

Changes in obstetric case fatality and early newborn mortality rates in hospitals after the implementation of the Expanding Maternal and Neonatal Survival program in Indonesia: Results from a health information system

Saifuddin Ahmed^{1,*} | Maya Tholandi² | Alisa Pedrana³ | Ali Zazri² | Nony Parmawaty² | Agus Rahmanto⁴ | Reena Sethi⁵

¹Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA

²Jhpiego Indonesia, Jakarta, Indonesia

³Disease Elimination Program, Burnet Institute, Melbourne, Victoria, Australia

⁴Research and Development Unit, Budi Kemuliaan Health Institute, Jakarta, Indonesia

⁵Jhpiego, Baltimore, MD, USA

*Correspondence

Saifuddin Ahmed, Department of Population, Family and Reproductive Health, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, USA.
Email: sahed3@jhu.edu

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Abstract

Objectives: Case fatality rates (CFRs) are often used as the key indicator for the measurement of quality of care at hospitals. We examine the trends of obstetric CFRs and very early neonatal mortality rates at hospitals in selected districts of Indonesia after implementation of a facility-based maternal and neonatal health intervention—the Expanding Maternal and Neonatal Survival (EMAS) program.

Methods: Random-effects Poisson regression models were fitted to routine facility data collected from 101 hospitals over approximately 4 years. Predicted incidence rates from the models were used for ascertaining the changes in CFRs and very early neonatal mortality rates during the EMAS intervention period.

Results: The obstetric CFR from any maternal complications decreased significantly by 50% (adjusted incidence rate ratio [IRR] 0.50; 95% confidence interval [CI] 0.42–0.61) at hospitals after the implementation of the EMAS program. On average, the CFR decreased from 5.4 to 2.6 deaths per 1000 cases of obstetric complications admitted during the program period. The very early neonatal mortality rate (deaths within 24 hours of birth) decreased by 21% (IRR 0.79; 95% CI, 0.65–0.96).

Conclusion: Our study suggests that overall obstetric case fatality and very early neonatal mortality rates—two indicators for tracking the quality of emergency obstetric care—decreased significantly at hospitals after the implementation of the EMAS intervention program in Indonesia.

KEYWORDS

Maternal mortality; Neonatal mortality; Obstetric case fatality rate; Quality of obstetric care

1 | INTRODUCTION

Indonesia has made remarkable progress in improving economic, social, and many health indicators in recent years: the gross domestic product increased from US \$440 billion to \$970 billion between 1990

and 2015, with almost 5% annual growth rate; the female literacy rate reached 98%¹; contraceptive use increased from 49% in early 1990 to 62% by 2015^{2,3}; and skilled birth attendance more than doubled to 83% in 2012 from the early 1990 period.¹ Indonesia is one of few countries globally that has achieved Millennium Development Goal 4

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of reducing child mortality by two-thirds between 1990 and 2015: the under-five mortality rate has reduced from 85 deaths per 1000 live births to 27 deaths per 1000 live births.⁴ The total fertility rate reduced from 5.57 to 2.45 between 1970 and 2015.⁵ Furthermore, the poverty level (US \$1.90 per day) reached an all-time low of 6.8% in 2016.⁶

It was expected that rapid social and economic developments and improvement in healthcare practices in Indonesia would have also reduced maternal mortality substantially. However, the recent maternal mortality ratio (MMR) estimate of 305 maternal deaths per 100 000 live births from the SUPAS 2015 data suggests that Indonesia has one of the highest maternal mortality ratios in Southeast Asia.⁷ Furthermore, Indonesia is one of 10 countries that contribute to almost 59% of the global maternal mortality burden.⁸ The Indonesia Demographic and Health Surveys in 1997 and 2012 estimated an MMR of 334 and 359 maternal deaths per 100 000 live births, respectively, which suggests that maternal mortality has not decreased over 15 years. During the same period, neonatal mortality—deaths in the first 28 days after birth, which are often attributed directly to perinatal maternal conditions and childbirth management—also remained almost stagnated in Indonesia. The neonatal mortality rate decreased only 14%, from 22 to 19 deaths per 1000 live births between 1997 and 2012, compared with a much higher reduction in postneonatal mortality (deaths between 28 days and 12 months after birth) rate, which decreased by almost half from 24 to 13 deaths per 1000 live births.¹ Poor obstetric care is considered to be one of the major determinants of high maternal and neonatal mortality in Indonesia.⁹

Findings from the Population Census 2010 (SP2010), which collected data on maternal mortality and causes of maternal death in Indonesia at the national level, indicated that 70.5% of maternal deaths occurred in health facilities: 41.9% in public hospitals, 16.1% in private hospitals, and 2.3% at *puskesmas* (community health centers).¹⁰ Only 29.4% of maternal deaths occurred at the home. Several studies have suggested that poor quality of maternal care at health facilities in Indonesia contributes to high maternal mortality.^{11–13} A study in Papua province suggests poor quality and delays in receiving appropriate care at facilities are the major causes of maternal mortality.¹⁴

