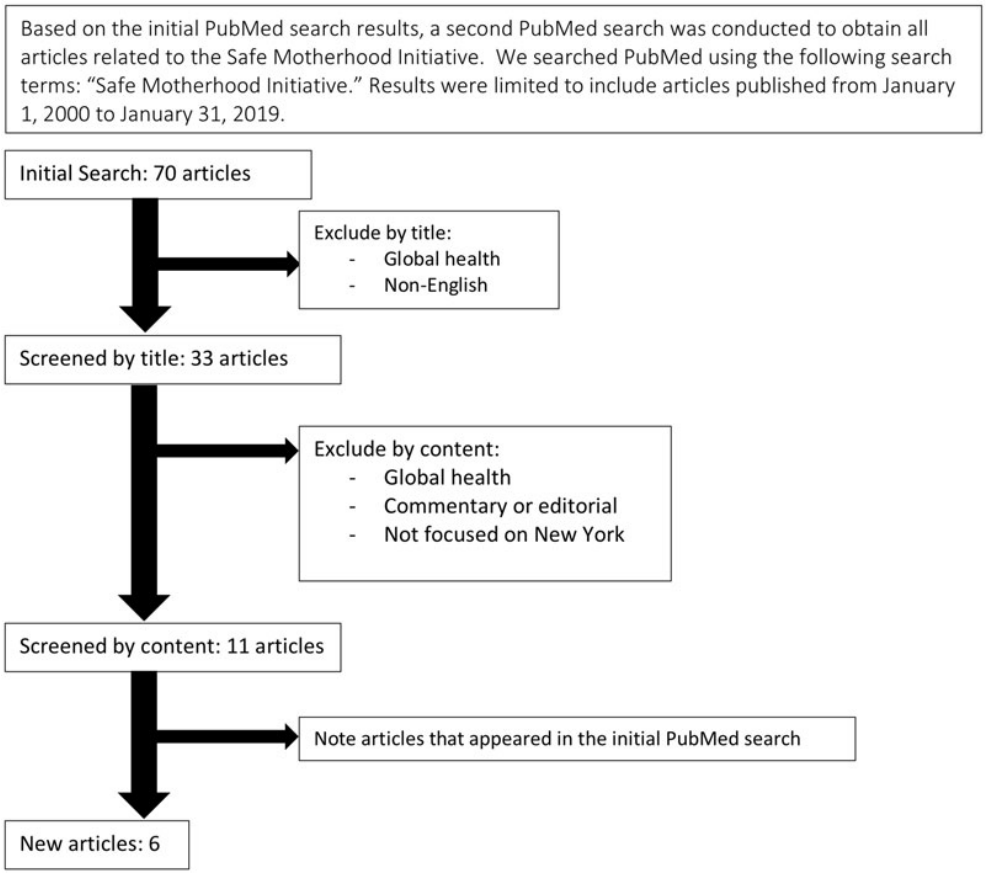

Figure 2 Flowchart outlining methods of study acquisition relating to the SMI.

mortality or risk of VTE [28]. Antihypertensive medication administration similarly did not change by implementing the severe HTN bundle despite a nonsignificant decrease in time to treatment [29]. Finally, the rate of hemorrhage morbidity did not change following obstetric hemorrhage bundle implementation [30]. In addition, studies evaluating the effect of SMI implementation thus far use retrospective data rather than data from randomized control trials. However, although the maternal mortality rate is too high, it remains a statistically rare event such that it may be difficult to detect meaningful changes. Even so, while the SMI may bring awareness and expert-opinion-led practice into hospital care, as we continue to evaluate the factors contributing to maternal mortality and morbidity in New York, we should consider whether solutions focused outside the confines of the hospital may augment and hasten the desired effects of the SMI in New York, especially since many women who experience adverse outcomes receive no prenatal care [13,14,33,34].

To that end, the single community-based intervention we identified showed significant results for two outcome measures (preterm birth and low birthweight) but not for lowering cesarean section rate. Notably, researchers determined that participants were satisfied with their doula services. This study, however, has theoretical and methodological problems. The study found no difference between groups in maternal morbidity (as measured by cesarean section rate) even as adverse pregnancy outcome (as measured by preterm birth and low birthweight) differed between groups. The study outcomes pertain more to infant mortality and morbidity than they do to maternal mortality and morbidity, and the study did not control for other factors affecting preterm birth and low birthweight. It remains to be seen whether such differences in adverse outcomes reflect decreases in other aspects of maternal morbidity; these metrics can be studied in future community-based programs. No other studies performed interventions.

Our findings demonstrate that community-based interventions in New York are either underrepresented in the literature or are not being adequately monitored for efficacy. Many initiatives may exist that are not documented in the peer-reviewed literature, and such programs may not collect outcome data. Other

Table 1 New York maternal mortality interventions (2000–2019).

