AHRQ Final Progress Report

Title: What about mom? Using Administrative Data to Develop Measures for Monitoring Healthcare Quality in Pregnancy & Childbirth

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Structured Abstract (250 words)

Purpose: To develop a set of pregnancy and childbirth related quality indicators.

Scope: Maternity care is the number one cause for hospital admission—over 4 million deliveries per year—yet little is known about what constitutes good quality obstetrical services. There is evidence of increasing maternal morbidity and mortality; hence, monitoring hospital- and provider-level quality of care is imperative.

Methods: We modified the AHRQ Indicator Sets (Prevention Quality Indicators, Inpatient Quality Indicators, Patient Safety Indicators) and set forth a proposed set of 38 additional indicators specific to pregnancy and childbirth. Using an administrative dataset from the State of California that links mothers and newborns, we evaluated the ability of these indicators to represent the quality of care of maternal healthcare services at the community or hospital level. All the indicators were empirically evaluated relative to criteria of the Public Reporting Evaluation Framework: (a) Importance, (b) Scientific acceptability, (c) Usability, and (d) Feasibility.

Results: We identified six "new" indicators from AHRQ's original set of indicators that were pertinent to the childbirth population and 16 additional potential indicators from a list drawn from a theoretical foundation and literature search. The selected indicators demonstrated variation across hospitals, suggesting an opportunity for learning from best practices. We propose a module of pregnancy and childbirth quality indicators that can be used by researchers, quality improvement experts, clinicians, and hospitals for piloting, benchmarking, and—ultimately—system-wide improvement in the quality of healthcare provided during pregnancy and childbirth.

Key words: quality of care, maternal morbidity, maternal mortality, patient safety, childbirth quality indicators

Purpose

1. Using the existing set of Agency for Healthcare Research and Quality (AHRQ) Quality Indicators—aimed predominantly at the adult non-pregnant population—we will provide a set of indicators (with appropriate case definitions) for quality improvement and tracking of pregnancy and childbirth services and outcomes.
2. Based on previous work by the study team, we will provide theoretical and empirical evidence for an additional 38 potential quality indicators specific to pregnancy and childbirth that have been either established for the adult non-pregnant population or proposed in the literature as being relevant for use in this population.

Our overarching goal is to develop a comprehensive set of quality indicators to monitor maternal healthcare quality using the rigorous framework and existing sets of quality indicators established by AHRQ and to develop a set of pregnancy and childbirth-related quality indicators.

Scope (Background, Context, Settings, Participants, Incidence, Prevalence)

Why study AHRQ Quality indicators in the obstetric population?

Significant effort and resources have been dedicated to developing valid, standardized measures of healthcare quality that can be gleaned from readily available administrative data (1-3). These indicators are primarily consensus based, although many have theoretical and/or evidence-based foundations. Of the myriad clinical indicators currently being monitored and reported, very few are specific to pregnancy and childbirth. This is unfortunate for several reasons. **First,** pregnancy and childbirth is the most common reason for hospital admission. Data from AHRQ's Healthcare Cost and Utilization Project (HCUP) regarding the Care of Women in US Hospitals reveal that in 2000, women accounted for 60% of all adult hospital stays and that 63% of discharges were related to pregnancy and childbirth (4). Among hospitalizations involving women, 1 in 4 were for obstetric indications. **Second**, many of the AHRQ indicators are just as applicable to pregnant and postpartum women as to the population as a whole; in fact, they may be even more relevant in obstetrics, given the volume of certain procedures. For example, high rates of cesarean delivery should make the monitoring of surgical complications, such as accidental punctures, lacerations, or retained foreign bodies, a priority. **Third,** although most of the indicators *explicitly exclude pregnancy-related diagnoses from the denominator*, a critical review of the indicator sets reveals that the *majority of the indicators* ***could have direct applicability*** *to this patient population.* The current study will evaluate the usefulness of the AHRQ indicators felt to be representative of the healthcare quality of the nation in the specific subset of pregnant and childbearing women—a cohort that has been excluded from case ascertainment, despite the fact that this population accounts for the largest number of hospital admissions and therefore is most frequently placed at risk. **Fourth**, maternal morbidity and mortality are on the rise nationally and statewide in California (5-7). In particular, rates of severe maternal morbidity have been rising and racial/ethnic disparities have widened (8,9). Given that childbirth is the most common reason for hospitalization in the US, at four million births per year, improved efforts are needed to monitor and address this observed increase in childbirth-related morbidity (10,11). For all the above reasons, a compelling rationale exists for including hospitalizations of pregnant women in quality assessment measures.

Methods (Study Design, Data Sources/Collection, Interventions, Measures, Limitations)

Study Design

The study is intended to evaluate a set of potential maternal quality indicators (MQI), which includes both AHRQ indicators to be adapted to the pregnant population, and 38 indicators proposed by the MQI Work Group (WG). These indicators were evaluated through cross-sectional, population-based datasets, both independently and in relevant combinations, to yield a set of proposed indicators for pregnancy and childbirth.

Selection of indicators: Potential indicators were selected based on previous experience in a non-pregnant population or through extensive review of the literature, recommendations of professional organizations, and discussions with maternal quality experts. All the indicators were defined based on ICD-9-CM codes, as defined by the AHRQ modules or our study group for the MQI WG Indicators. This current proposal is not intended to establish the face validity of these indicators, for which there is already a large body of evidence. Rather, the focus of this proposal was to perform an empirical evaluation for each proposed indicator, using the methods established by the Public Reporting Evaluation Framework (1).

Data sources: Because of a delay in obtaining the most recent California Patient Discharge Dataset (PDD), we used the 2005 California PDD to write the code, evaluate data trends, and develop empirical rules for inclusion criteria. Analyses were reproduced using 2009 data (most recently released) once it became available. The California PDD includes mandatory reports on all California hospital discharges. The data are routinely validated and queried to maintain a high level of data quality.

Framework for the Evaluation of Potential Indicators—Methods

Technical specifications for the AHRQ Patient Safety Indicators (PSI), Inpatient Quality Indicators (IQI), and Prevention Quality Indicators (PQI) Version 4.2 (12) were used in this report.

There are two principal conceptual issues that arise when considering the inclusion of pregnant women in the AHRQ quality measures. The first is that there are several subpopulations of pregnant women, each of which may have a different risk for the morbidity of interest. These subpopulations include women admitted antepartum (without delivering the fetus), women admitted and delivered, and women admitted postpartum after having previously been discharged after delivery. Women admitted for delivery also need to be considered separately with respect to whether they had a cesarean or vaginal delivery, as risks of morbidity may increase with a surgical procedure. Furthermore, there are women who are hospitalized for early pregnancy complications, such as ectopic pregnancy, or pregnancy terminations, which may be either spontaneous or associated with a surgical or medical procedure. Given these considerations, some subpopulations may be appropriate for including in a particular PSI measure, and others may not.

Pregnant patients may also undergo hospital admission for conditions entirely unrelated to the pregnancy. These admissions receive an International Classification of Diseases, 9th Revision-Clinical Modification (ICD-9-CM) code of V22.2 (incidental pregnancy), but they are allocated to Diagnosis-Related Groups (DRG) in other Main Diagnostic Categories (MDC) and should be included in the routine measurement of PSI as currently performed by AHRQ. In other words, PSI that exclude MDC 14 would routinely retain patients with a V22.2 code. Consequently, these patients will not be monitored in this study unless there is a compelling reason to track them separately from the general population.

