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SPECIAL ARTICLE

The MANDATE model for evaluating interventions to reduce postpartum hemorrhage

Elizabeth M. McClure [a,*], Doris J. Rouse [a], Emily R. MacGuire [a], Bonnie Jones [a], Jennifer B. Griffin [a], Alan H. Jobe [b], Beena D. Kamath-Rayne [b], Craig Shaffer [c], Robert L. Goldenberg [d]

[a] Department of Statistics and Epidemiology, Research Triangle Institute, Durham, USA
[b] Department of Pediatrics, University of Cincinnati, Cincinnati, USA
[c] Applied Strategies, San Manteo, USA
[d] Department of Obstetrics, Columbia University, NY, USA

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ABSTRACT

Objective: To create a comprehensive model of the comparative impact of various interventions on maternal, fetal, and neonatal (MFN) mortality. *Methods:* The major conditions and sub-conditions contributing to MFN mortality in low-resource areas were identified, and the prevalence and case fatality rates documented. Available interventions were mapped to these conditions, and intervention coverage and efficacy were identified. Finally, a computer model developed by the Maternal and Neonatal Directed Assessment of Technology (MANDATE) initiative estimated the potential of current and new interventions to reduce mortality. *Results:* For PPH, the sub-causes, prevalence, and MFN case fatality rates were calculated. Available interventions were mapped to these sub-causes. Most available interventions did not prevent or treat the overall condition of PPH, but rather sub-conditions associated with hemorrhage and thus prevented only a fraction of the associated deaths. *Conclusion:* The majority of current interventions address sub-conditions that cause death, rather than the overall condition; thus, the potential number of lives saved is likely to be overestimated. Additionally, the location at which mother and infant receive care affects intervention effectiveness and, therefore, the potential to save lives. A comprehensive view of MFN conditions is needed to understand the impact of any potential intervention.

1. Introduction

Maternal, fetal, and neonatal (MFN) mortality rates are unacceptably high, especially in low- and middle-income countries (LMICs) [1–4]. Most MFN mortality arises from common conditions, often occurring around birth [5–7]. The majority of these deaths could be prevented with access to adequate care, especially emergency obstetric and neonatal care at delivery. More than half of births worldwide occur outside a health facility, without a skilled attendant or the life-saving interventions available in high-income settings [8]. Many other births occur in facilities without adequate equipment or trained staff. Currently available interventions are often too complex for unskilled workers and hinder the widespread adoption of interventions to reduce MFN mortality [9]. Thus, innovative solutions are necessary to adapt many interventions for LMIC settings.

Although studies have estimated the effects of interventions on MFN mortality [2–5], no quantitative process currently compares specific medical interventions based on the potential to save lives in low-resource settings, given their availability, utilization, and efficacy. Innovative interventions across the continuum of care—including interventions for use in homes, health centers, and hospitals—may significantly improve perinatal outcomes. Comprehensive analyses are needed regarding the relationships between the causes of MFN mortality, in addition to the impact of interventions on these mortalities. Such analyses are of particular importance for low-resource settings with the highest mortality burden.

Most estimates of global maternal and neonatal mortality include broad causes of death (e.g. hemorrhage for maternal mortality). These categories, however, provide little guidance for which interventions would reduce mortality because the interventions are often directed at specific causes of death (e.g. retained placenta for postpartum hemorrhage [PPH]). To evaluate interventions that are likely to reduce mortality, the specific sub-causes of each condition must be addressed. When considering PPH, for example, uterotonics may reduce maternal mortality from postpartum uterine atony but not from other causes of hemorrhage. Only rarely do interventions address the overall condition. The proportion of deaths associated with each sub-cause is crucial, and in the example of PPH the number of deaths from atonic uterus must first be assessed to estimate the potential of an intervention to reduce the component of death associated with PPH.

The Maternal and Neonatal Directed Assessment of Technology (MANDATE) initiative was developed by the authors to address

* Corresponding author at: Department of Statistics and Epidemiology, Research Triangle Institute, 3040 Cornwallis Road, Durham, NC 27709, USA. Tel.: +1 919 316 3773; fax: +1 919 647 4160.
E-mail address: mcclure@rti.org (E.M. McClure).

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these needs. The primary objective was to evaluate the potential of interventions to reduce MFN mortality, with emphasis on low-resource settings. MANDATE has developed a web-based model to estimate the number of MFN lives saved through various interventions in order to inform which interventions, either new or adapted for use in various settings, could significantly reduce MFN mortalities. The present paper describes the MANDATE methods, using PPH as an example.

2. Materials and methods

A comprehensive English-language literature review of MFN mortality and relevant websites (WHO, UN, Cochrane Database of Systematic reviews) since 1980 was performed. The major conditions associated with MFN mortality and the specific etiologies associated with each condition were determined. The proportion of mortality associated with each etiology was calculated. Only previously published data were used, so Institutional Review Board approval was not required.

Next, the literature on interventions to reduce MFN mortality was reviewed to determine the efficacy, utilization, and penetration rates. Because a range of interventions (e.g. economic improvement and improved infrastructure) can impact mortality, medical interventions shown to reduce MFN mortality were examined and then mapped to the relevant causes of death [9,10]. To illustrate the framework, the present paper describes this process in detail for PPH specifically, but discusses its applicability across all causes of MFN mortality.