Study author, year	Study type	Hospital- or community-based	SMI	Of women included	Intervention	Outcome measure(s)	Results	Conclusions
Ananth and D Alton, 2016 [17]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI bundle	N/A	N/A	• Call to action • Cultural change as major barrier
Burgansky et al., 2016 [18][a]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI bundle	N/A	N/A	• SMI 90% adoption rate • Outlines barrier to implement
Chazotte and D Alton, 2016 [16][a]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI bundle	N/A	N/A	• Bundles created and implemented data collection planned
Clark, 2016 [22]a	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI postpartum hemorrhage (PPH) bundle	N/A	N/A	• Provider bundle education • Reviews PPH
Fleischer and Meirowitz, 2016 [23][b]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI PPH bundle	N/A	N/A	Reviews PPH
Friedman AM, D Alton ME, 2016 [24][a]	Description of intervention (theoretical	Hospital-based	Yes	N/A	SMI VTE bundle	N/A	N/A	VTE treatment is postulated to reduce maternal mortality
Martin, 2016 [25][a]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI severe HTN bundle	N/A	N/A	Universal bundles application for efficacy
Walsh and Malone, 2016 [26][b]	Description of intervention (theoretical)	Hospital-based	Yes	N/A	SMI VTE bundle	N/A	N/A	• Risk assessment is key • Emphasizes chemoprophylaxis
Skupski et al., 2006 [19]	Observational (retrospective)	Hospital-based	No	18,723 births	Implementation of a rapid response team, hemorrhage protocols, and other policies	CS, repeat CS, major obstetric hemorrhage, mortality due to hemorrhage, lowest pH, lowest temperature, severity of hemorrhage, placenta accreta, estimated blood loss, and coagulopathy	• Increases in CS, repeat CS, and major hemorrhage AFTER intervention • Decreased mortality due to hemorrhage	Systematic changes in hospitals can reduce maternal mortality Multiple interventions assessed as an aggregate over time period
Bajaj et al., 2016 [27][b]	Prospective unblinded randomized controlled trial	Hospital-based	Yes	136 healthcare staff	Simulated use of SMI checklist in eclampsia and PPH emergencies	Completion of critical steps in care	No improvement in critical step completion	Despite results authors believe checklists should be used
Howell et al., 2017 [21]	Observational (prospective)	Hospital-based	No	468	Program to improve postpartum care that integrates a healthcare system, a Medicaid program, and a multidisciplinary team	• Primary outcome: timely postpartum visit • Secondary outcomes: care measures (blood pressure monitoring, glucose screening) in high-risk patients, ED visits, readmissions, depression screens, costs	Ongoing study	N/A

(*ontinued*)

Table 1 Continued.

Study author, year	Study type	Hospital- or community-based	SMI	Of women included	Intervention	Outcome measure(s)	Results	Conclusions
Skupski et al., 2017 [20]	Observational (retrospective)	Hospital-based	No	Comparison of 3 uneven time periods ((1) 5811, (2) 12,912, and (3) 38,971 births)	Implementation of a rapid response team, transfusion protocol, safety cultures, and multiple management guidelines instituted	Compares morbidity (lowest mean temperature, lowest mean pH, coagulopathy, hysterectomy) and mortality between three time periods	• Rate of PPH increased • Mortality decreased • Median lowest pH, median lowest maternal temperature, and rate of coagulopathy improved • Peripartum hysterectomies increased	Patient outcomes improved with implementation of multiple systematic changes over prolonged time course
Friedman et al., 2018 [28][b]	Observational (retrospective)	Hospital-based	Yes	250,719 births	SMI obstetric VTE bundle • Few low-acuity hospitals participated • All hospitals mechanical prophylaxis	Number of thromboembolism events, thromboprophylaxis, and implementation of VTE bundle	• SMI hospitals used pharmacologic prophylaxis in CS more frequently • No difference in risk of VTE	Risk of VTE did not differ by bundle implementation
Simpson et al., 2018 [29][b]	Observational (retrospective)	Hospital-based	Yes	Not stated	SMI severe HTN in pregnancy bundle	Timely administration of antihypertensive agent, maternal death, intracranial hemorrhage, seizures, intensive care unit admissions, and transfer to other facility	No difference in timely administration of antihypertensive agents	No changes in maternal mortality, intracranial hemorrhage, or seizure activity.
Goffman et al., 2019 [30][b]	Observational (retrospective)	Hospital-based	Yes	250,719 deliveries	SMI obstetric hemorrhage bundle	Maternal mortality, intensive care unit admission, cardiovascular collapse, hysterectomy, and transfusion	PPH morbidity did not change • Transfusion morbidity decreased	PPH morbidity and mortality did not change.
Thomas et al., 2017 [31]	Observational (retrospective)	Community-based	No	489	NYC DOH and Mental Hygiene s Healthy Start Brooklyn developed the By My Side Birth Support Program to provide doula support prenatally, during labor and birth, and postnatally	Rate of preterm birth, low-birthweight, cesarean delivery, patient satisfaction with the program	• Lower rates of preterm birth and low birthweight • No difference in cesarean sections • Patient satisfaction was high	Using doula services may improve outcomes and patient satisfaction can help disparities in outcomes