Definitions of the MDC 14 subpopulations: MDC 14 contains all DRG associated with pregnancy. The following table describes the MDC 14 subpopulations used in this study (Table 1).

Table 1. MDC 14 Population Characteristics

MDC 14 Subpopulation	Definition
Antepartum admission (undelivered)	MS-DRG 781-782 MS-DRG 780 was excluded because it describes admissions for uncomplicated preterm labor, which is a frequent admission, inflating the denominator for complication rates and providing no cases for the numerator
Delivery admission	MS-DRG 765-768, 774, 775
Postpartum admission	MS-DRG 769, 776, excluding cases with ICD-9-CM diagnosis code 639.xx, related to abortion and gynecological conditions
Gynecological admission	MS-DRG 770, 777-779, and 769 or 776 cases with ICD-9-CM code 639.xx

The Delivery Population was used as the denominator for both Antepartum and Postpartum strata to create a standardized ratio for improved interpretability of the morbidity rates, with the recognition that such an approach would need further exploration if subsequent analyses at the hospital level became indicated. For some indicators, a different denominator was deemed clinically appropriate, and this is noted in the various tables in the row pertinent for that variable (e.g., see Table 4, MQI 2b).

A second conceptual issue that guided our approach was that the evidence base for safety indicators in pregnancy is less robust than in other fields of medicine. In contrast to outcome studies of both elective and emergency surgical procedures, the degree to which hospital services can be expected to prevent morbidity in childbirth has not been well defined. Thus, for example, we know that most hospitals can achieve postpartum hemorrhage rates under 2%, yet, when comparing hospitals with a 2% rate versus those with a 10% rate, specific differences in practices, and perhaps patient populations, remain unelucidated. Consequently, inclusion of the pregnant population in a PSI may alter its interpretation. Those PSI that are intended to identify underperforming hospitals with respect to quality or safety may not benefit from the inclusion of patients with morbidity that may not be preventable.

Such circumstances may necessitate the creation of Maternal Health “Surveillance” Indicators (MHSI) designed to track this morbidity either at the hospital or regional level, as a more fundamental surveillance measure that may not be necessarily synonymous with a "quality" or "safety" indicator (e.g., uterine rupture).

For most AHRQ indicators, the definition of the numerators also needed modification. Within each stratum, we used the appropriate ICD-9-CM codes to modify the AHRQ definition to allow for the coding rules of pregnancy. For example, in the case of PSI #9, Post-operative Hemorrhage or Hematoma, there are additional codes used in pregnancy to document this condition. Furthermore, there may be groups of obstetrical patients that should be excluded from the measure—in this case, women with placenta previa or abruption, because bleeding in these cases is largely considered unpreventable or, at least, not appropriate for aggregation within the same measure. In some cases, this modification of the definition of the numerator by use of specific obstetrical codes substantially changed the definition of the PSI and required pregnant patients to be monitored separately. Suggested coding modifications (technical specifications) are available from the MQI WG upon request.

We then calculated the overall rate of the indicator within each of the above MDC 14 subpopulations and attempted to address the following questions:

Given the measure definition and the resulting rates for MDC 14 patients, should MDC 14 (for any of the strata) be included in the AHRQ measure?

- If yes, this measure will go on for further evaluation at the hospital and/or area-level

If not, is this a measure that merits follow up for consideration as an indicator specific to maternal health care?

- If fewer than half of the hospitals have patients in the numerator of the measure, then this measure will be dropped from further consideration at the hospital level.
  - Such a measure may still be informative for case finding within a hospital or region or for area-level surveillance.
- If rates are sufficiently high to be evaluated at the hospital level, then this measure will go on for more evaluation.
- We then developed empirical criteria to evaluate whether rates of the indicator varied across hospitals.

Additional technical concerns

Principal vs. Secondary diagnosis: For several indicators, the AHRQ definition excludes cases in which the condition of interest is coded as a principal diagnosis. For the delivery stratum, the rules regarding the assignment of the principal diagnosis differ from the rules for other hospitalized patients. For delivery admissions, the principal diagnosis is the main outcome or complication of the **delivery**, not necessarily the reason for admission (13). For example, in PSI #9, "postoperative hemorrhage or hematoma," cases for which the hemorrhage is coded as a principal diagnosis are excluded to avoid counting cases when patients were admitted with a hemorrhage. However, if a woman has a postpartum hemorrhage (a specific code used only in MDC 14), this is likely to be listed as the principal diagnosis, even though it happened after the delivery. Thus, it is not appropriate to exclude cases with a principal diagnosis of postpartum hemorrhage from the numerator of a measure that reports the hemorrhage rate. In those cases when the code for the complication is not limited to MDC 14, such as the codes for retained foreign body or accidental puncture, the exclusion of cases when the code is a principal diagnosis becomes irrelevant, because such codes cannot be used as principal diagnoses in MDC 14.

Patients in the antepartum, postpartum, and gynecological strata (patients who did not undergo a delivery at the time of the admission) require a principal diagnosis to be the main complication of the pregnancy that necessitated the admission. However, because of the wide variation in the use of obstetric codes as principal versus secondary diagnoses, we did not use this requirement for any of these subpopulations (14). Specifically, when looking at a condition, we included the case if the condition was a principal or secondary diagnosis. As a consequence, the algorithms developed for the AHRQ indicators need to be modified with respect to primary and secondary diagnoses and procedures if deliveries are included.

Condition present on admission (POA): For several indicators, the AHRQ definition counts only those diagnoses that were not POA. In an effort to be consistent with the intention of the PSI, and recognizing the improved coding of the POA field since 2007, we attempt to maintain the POA exclusion in all of the subpopulations, with the exception of the postpartum stratum, in which we would expect that the condition of interest may indeed be POA (15, 16). For area-level indicators, when hospital of occurrence is irrelevant, the POA exclusion was relaxed to allow for increased ascertainment of cases.

Aggregate (State) Level Analyses: We calculated the statewide rate of each indicator for each of the strata. For each measure, we considered the modifications of both numerator and denominator in determining which subpopulations of pregnant women could be combined with the original AHRQ measure and which, for reasons of clinical interpretability, would not be compatible. We required that at least half the hospitals in the sample needed more than one patient in the numerator to be eligible for additional consideration of a rate calculation at the hospital level.

Hospital Level Analyses: To evaluate normative hospital-level rates and estimate the between-hospital variation for each indicator, we fitted multi-level multiple logistic regression models, using the GLIMMIX procedure in SAS, version 9.2, with patient-level data clustered by hospital (17). Models were fitted with a hospital error term that was assumed to be uncorrelated across hospitals. The probability of the binary outcomes (indicating the occurrence of a PSI event for a patient) was modeled with a Bernoulli distribution and related to the patients' case-mix covariates and hospital random effect by a logit link function. In effect, the hospital error term allows for an intra-hospital correlation between patient outcomes within the same hospital. This model specification is also referred to as a "random intercept model." The stronger the intra-hospital correlation, the bigger the hospital effect (and the between-hospital variation) on the outcome. The intra-hospital correlation is calculated as a ratio of the variation associated with the hospital clustering to the total variation and generally is referred to as the variance partition coefficient (VPC). Indicators with the largest VPC will have the maximum potential for improvement in outcome by hospital structural, organizational, or practice pattern modifications.