In summary, to evaluate conditions causing death, maps of the major conditions and specific etiologies within them were created (Fig. 1). For each maternal and neonatal condition and sub-condition, MFN death rates were estimated. Additionally, the impact of maternal conditions on the prevalence of neonatal conditions was estimated. For example, placental abruption increases the prevalence of neonatal asphyxia and, subsequently, neonatal mortality. Once the flow through conditions leading to death was determined, an Excel-based (Microsoft, Redmond, WA, USA) computer model was used to estimate the impact of the interventions. The interventions were defined as prevention, diagnostic, or treatment (Box 1). An important concept is intervention coverage, which includes penetration, as defined by the availability of the technology and by actual utilization. Utilization also incorporates the skills of the user. The model quantifies less effective utilization in a given location or by certain levels of caregiver as a decrease in utilization. Using the concepts of coverage and efficacy, one can estimate the potential of an intervention to prevent a condition, to diagnose a condition, or to save MFN lives affected by that condition in different settings.

Because interventions are administered at a location, within the model, an intervention can occur at home, in a clinic, or in a hospital. Certain interventions may be rationally used in some settings and not others; therefore, place of administration, defined in part by the skill of the practitioners generally available at that location, is crucial for understanding the potential impact of an intervention. A related feature is that mothers and/or newborns can and do move from one setting to another for medical care during the prenatal, delivery, and postpartum periods. Conceptually, improved or readily available diagnostics should lead to the use of effective treatments for a specific condition. However, a major impact of better or more available diagnostics might also be a change in the setting in which the treatment is administered.

In summary, the computer model simulates the relationships illustrated by the clinical conditions map. Each condition starts with the population at risk for that condition. The clinical condition (e.g. PPH) is divided into sub-causes of death, such as atonic uterus or retained placenta. The incidence and place of care (home, clinic, or hospital) are determined by sub-condition. The death rates associated with each sub-condition are determined and quantified, including the case fatality rates for mother, fetus, and neonate. Prevention, diagnostic, and treatment technologies, in addition to their coverage and efficacy, are estimated with regard to impact on mortality in the home, clinic, and hospital. Furthermore, the potential of an intervention to encourage patient movement between settings may be incorporated.

To analyze potential interventions to reduce obstetric hemorrhage, which is the leading cause of maternal death, PPH was examined. In this example, prepartum hemorrhage—which generally

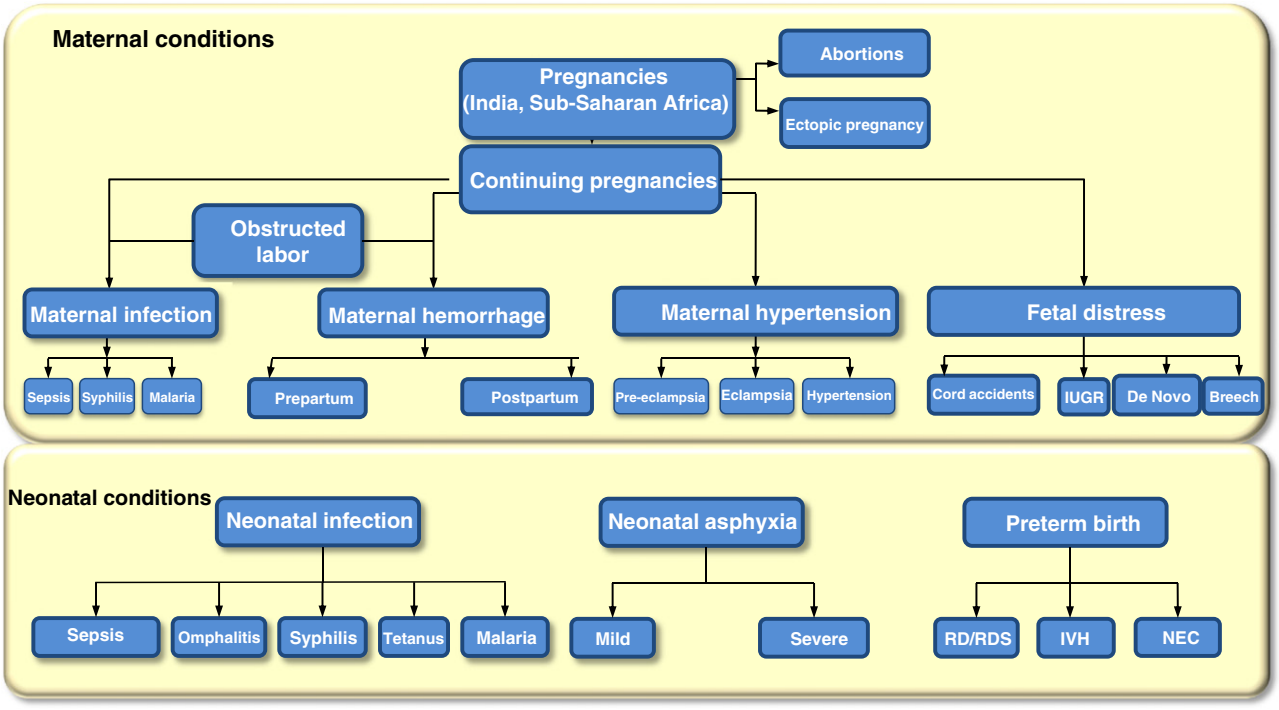

Fig. 1. MANDATE framework. Abbreviations: IUGR, intrauterine growth restriction; IVS, interventricular hemorrhage; MANDATE, Maternal and Neonatal Directed Assessment of Technology. NEC, necrotizing enterocolitis; RD/RDS, respiratory distress/respiratory distress syndrome.