[a]Article appeared in both PubMed searches.
[b]Article appeared only in the SMI PubMed search.

nonprovider-based options for improving maternal outcomes have been suggested. For example, improving women s preconception health may improve birth outcomes [35]. Other studies include Centering programs that use group medical appointments [35].

Differences in access to prenatal care may have stark effects on pregnancy-related mortality and morbidity in the United States [33]. In terms of mortality, not receiving prenatal care puts a woman at a three to four times higher risk of death due to pregnancy-related complications [34]. In terms of morbidity, in New York City from 2008 to 2012, morbidity was highest for women who received no or late prenatal care [13]. The severe maternal mortality rate for women who never received prenatal care was 574.8 women per 10,000 deliveries, compared to 208.2 per 10,000 who received care in the first trimester and 296.7 per 10,000 who received care in the third trimester [13]. Unfortunately, similar rates have persisted from 2013 to 2014; while most women received prenatal care in the first trimester, those who received no prenatal care had high rates of severe maternal morbidity (501.1 per 10,000 deliveries) compared to those who received third-trimester prenatal care (327.1 per 10,000) [14]. The effects of this relationship between prenatal care and maternal mortality and morbidity may be heightened for black women in the United States, who are more likely to have no prenatal care or later access prenatal care, to receive poorer quality health care, and to have impediments to accessing public health insurance [36,37].

Fundamentally, since many women with adverse outcomes do not receive prenatal care, bringing healthcare into the community may reduce such outcomes. Indeed, Community Health Worker (CHW) programs in other states have encouraged women to take ownership of their prenatal care. The Promotora de Salud program in North Carolina observationally evaluated folic acid supplementation education, and found that their program increased knowledge, awareness, and use of supplementation [38,39]. Similarly, a preliminary randomized control trial using a smartphone platform in Nebraska showed higher patient activation in the intervention group (0.19 compared to 0.15 increase) [40]. However, the data are more equivocal about whether CHW programs increase formal prenatal care. On the one hand, in an observational study, when a nurse or outreach worker contacted women encouraging them to receive postpartum glucose tests, more women attended their appointments after the intervention than had before (59.4 compared to 43.1 , .01, hazard ratio 1.59) [41]. Likewise, in a randomized control trial comparing enrollment in prenatal care, more women participated in the nurse-CHW program [42]. On the other hand, attendance at medical appointments was lower for the Nebraskan smartphone platform intervention group (93.85 compared to 95.06) [40]. In a randomized control trial comparing women who participated in the Maternal Infant Health Outreach Worker program to women with a minimal education intervention, there was no difference in the number of prenatal visits between the groups [43].

Even so, CHW programs have shown promise in other states in improving factors that contribute to adverse outcomes, particularly obesity. In a randomized control trial in the Southwest, women enrolled in the Madres para la Salud trial, which evaluated the effect of social support by promotoras (CHWs), showed an increase in aerobic exercise and total steps, as well as a decrease in body adiposity postpartum [44]. From a nutritional perspective, a randomized control trial compared mothers with minimal intervention to mothers enrolled in the Healthy Mothers on the Move intervention in Detroit, which included home visits, group meetings, and support from CHWs and peers; an observational portion of the study also examined nutrition pre- and postintervention [45]. Compared with the minimal intervention group, enrolled mothers ate less added sugar, total fat, and percent daily calories from saturated fats and solid fats and added sugar [45]. Postintervention results showed dietary improvement, except with regard to fruit and fiber [45].

Our study shows that despite years of hospital-based programs in New York, the outcomes measures they address have seen little improvement. Additionally, limited documented outcome data exist with regard community-based programs. Community-based efforts and new approaches should also be considered in New York City that improve access to care, provide improved continuity of care, and allow for outpatient follow-up of care in the obstetrically vulnerable population. These interventions have shown promise in other states in improving prenatal care and improving maternal health before, during, and after pregnancy. We posit that a combination of community-based interventions streamlined with appropriately focused hospital-based interventions may lead to more coordinated care and decreased maternal mortality. We propose developing, supporting, and monitoring programs within communities that complement our hospital-based efforts to end the devastating maternal mortality in New York.

Disclosure statement

No potential conflict of interest was reported by the authors.

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