The VPC was estimated by simulation of the hospital error term distribution assumed to be normal, with mean = 0 and variance estimated by the model (18,19). Given the nonlinear nature of the model, approximate VPC measures are dependent on the particular values of the covariates. Therefore, we used the population averages for covariates (or population proportion for binary covariates) in the approximation of the VPC. Hospitals with fewer than a total of 200 annual deliveries were excluded from this analysis to facilitate a more robust estimation of model parameters. To assess between-hospital variation, we report the VPC and the number of hospitals with "extremely" low or high rates for the indicator. A hospital with an extreme rate was defined as having its estimated 95% confidence interval (CI) for an "average patient" completely included in the lower or upper quartile of the adjusted (for the average patient) hospital rate distribution for the indicator. Hospital 95% CI were calculated using the model-estimated slope coefficients and hospital-specific intercepts with overall sample mean values or rates, using the Best Linear Unbiased Predictions with inverse-link function in the SAS GLIMMIX procedure. The hospital rate distributions (mean, standard deviation [SD], median, minimum, and maximum) are also described for each indicator. Recommendations for adoption of an indicator for between-hospital comparisons were made based on the magnitude of the VPC and the presence of at least 5% of the hospitals in the "extremely" low or high rate ranges.

Case-mix Adjustment for Hospital Level Analysis: Using administrative data and ICD-9-CM codes, we adjusted for common clinical conditions using patient-level covariates in these models. These conditions included age, race, prior CD (yes/no), preterm (<37 completed weeks of gestational age) (yes/no), multiple gestation (yes/no), and a composite variable designating the presence of "Other Pregnancy Complications" (yes/no). The 31 conditions indicating Other Pregnancy Complications are specified in Korst et al (20) and were aggregated after testing these conditions individually with the findings that they had a significant positive association or a nonsignificant association with each of the PSI (data not shown). We calculated the odds ratios (OR) and Wald-test p values for the covariates used as adjustors in the model. To assess the effect of the case-mix adjustment on the between-hospital variation, we calculated the VPC of the "empty model" (models without any patient covariates). An example of how this was done can be found in reference 20, which summarizes our results related to the AHRQ PSIs (20).

Results Summary: Finally, we characterized each indicator based on the above results, specifically noting a) the relevant MDC 14 subpopulations for the indicator, b) whether the indicator definition for these populations was compatible with the AHRQ definition, c) whether there was potential for including MDC 14 subpopulations in the AHRQ definition, d) whether hospital variation in the indicator was evident, and e) a summary of the evidence with respect to the relevance of monitoring the indicated condition among MDC 14 patients at the hospital or area level.

Inclusion and exclusion criteria – Appropriate inclusion and exclusion criteria for the population to be examined by the indicator was selected so that the results of the analyses could be interpreted across hospitals or geographic regions. In addition, hospitals with fewer than 200 deliveries per year were excluded from hospital specific analyses because of the difficulty in estimating rates of relatively rare events and in making inferences on practice patterns in such low-volume hospitals. Methods of measurement of each indicator (e.g., rates or ratios) were explored and reported as deemed appropriate.

Case-mix adjustment – Because variations in outcome rates measured by the quality indicators may be attributable to differences in hospital case-mix rather than practice patterns, patient-level adjustments may be necessary. One option to simplify the modeling process will be to create homogeneity of the patient population across hospitals by excluding certain atypical maternal, fetal, or placental conditions that may be related to the outcome at hand rather than to try to adjust for those conditions in the model. A comparison will be made with the unadjusted model to see if this additional work is warranted. Obviously, the ultimate goal is to derive models that are clinically relevant but also easy to use and interpret. For example, postpartum hemorrhage secondary to abruption or placenta previa is likely to be associated with different practice patterns when compared with uterine atony. Thus, exclusion of these placental abnormalities allows for a more direct interpretation of postpartum hemorrhage rates. Frequently, we will want the modeling results to apply to women carrying live, singleton, term fetuses. Common clinical conditions will be adjusted for in the models using indicator variables as patient level covariates. For example, a history of prior cesarean delivery often complicates medical decision making during labor and should be accounted for in the model. Demographic patient factors such as age, race/ethnicity, and insurance status significantly associated with an indicator will also be retained as model covariates.

Missing values – Clinical patient data obtained from California PDD are for the most part complete because of the mandatory reporting regulation to this administrative database. The data are continuously checked for logical consistency before publication by the State of California.

Indicator selection criteria – Observed hospital rates for the indicators and covariates are reported for all indicators. Results from the fitted models, including the VPC and the odds ratios for the covariates, are also reported for selected indicators. Given these results, an assessment of the importance and scientific acceptability of the proposed indicators was undertaken by addressing the following specific issues:
Importance: does the indicator show substantial variation between hospitals/regions?
Scientific acceptability

a. Does the indicator have a large VPC?
b. Does the structure of the indicator (e.g., coding, denominator, method of reporting) allow a well-defined and precise definition of the condition to be reported?
c. Does the indicator show precision, allowing discrimination among best and worst performers?
d. Do risk adjustment methods adequately account for potential confounding?

Indicators that showed the most potential based on the results of the multilevel modeling were retained for more analyses. Specifically, the indicators exhibiting the largest variation attributable to the hospital or region after adjusting for patient-level covariates were evaluated for the remaining criteria of scientific acceptability: construct validity, robustness, and adaptability.

a. Construct validity could be assessed by determination of whether measures of related outcomes behaved similarly. For example, cesarean rates may be examined for an association with postpartum

hemorrhage or unintentional injuries. Differences in hospital rates will be compared with rates of similar indicators, if applicable.

b. Adaptability – Differences in hospital rates were compared with rates for similar indicators in non-pregnant populations, if applicable (e.g., childbearing women aged 18-44). Differences in hospital rates for the potential indicator were compared with rates within the adult non-pregnant population of the same hospital, if applicable. Regional differences in county (for California data) or US regions (for HCUP data) rates will be examined if the indicator appears to be more interpretable at a regional rather than a hospital, level.

In essence, we used the above methods to reduce the proposed indicators from the 69 potential indicators to approximately 30 (excluding overlapping) indicators. The remaining "candidate indicators" were amenable to a full assessment of the last two criteria listed in the above framework, usability and feasibility.

Usability – We assessed usability of indicators through an examination of adjusted hospital rates and outliers. Adjusted rates were assessed for an average patient represented by the population mean or proportion for the continuous or categorical patient covariates. Then, each hospital's adjusted rate was calculated by applying the average patient values and hospital intercept to the equation estimated by the hierarchical logistic regression. In other words, for each hospital/region, we calculated the expected rate for a standardized average patient. The distribution of adjusted hospital/regional rates was examined, and outliers were determined for each indicator by identifying hospitals for which 95% confidence sets were outside the population's interquartile interval. Promising indicators were those with the largest amount of hospitals/regions with rates significantly higher than the 75^{th} percentile or lower than the 25^{th} percentile.

Important concepts to be considered include the indicator's consistency with other similar indicators. Do hospitals score similarly with respect to this and other related or existing indicators? Furthermore, is outlier status of an indicator meaningful? Are differences between hospitals interpretable? Our methods, looking at extreme groups (hospitals with high vs. low rates of the proposed indicators), can provide insight into the "black box" of hospital structure and/or clinical processes that can be modified to decrease variation within and across hospitals. Do "good" outcomes aggregate within a hospital or in a type of hospital? What are the attributes of hospitals with consistently high performance, and vice versa?

Feasibility – We assessed the feasibility of indicators through examination of the processes necessary for hospitals or regional public health departments to collect the necessary data, assess the administrative burden of monitoring and implementing the indicators, examine any unique data confidentiality issues for each indicator, and assess the quality of the data. First, we determined if the necessary data are routinely available to hospitals and regulatory organizations. For some of the indicators, we may be able to assess the data quality by comparing observed rates to published rates abstracted from medical charts and collected from large networks. Similarity in indicator rates would suggest that hospital discharge data collected by states are sufficiently reliable and that the data quality is reasonable.

Those indicators that satisfied each of the four criteria are included in the proposed set of recommended "candidate" indicators for quality improvement and tracking of childbirth services and outcomes. The results section provides a summary of what we have learned from this effort. Although some of the proposed indicators could be implemented immediately, most require further validation and exploration and may require the use of more extensive datasets. Through this work, we provide empirical evidence of the breadth and utility of potential maternal quality indicators currently available using administrative data.

Limitations

This study is a population-based retrospective analysis based on administrative hospital discharge data. It has several limitations. First, and foremost, the project relies on the accuracy of coding of diagnoses and procedures. As indicated by various authors the accuracy of secondary data, in particular the sensitivity, may be of concern. For example, Romano et al. (21) have found that most postpartum complications were reported with less than 70% sensitivity but at least 80% positive predictive value. This is a limitation for all systems that rely on population-based secondary data sources. At the same time, the development and implementation of quality indicators requires the use of comprehensive and diverse databases to achieve success in improving

quality of care. We believe that one way to improve the accuracy of secondary data sources is by reporting back to the providers their own data, summarized as quality indicator rate estimates and rankings for their institutions. Providers who are unhappy with their results can scrutinize their data quality and work toward improvement of data quality. Experience within institutions, and as advisor/consultants to quality improvement personnel, shows that many institutions do respond to external pressures associated with voluntary or mandatory public reporting. Education about improved documentation and accurate coding is usually a necessary and inevitable first step (22). Institutions participating in voluntary reporting and/or subject to P4P reimbursement incentives have systematically implemented physician education regarding medical record documentation as well as concurrent review by coders to enhance documentation for APR Groupers which impacts both morbidity (case mix), expected mortality, and reimbursement. Again, this is an active evolving issue for medical and surgical conditions and less of a concern in obstetrics. But the increased rates of delayed childbearing will contribute to increased rates of comorbidity conditions that will need to be accurately captured for optimal case-mix adjustment and hospital reimbursement (23).

Another common limitation of using population-based administrative data is the time lag in the release of the data. For example, California linked data is available about 3 years behind due to the extensive work required to merge the different sources of information and the collection of 1-year of maternal and neonatal admissions post delivery, as well as maternal and neonatal vital statistics (specifically death, if indicated).

The temporality of a condition with respect to admission or delivery status may be limited depending on the dataset used. For the majority of the proposed indicators, the actual condition measured is likely to be easily classified as occurring before or during a hospital admission. Some conditions, such as a ruptured uterus, actually have a specific code to indicate such timing. Others, such as an embolic or thrombotic event, may not be clearly specified as to whether the condition was or was not present upon admission and thus may not be correctly attributed to hospital care. The value (accuracy) of the ICD-9-CM 5th digit, which is designed to specify timing of diagnosis relative to delivery, has not been specifically addressed in the literature. Attempts to address this apparent deficiency, by specifying whether the condition was present on admission, were explored as part of this study and will need to be explored in future studies.

Last, we have already mentioned the problems associated with trying to develop and implement obstetrical quality indicators without a linked maternal-neonatal database, and this also applies to maternal antepartum and maternal and neonatal postpartum admissions. Several indicators may not be feasible without a linked dataset. This is particularly true for composite indicators that include several maternal, neonatal, or maternal and neonatal outcomes. Hence, we are using both types of datasets to show both the strengths and limitations of an unlinked dataset and to begin to make the case for collection of merged datasets as a necessary criterion for tracking health outcomes for the obstetric population (24).

A technical limitation was the stringency required to procure the state discharge data. We had to submit and get approval from three separate IRBs (CSMC, UCLA, and the State of California) as well as a separate and distinct approval process for the variables obtained from OSHPD. All of this occurred within the context of State-mandated Friday furloughs, which contributed to delays due to suboptimal access and availability.

RESULTS (Principal Findings, Outcomes, Discussion, Conclusions, Significance, Implications)

In 2009, a total of 508,842 deliveries occurred in 254 hospitals in California. Hospitals with fewer than 200 annual deliveries (N=12) were eliminated from subsequent analyses. For the remaining 242 hospitals, the mean (SD) of the delivery volume was 2,003 (1,517), with a median (range) of 1,717 (212-7,511). The mean age (SD) at delivery was 28.2 (6.3), and the race/ethnicity distribution of women undergoing childbirth was as follows: Hispanic 48.7%, White 30.2%, Asian/Pacific Islander 11.3%, African American 5.7%, American Indian/ Alaskan Native 3.2%, and Unknown 0.8%.

Patient Safety Indicators (PSIs)
There were nine PSIs not evaluated because they were deemed to be not relevant for this population (PSI #2: Death in low-mortality DRGs, PSI #3: Decubitus ulcer, PSI #4: Failure to rescue, PSI #6: Iatrogenic pneumothorax, PSI #7: Selected infections due to medical care*, PSI #8: Postoperative hip fracture, PSI #10:

Postoperative physiologic and metabolic derangements, PSI #11: Postoperative respiratory failure, PSI #16: Transfusion reaction). Two PSIs, (#2 death and #4 failure to rescue), bear further mention. Although they were not evaluated as part of the current study, we feel that all maternal deaths and near misses should be monitored and evaluated as sentinel events and tracked as Maternal Health Surveillance Indicators (MHSI). MHSIs are conditions that did not meet criteria as a quality indicator because they were rare and/or did not demonstrate hospital level variation; however, because of the significant potential morbidity and liability, they should be considered for surveillance. Potential MHSIs are italicized in the tables that follow.

Seven PSI were evaluated across each of the reproductive subpopulations and for the standard AHRQ population. Evaluation of rates at the hospital level revealed that two indicators occurred very infrequently. Specifically, PSI #5: Foreign Body identified one or more cases in only 15 hospitals [6.2%]), and PSI #12: VTE identified one or more cases in only 59 hospitals [24.4%]; consequently, neither was evaluated at the hospital level. Because of the small numbers of cases found in the other subgroups, only the Delivery Population could be evaluated at the hospital level. Currently, there are two PSIs specific to pregnancy (bold, underline text, Table 2). Three new PSIs—with modifications—are proposed as candidates for Maternal Quality Indicators (MQI)(bold text). Six were rare and/or did not demonstrate hospital level variation but, because of the potential morbidity/liability, could be considered for surveillance (MHSI) (italic text). An (*) indicates additional codes were required to define the indicator. This information is available from the study team per request.

Patient Safety Indicators (PSI)

Table 2. AHRQ PSI's Evaluated as Potential Maternal Quality Indicators

Indicator	Pregnancy Part of AHRQ Specifications	Recommend as Potential MQI (Yes/No) Comment about coding	Hospital Variation Variation Mean±SD, Median (range for hospitals) Hospital n=242
PSI #1: Complications of anesthesia (experimental)	Yes (includes cesarean delivery)	**Potential MQI—Yes** Modified to include vaginal deliveries, and additional anesthesia codes	Yes 0.3354 ± 0.3433, 0.2458 (0-2.4559)
PSI #5: Foreign body left during procedure*	Yes, pregnancy (MDC 14) included	Potential MQI—No No changes made to AHRQ specifications	No Only 15 cases with overall rate=0.004
PSI #9: Post-operative hemorrhage or hematoma*	No- different definition	**Potential MQI—Yes** Modified to include pregnancy related conditions	Yes 2.5189 ± 2.0959, 1.9240 (0-13.2257)
PSI #12: Post-operative VTE	No — so few cases	Potential MQI—No Modifications made to include MDC 14	No 0.01478 ± 0.3583, 0 (0-0.2740)
PSI #13: Post-operative sepsis	No-different definition	**Potential MQI—Yes** Redefined to be specific for pregnancy	Yes 0.1487 ± 0.1980, 0.7886 (0-1.1534)
PSI #14: Post-operative wound dehiscence*	Excluded MDC 14, included some gyn codes	Potential MQI--No Redefined to be specific for pregnancy Little variation by hospital	No 0.1229 ± 0.2369, 0 (0-2.2049) (N= 4 hospitals in upper quartile)
PSI #15: Accidental puncture/laceration*	Excludes MDC 14	Potential MQI—Yes/No Modified to include MDC 14 Rate in pregnancy =adult med/surg population, but small variation by hospital	No 0.2880 ± 0.4159, 0.1728 (0-3.9966) (N=22 hospitals in upper quartile)
PSI #17: Birth trauma	Yes, specific to pregnancy	**Current MQI** Alternative codes evaluated	Yes 1.0931 ± 1.4021 0.6600 (0-13.6126) excluding clavicle, brachial nerve injury
PSI #18: Obstetric trauma with instrument	Yes, specific to pregnancy	**Current MQI** Alternative codes evaluated	Yes* 11.77 ± 0.0713, 11.15 (0-42.8571)

*Rate increased 14.05% if additional codes were included.

Inpatient Quality Indicators (IQI)

The process was repeated sequentially for the Inpatient Quality Indicators (IQIs) and Prevention Quality Indicators. The IQIs are a set of measures designed to reflect the quality of care inside hospitals. The IQIs include inpatient mortality from certain procedures and medical conditions, utilization of procedures for which there is potential for inappropriate usage (overuse, underuse, and misuse), and utilization of procedures for which there is evidence to suggest that outcomes may be related to the volume of procedures performed (e.g., higher volume of procedures is associated with lower mortality) (25). There are 32 IQIs that can be used to help hospitals identify potential problem areas that need further study (26). Twenty-five of the 32 indicators are specific to medical or surgical conditions or procedures that are not likely to occur in healthy reproductive age women. Three indicators (#20 Pneumonia Mortality Rate, #23 Laparoscopic Cholecystectomy Rate, and #28 Hysterectomy Rate) were evaluated in each of the reproductive subpopulations and not recommended as potential MQIs because of low prevalence; however, hysterectomy was recommended as a MHSI (data not shown). The remaining four IQIs are specific to pregnancy and pertinent to method of delivery.

IQI 21: Cesarean delivery rate;
IQI 22: Vaginal birth after cesarean (VBAC) rate (uncomplicated);
IQI 33: Primary cesarean rate;
IQI 34: VBAC rate (all)

Because delivery method is particularly susceptible to environment and practice patterns, we derived a number of process quality measures for this outcome (See Table 4 and MQI #10-17).

However, Table 2 lists three other indicators that may be appropriate to monitor in pregnant women, because the conditions or procedure occurs during pregnancy and could identify potential problems at the hospital level. None of the AHRQ IQIs were recommended for further consideration as a MQI, although hysterectomy was considered as an MHSI (see Table 4).

Prevention Quality Indicators (PQI)

There are 14 PQIs designed to identify quality of care for ambulatory care sensitive conditions (27). Conceptually, good outpatient care should prevent hospitalization. We identified six that had potential relevance as a Maternal Quality Indicator. In addition to changing the denominator to include MDC 14, and conditions specific to the reproductive system, we had to modify codes to be inclusive of pregnancy-related conditions and include cases for which the condition of interest was noted as a secondary diagnoses or POA (see technical concerns above). If the rate of the condition was lower in pregnancy relative to the AHRQ population, then the indicator was not recommended for further consideration as a potential MQI. Using these criteria, two conditions were excluded (asthma and urinary tract infections); three remained for further exploration (perforated appendix, uncontrolled hypertension, uncontrolled diabetes).

Table3. Prevention Quality Indicators

Indicator	Pregnancy Part of AHRQ Specifications	Recommend as Potential MQI (Yes/No) Comment about coding	Prevalence of Condition in Reproductive Subpopulations
PQI #1 Perforated appendix admission	Excludes MDC 14	**Potential MQI**—Yes Modification made to include MDC 14	Incidence higher relative to AHRQ population AHRQ pop: 26.52 Delivery: 32.26 Antepartum: 13.29 Postpartum: 21.21 Gyn: 14.29
PQI #7 Uncontrolled hypertension admission	Excludes MDC 14	**Potential MQI—Yes** Modification made to include pregnancy specific conditions;Further subset to include primary & secondary diagnoses	Incidence higher relative to AHRQ population AHRQ pop: 0.413 Delivery: 3.297 Antepartum: 0.438 Postpartum: 0.005 Gyn: 0

PQI #9 Low birthweight admission	Yes Per 100,000 live births	**Potential MQI—Yes** Current Pediatric Indicator	5.464
PQI #12 Urinary tract infection admission	Excludes MDC 14	Potential MQI—Not recommended Modifications made to include gynecology and pregnancy specific conditions Further subset to include primary & secondary diagnoses	Low incidence relative to AHRQ population AHRQ pop: 1.682 Delivery: 0.126 Antepartum: 0.871 Postpartum: 0.046 Gyn: 0
PQI #14 Uncontrolled diabetes admission	Excludes MDC 14	**Potential MQI—Yes** Modifications made to include pregnancy specific conditions Further subset to include primary & secondary diagnoses[#] Example demonstrates impact of secondary codes	Incidence higher relative to AHRQ population AHRQ pop: 0.131/1.356[#] Delivery: 2.437/8.098[#] Antepartum: 0.328/0.735[#] Postpartum: 0.006/0.042[#] Gyn: 0/5.326
PQI #15 Asthma admission	Excludes MDC 14	Potential MQI—Not recommended Modifications made to include MDC 14; primary & secondary diagnoses[#]	Low incidence relative to AHRQ population AHRQ pop: 1.041/7.844[#] Delivery: 0/2.455[#] Antepartum: 0/0.317[#] Postpartum: 00.045[#] Gyn: 0/3.187[#]

Based on literature review and prior work, the MQI WG proposed 38 additional "pilot" indicators along with potential rationale for consideration as potential MQIs. The candidate indicators extended across the continuum of care, including early pregnancy, pregnancy (antepartum, intrapartum, delivery), postpartum, and interconception. Most of the pilot indicators did not meet criteria for recommendation due to low prevalence, minimal variability across hospitals, or inability to reliably measure. Indicators meeting criteria for further consideration were primarily associated with delivery and are listed in Table 4, along with potential rationale for monitoring and the mean rate (SD), median and range for the childbirth cohort (delivery discharges). Some indicators are duplicates expanded/modified versions of AHRQ indicators. Coding specifications for Table 4 (denoted with *) and suggested modifications for Tables 2-4 are available on request.

Table 4. Additional "Pilot" Quality Indicators for Pregnancy & Childbirth

Indicator	**Definition (ICD-9-CM codes)**	**Recommendation/ Comment**	**Rate/number of deliveries Mean±SD, Median (range for hospitals) Hospital n=242**
MQI #1. Pregnancy-related Hypertension	642.3 transient 642.4 mild 642.5 severe 642.6 eclampsia 642.7 superimposed	Potential MQI—No Monitor for prevalence; *Potential MHSI* Use as denominator for eclampsia	0.05413 ± 0.02164 0.05018 (0.00621-0.14154)
MQI #2a. Eclampsia/number of deliveries	Number of deliveries = 506674	Potential MQI—No;	0.00081 ± 0.00132 0.00050 (0-0.01227)
MQI #2b. Eclampsia/number of pregnancy-related hypertension	Number of pregnancy related hypertension = 28135	**Potential MQI--Yes** Theoretically preventable with prophylaxis (Hospital or provider level)	0.01633 ± 0.02762 0.00903 (0-0.22222)
MQI #3. Diabetes	See PQI above	Overlap	
MQI #4. Intrauterine Growth Restriction (IUGR)	656.5 poor fetal growth	Potential MQI-No Probably not amenable to prevention; *Potential MHSI*	0.01315 ± 0.00848 0.01137 (0-0.05817)
MQI #5. Multiple Gestation	All of 651 (includes stillbirths with retention of at least one living fetus)	Potential MQI—No Preventable; Process measure for infertility treatments; (Provider or Area level)	0.01475 ± 0.00826 0.01308 (0-0.04987)

MQI #6. Preterm delivery	644.2 only spontaneous onset of delivery	Potential MQI--Unknown Need linked dataset; Similar to current Pediatric Indicator (old PQI #9 Low Birth weight)	Not available using current data set
MQI #7. Hyperemesis	643: excessive vomiting in pregnancy	Potential MQI—No Not recommended; rare relative to other AHRQ conditions; Potential for Ambulatory Prevention	0.00120 ± 0.00208 0.00067 (0-0.02435)
MQI #8. VTE	See AHRQ PSI #12	Potential MQI—No Monitor for prevalence *Potential MHSI* Hospital Level	0.00015 ± 0.00358 0 (0-0.00274)
MQI #9. Elective cesarean Section (CS) (Total) N = 506674	Use algorithm to identify those without labor*; overlaps IQI's	**Potential MQI—Yes** Hospital/provider level	0.17728 + 0.05068 0.17079 (0.08085-0.41768)
MQI # 10. Elective CS Primary	Use algorithm to identify those without labor and with no prior CS *	**Potential MQI—Yes** **Current IQI #33** Hospital/provider level	0.04541 ± 0.02175 0.04104 (0-0.1386)
MQI #11. Elective CS Repeat	Use algorithm to identify those without labor with a prior CS*	**Potential MQI—Yes** Hospital/provider level	0.13186 ± 0.03710 0.12961 (0.05162-0.28354)
MQI #12. Emergent CS (Total)	Use algorithm to identify those with labor per all deliveries*	**Potential MQI—Yes** Hospital/provider level	0.15002 ± 0.03459 0.14825 (0.05229-0.27134)
MQI #13. Emergent CS Primary	Use algorithm to identify those with labor with no prior per all deliveries*	**Potential MQI—Yes** Hospital/provider level	0.12969 ± 0.03029 0.12838 (0.04943-0.26829)
MQI #14. Emergent CS Repeat	Use algorithm to identify those with labor with prior CS per all deliveries*	Potential MQI—No Hospital/provider level	0.02033 ± 0.01052 0.01883 (0-0.06879)
MQI #15. VBAC attempt all deliveries	Use algorithm to identify those women with prior CS who labored per all deliveries*	Potential MQI—No Hospital/provider level	0.03163 ± 0.01975 0.02720 (0.00240-0.11436)
MQI #16. VBAC attempt among priors N=84593 prior CS	Use algorithm to identify those women with prior CS who labored per those with prior CS only*	**Potential MQI—Yes** Hospital/provider level	0.19547 ± 0.11985 0.16154 (0.01064-0.56886)
MQI #17. VBAC success all priors	Use algorithm to identify those women with prior CS who had a vaginal delivery per all priors*	**Potential MQI—Yes** **Current IQI #34** Hospital/provider level	0.07042 ± 0.07779 0.03597 (0-0.36527)
MQI #18. VBAC success among attempts N=18170 attempts	Use algorithm to identify those women with prior CS who had a vaginal delivery per those who attempted*	**Potential MQI—Yes** Hospital/provider level	0.27418 ± 0.20974 0.25000 (0-1.0000)
MQI #19. Operative vaginal delivery N=338,635 vaginal deliveries	669.5 Forceps or vacuum extractor delivery without mention of indication Procedure codes: 72.0-72.4 forceps 72.5,6: forceps 72.7 vacuum 72.8 other specified operative delivery 72.9 other unspecified operative delivery 73.3 failed forceps	**Potential MQI—Yes** Hospital/provider level	0.80407 ± 0.04643 0.07147 (0.00833 - 0.29060)
MQI #20. Vaginal or forceps procedure associated with cesarean delivery N=168,039 CS	All of the above codes + cesarean delivery	**Potential MQI—Yes** Hospital/provider level; Potential patient safety, provider skill; potential process measure for failed operative vaginal delivery	0.0531 ± 0.0709 0.0347 (0-0.5526)

MQI #21. Uterine Rupture or Dehiscence Per all deliveries N = 506,674	665.0 before labor 665.1 during labor 674.1 dehiscence/disruption of uterine wound +Present on Admission (POA) See text	Potential MQI—No Not recommended; very rare Patient Safety; Area level *Potential MHSI*	0.00056 ± 0.00088 0.00034 (0-0.00851)
MQI #21a. Uterine Rupture or Dehiscence among prior CS	Above codes + POA N = 84593	Potential MQI—No Not Recommended; rare but needed to support VBAC Patient Safety; Hospital/ Area level; *Potential MHSI*	0.00232 ± 0.00426 0 (0-0.03533)
MQI #21b. Uterine Rupture or Dehiscence among VBAC attempts	Above codes + POA N=18170	Potential MQI—No Not Recommended; rare but needed to support VBAC Patient Safety; Hospital/ Area level; *Potential MHSI*	0.00360 ± 0.00980 0 (0-0.11111)
MQI #21c. Uterine Rupture or Dehiscence among VBAC success	Above codes + POA N=6577	Potential MQI—No Not Recommended; rare but needed to support VBAC Patient Safety; Hospital/ Area level' *Potential MHSI*	0.00083 ± 0.00561 0 (0-0.06667)
MQI #21d. Uterine Rupture or Dehiscence among non-laboring women	+POA N = 66423	Potential MQI—No Not recommended; very rare Patient Safety; Area level	0.00192 ± 0.00441 0 (0-0.03483)
MQI #22. Maternal birth trauma	Use AHRQ definition PSI 18 and 19? augmented by MQI (with and without instrument)	**Potential MQI--Yes** **Current Indicator** Overlaps with PSI 18,19;	With Instrument 0.11774 ± 0.07133 0.11150 (0-0.42857) Without Instrument 0.01984 ± 0.01012 0.08591 (0-0.06747)
MQI #23. Maternal Infection Per all deliveries	Use AHRQ definition PSI 13 augmented by MQI, and add on chorioamnionitis* ICD9: 658.4 Not POA	**Potential MQI—Yes** Patient safety/prevention Hospital level	0.00226 ± 0.00314 0.00126(0-0.02400)
MQI #24. Obstetrical Hemorrhage or Hematoma	Use AHRQ PSI 9 modified by MQI	**Potential MQI—Yes** Overlap with PSI 9 Patient safety	0.02519 ± 0.02096 0.01924 (0-0.13226)
MQI #25. Transfusion	Procedure codes: 99.00-99.04 Whole blood and PRBC only	*Potential MQI—No* Patient safety *Potential MHSI*	0.00871 ± 0.00618 0.00732 (0-0.03517)
MQI #26. Hysterectomy	Procedure codes:	Potential MQI—No Not recommended; rare *Patient safety; area level* *Potential MHSI*	0.00088 ± 0.00121 0.00054 (0-0.00946)
MQI #27. Return to OR	Includes AHRQ FB (PSI 5) and Accidental Puncture (PSI 15) and Procedure Codes 54.11 Exploratory lap 54.12 Re-opening 54.19 Other lap	Potential MQI—No Not recommended; rare Patient safety; area level	0.00086 ± 0.00110 0.00062 (0-0.00732)
	FB only (N=15) (no denominator)	Potential MQI—No Not recommended; rare Patient safety	1 (count only)
	Accidental puncture only per all deliveries	Potential MQI—No Not recommended; rare Patient safety	0.00041 ± 0.00077 0 (0-0.00488)
	Return to OR only	Potential MQI—No Not recommended; rare Patient safety	0.00043 ± 0.00063 0 (0-0.004141)
MQI #28. Induction of Labor	659.0, 1 failed induction Procedure codes: 73.1, 01, 4 96.49 prostin Per all deliveries	Potential MQI—Unknown Process measure	0.15981 ± 0.07571 0.15878 (0.00057-1.0000)

MQI #29. Cesareans per inductions	Per all inductions (N=81138)	Potential MQI—Unknown Process measure	0.25819 ± 0.16145 0.22222 (0-1.0000)
MQI #30. Maternal composite morbidity (Low Risk)	Per our definition* N = 273686	**Potential MQI—Yes** Hospital level	0.11513 ± 0.04801 0.11633 (0.01818-0.36191)
MQI #31. Maternal composite morbidity (High Risk)	Per our definition* N = 232988	**Potential MQI—Yes** Hospital level	0.13873 ± 0.06941 0.12720 (0.01949-0.38593)
MQI #31. Maternal severe morbidity (Low Risk)	Per our definition* N = 273686	Potential MQI—No Hospital level	0.00720 ± 0.00527 0.00605 (0-0.02717)
MQI #32. Maternal severe morbidity (High Risk)	Per our definition N = 232988	Potential MQI—No Hospital level	0.02059 ± 0.01162 0.01843 (0-0.07033)
MQI #33. Neonatal complications	Calculated from healthy term newborn complement* Denominator total low risk newborns N = 409575	**Potential MQI—Yes** Hospital level	0.05915 ± 0.03817 0.05054 (0-0.26009)
MQI #34. Hypoxic-Ischemic Encephalopathy	Calculated from healthy term newborn *	Potential MQI—No Component measure	0.00033 ± 0.00107 0 (0-0.01306)
MQI #35. Neonatal Infection	Calculated from healthy term newborn*, eliminated high risk deliveries except phototherapy; Subgroup Infection	**Potential MQI—Yes**	0.00902 ± 0.01241 0 (0-0.10511)
MQI #36. Neonatal death	Calculated from healthy term newborn* Subgroup neonatal death	Potential MQI—No	0.00020 ± 0.0005 0 (0-0.0042)
MQI #37. Transfer of newborn to higher level of care	Take number of cases from discharge record per total newborns (not total deliveries) N = 512685	**Potential MQI—Yes** Hospital level	0.01863 ± 0.01767 0.01316 (0.00058 -0.10839)

Table 5 lists the results of the MQI WG proposed Pregnancy and Childbirth Indicators pertinent to delivery. For each proposed indicator the number of cases, VPC%, mean (SD), range of the bottom and top quartile, and the number of hospitals in the quartiles is displayed, providing a perspective on the amount of variation demonstrated at the hospital level for that condition. For example, for maternal hemorrhage, after adjusting for case-mix, there were 19 hospitals in the bottom quartile with a mean rate of 0.50% and a range of 0.28-0.76% compared to 39 hospitals in the upper quartile with a mean rate of 5.88% and a range of 3.66-12.24%. This variation suggests a need to determine if there are system-level factors that account for high or low rates in these hospitals. Lessons about best practices may be gleaned from the hospitals with low rates, and opportunity for improvement likely exists for the hospitals with high rates.

Discussion, Conclusions, Significance, Implications

We used the existing set of Agency for Healthcare Research and Quality (AHRQ) Quality Indicators—aimed predominantly at the adult non-pregnant population—to proposed a set of indicators (with appropriate case definitions) for quality improvement and tracking of pregnancy and childbirth services and outcomes. In addition, we provided theoretical and empirical evidence for additional potential quality indicators specific to pregnancy and childbirth. Though we are still in the process of submitting manuscripts that summarize and support our findings, the conclusions of our work to date are enumerated below.

1. For the indicators to be meaningful, coding modifications were required to include primary and secondary diagnoses, present on admission, and inclusion of some pregnancy-specific codes/diagnoses.

For many of the proposed indicators, we suggest using delivery discharges as the denominator in order to provide a ratio for meaningful comparisons.

2. There are six current AHRQ indicators pertinent to pregnancy (2 PSI, 4 IQI) and one PQI that has been re-categorized as a Pediatric Indicator. Our analyses revealed six additional AHRQ indicators pertinent to pregnancy and childbirth that are amenable to monitoring with coding modifications. These indicators have rates comparable or higher than the currently defined AHRQ adult medical/ surgical population. Specifically, we recommend three additional PSIs (PSI #1 complications of anesthesia, PSI #9 Postoperative hemorrhage or hematoma, and PSI #13 Postoperative sepsis), as well as three additional PQIs (PSI #1 Perforated appendix, PQI #7 Uncontrolled hypertension, PQI #14 Uncontrolled diabetes). All would require coding modifications, including primary and secondary diagnosis and, in some instances, present on admission, because the rules regarding the assignment of principal diagnosis differ in pregnancy. Eleven AHRQ indicators were appropriate for pregnancy and childbirth with modification (excluding Pediatric Indicator—low birthweight).
3. The study team evaluated other potential indicators across the continuum of the reproductive/pregnancy continuum and proposed 16 new as well as five overlapping or duplicate (or expanded) AHRQ indicators. These 27 indicators have been referred to as potential Maternal Quality Indicators (MQI) and need validation with primary data and vetting for consensus building and understanding of preventability and of practice changes that could alter/improve outcome.
4. Significant adverse outcomes are rare, prompting the need for Maternal Health Surveillance Indicators, and we have proposed eight MHSI (35 total as of now).
5. We will not evaluate the contribution of specific hospital characteristics (hospital structure variables) as part of this analysis. Our goal is to demonstrate that variation exists within and across hospitals. We did not attempt to explain the variation by structure or process during this initial empirical analytic phase. Obviously, that would be an important next step to facilitate quality improvement initiatives.

Significance & Implications

We have set forth a preliminary set of quality indicators focused on pregnancy and childbirth. Given that pregnancy is the leading cause of hospital admissions, monitoring safety and quality is imperative. Next steps will be directed toward validating the indicators via primary chart reviews and developing the chain of evidence that the indicator is linked to a structure or process that is modifiable and that there is evidence of known best practice (or one capable of being developed), building consensus for the measures, and vetting them through the necessary steps for national endorsement (e.g., Leapfrog or NQF). A final goal in this process is to obtain patient input, allowing us to translate these measures so that they are meaningful from the patient and lay public perspective.

List of publication and products

1. **Gregory KD**, Korst L, Fridman M, Lu MC. AHRQ Patient Safety Indicators: Time to include hemorrhage and infection during childbirth. Jt Comm J Qual Patient Saf 2013, 39(3):114-22.
2. El HajIbrahim S, Korst LM, Fridman M, Gregory KD. Variation in anesthesia complications in pregnancy as a maternal quality of care Indicator. Anesth (accepted, pending revisions)
3. Korst LM, Fridman M, Lu MC, Mitchell C, Laughton E, Griffin F, Gregory KD. Monitoring childbirth morbidity using hospital discharge data: further development and application of a composite measure. Am J Obstet Gynecol (accepted, in press)

4. Anticipated minimum manuscripts currently in preparation

a. Obstetrical Inpatient Quality Indicators/Obstetrical Prevention Quality Indicators
b. MQI Work group Proposed Childbirth Specific Quality Indicators (across the continuum of care)
c. Final Recommendations for Maternal Quality Indicators
d. Technical specifications

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Table 5a. MQI MATERNAL LIVEBORN DELIVERY INDICATORS (OSHPD 2009)

Results from mixed models with 242 hospitals adjusting for maternal age, race, hr/lr status, prior CS, preterm and multiple gestation (unless otherwise specified)

Indicator	N	Cases	VPC (%)	25%-ile adj rates	75%-ile adj rates	Extreme low rate hospitals				Extreme high rate hospitals			
						# hospitals	mean (sd) rate	Min rate	Max Rate	# hospitals	mean (sd) rate	Min rate	Max Rate
Eclampsia per # gest htn	27904	373	0.86	0.82	1.31	0	-	-	-	5	5.79 (3.90)	3.48	12.66
Hemorrhage/Hematoma PSI #9	49326	12286	1.91	1.18	3.08	19	0.50 (0.14)	0.28	0.76	39	5.88 (1.87)	3.66	12.24
Maternal Infection	50249	1331	0.30	0.07	0.22	0	-	-	-	23	0.64 (0.32)	0.35	1.52
Instrumental VD	33578	2778	2.71	5.23	10.57	24	2.96 (0.56)	2.12	4.00	35	16.32 (3.80)	12.18	27.04
Instrumental CS	16725	8175	7.91	1.48	6.14	12	0.46 (0.15)	0.33	0.86	37	16.49 (10.63)	8.08	52.55
OB Trauma per # of instrumental VD PSI #18	27606	3244	2.70	8.33	13.87	4	4.47 (0.52)	3.93	5.01	5	22.74 (4.11)	17.91	27.79
Maternal Composite Comps Low Risk[1]	27122	30957	2.42	7.93	13.73	30	4.98 (0.98)	3.17	6.43	28	19.24 (3.82)	14.96	34.71
Maternal Composite Comps High Risk	23129	35876	2.54	7.29	12.59	21	4.30 (0.98)	2.44	5.84	38	18.61 (3.72)	14.00	27.24
Severe Mat Composite Comps High Risk	23129	5029	0.23	0.95	1.42	3	0.59 (0.06)	0.52	0.64	17	2.33 (0.46)	1.74	3.25
TSV Route Indicators:													
CS IQI #21[2]	45218	13484	4.56	21.86	32.97	40	16.64 (2.60)	9.88	20.46	49	43.37 (8.07)	34.97	74.09
Repeat CS IQI #21b[2]	73959	68060	18.04	88.51	98.93	45	77.90 (5.26)	20.49	58.59	0	-	-	-
Primary CS IQI #33[2]	37825	6676	2.87	11.78	19.03	25	8.73 (1.15)	5.99	10.53	49	26.85 (7.21)	20.51	57.61
Elective CS	45218	7058	3.25	4.31	9.63	37	2.76 (0.55)	1.68	3.76	28	17.98 (9.13)	11.04	59.45
Emergent CS	45218	6424	1.08	11.07	15.28	23	8.57 (1.17)	4.88	8.01	38	19.15 (2.55)	16.45	27.53
Emergent Repeat CS[2]	73959	12332	4.00	11.85	20.85	20	6.59 (1.55)	3.19	9.18	16	29.88 (5.97)	24.11	45.40
Emergent Primary CS[2]	37825	5191	1.28	10.44	14.88	24	7.87 (1.00)	5.23	9.07	33	19.73 (3.53)	16.04	30.83
Elective Repeat CS[2]	73959	55728	8.02	69.11	84.70	34	57.03 (5.24)	42.28	66.01	25	92.01 (2.28)	88.33	96.62
Elective Primary CS[2]	37825	14855	1.94	1.40	3.38	22	0.81 (0.15)	0.52	1.06	37	7.93 (6.81)	3.96	44.96
Hospitals w/attempt>10%	N=210												
VBAC Attempt per # of prior CS[2]	68060	17811	5.02	19.11	31.66	16	13.53 (1.20)	11.51	16.07	30	43.41 (4.88)	36.00	57.46
VBAC Success per # of prior CS IQI #22[2]	68060	5827	18.04	1.38	12.73	2	0.41 (0.06)	0.37	0.46	40	22.91 (5.01)	15.43	41.34
VBAC Success per # of attempts[2]	17811	5827	26.41	7.27	47.38	3	2.23 (2.78)	1.95	2.50	17	62.78 (6.11)	56.16	74.50

[1] No adjustment for risk group or prior CS; No [2] No adjustment for prior CS

Table 5b. MQI NEONATAL LIVEBORN DELIVERY INDICATORS (OSHPD 2009)

Results from mixed models with 242 hospitals adjusting for NN race, NN hr/lr status, preterm, and multiple gestation (unless otherwise specified)

Indicator	N	Cases	VPC (%)	25%-ile adj rates	75%-ile adj rates	Extreme low rate hospitals				Extreme high rate hospitals			
						# hospitals	mean (sd) rate	Min rate	Max Rate	# hospitals	mean (sd) rate	Min rate	Max Rate
NN Infection (low risk, term, singleton)[1]	404077	4088	1.59	0.29	0.92	3	0.08 (0.02)	0.06	0.11	38	2.93 (1.80)	1.35	10.00
NN Composite Comps (low risk, term, singleton)[1]	404077	22129	1.92	3.60	6.99	23	2.30 (0.38)	1.46	2.99	33	12.81 (4.44)	8.30	25.33
NN Trauma PSI #17	468851	4623	1.08	0.39	1.12	5	0.18 (0.02)	0.15	0.21	36	3.20 (2.11)	1.70	13.00
NN Transfer	505665	7724	3.06	0.27	1.66	23	0.11 (0.04)	0.03	0.19	37	4.03 (1.41)	2.24	8.62

[1]No adjustment for NN risk, preterm and multiple gestation status