Since the mid-nineteenth century, hospital mortality rates have emerged as the key indicator for the measurement of quality of care at hospitals.¹⁵ The World Health Organization (WHO) and partner organizations recommend the direct obstetric case fatality rate (CFR), defined as the proportion of women who died among all women admitted with major obstetric complications in a facility during a reference period, and the intrapartum or very early (<24 hours) neonatal death rate as the key indicators for measuring the quality of emergency obstetric care (EmOC) at health facilities.¹⁶ The CFR is one of the six United Nations process indicators used to track EmOC, and 1% is the recommended maximum limit for an acceptable level of quality.¹⁷ However, measuring and tracking mortality rates is challenging where hospital records are poor and the routine health information system (HIS) is weak.¹⁸

The Indonesia Ministry of Health has implemented two systems that compile and report deaths at health facilities: a national HIS

(*Sistem Informasi Kesehatan Nasional*) and a provincial HIS (*Sistem Informasi Kesehatan Daerah*).¹⁹ However, each provincial HIS has its own system and the methods for data collection are not standardized. In 2001, a large degree of fiscal and political autonomy was granted to Indonesian district governments, and following decentralization, the strength of the HIS has declined further, contributing to the absence of quality data at all health system levels. The lack of meaningful, routine measures, compounded by concerns over data quality, affects Indonesia's ability to assess the effectiveness of policies and strategies to accelerate reductions in mortality. A 2013 review concluded that the limitations of facility-based data sources are at least partly attributable to the inadequate HIS.⁹ Overall, Indonesia's HIS is considered to be weak and not optimal for tracking maternal and neonatal mortality at hospital settings.

A key strategy of safe motherhood interventions to reduce mortality is to improve the timely utilization of life-saving drugs to prevent or treat emergency obstetric complications. These drugs include the administration of uterotonic drugs immediately after birth for the prevention of postpartum hemorrhage (PPH), and the use of magnesium sulfate ($MgSO_4$) for women with severe pre-eclampsia for the prevention of eclampsia and for treatment of women with eclampsia.²⁰ Tracking the use of these interventions and evaluating their impact on maternal mortality remain a major challenge in low- and middle-income countries, where data on meaningful maternal and neonatal health (MNH) process indicators are not systematically recorded or reported. For example, tracking the proportion of patients who receive a uterotonic can help understand the related health outcomes and the specific causes of high MMR.

To address the continuing high maternal and neonatal mortality levels in Indonesia, the United States Agency for International Development (USAID) funded the Expanding Maternal and Neonatal Survival (EMAS) program, which developed and implemented a facility-based health information monitoring system in over 400 hospitals and *puskesmas*. This study examines the trends in CFR from any obstetric complications, cause-specific direct obstetric CFRs, very early neonatal mortality rates, and timely use of life-saving drugs for emergency obstetric complications (uterotonic drugs for PPH prevention and $MgSO_4$ use among patients with severe pre-eclampsia/eclampsia) in EMAS intervention facilities between 2013 and 2016. Our key interests are to evaluate whether mortality significantly declined and the use of life-saving drugs significantly improved after the implementation of the EMAS program.

2 | MATERIAL AND METHODS

Full details of the EMAS program are described in a companion article.²¹ A facility-based HIS, using a standardized set of registers, was introduced in project-supported hospitals and *puskesmas* so that clinical performance of evidence-based MNH practices could be recorded and reported, and monitored and evaluated.

2.1 | MNH monitoring system and data collection procedures

An initial baseline assessment was conducted in 2012 in six EMAS program provinces to determine the status of the HIS. Site visits were conducted in health facilities to review primary and secondary data sources, data quality, current recording and reporting practices, forms and tools, and information flow and use. The MEASURE Routine Data Quality Assessment (RDQA) tool²² was used during these visits. Findings suggested that facility data systems were unable to reliably generate the prioritized MNH indicators. Data registers routinely used for labor and birth and in postnatal wards were not standardized and data were often handwritten in log-books rather than using registers provided by the Ministry of Health (MOH). Hospital staff reported that the MOH registers only tracked limited data elements so the facility staff took the initiative to make handwritten registers. Across facilities, registers varied in the data elements tracked and how information was recorded. Facility-created registers did not fully align with monthly MOH reporting forms for MNH service tracking and the time burden to complete both registers was a major imposition on staff time. The majority of facilities were not able to report obstetric CFRs accurately or use these data for analysis or decision making.

A standardized HIS was developed to track key maternal and newborn evidence-based practices. Registers were piloted in *puskesmas* and in both public and private hospitals and facility feedback was incorporated to ensure ease of use, relevance, and acceptability. At the national level, the EMAS monitoring and evaluation team shared drafts of pilot registers with MOH colleagues.

The registers were introduced through 2-day sensitization workshops involving staff from health facilities and provincial and district-level government stakeholders. Staff were oriented and trained on how to use and report from the new registers. Seven registers were introduced; hospitals, labor and delivery room services, neonatal services, maternal deaths, and neonatal deaths each had their own register; *puskesmas* used three separate registers for recording maternal and neonatal services, maternal deaths, and neonatal deaths. Staff at both hospitals and *puskesmas* entered data into the facility register as routine recording and then completed a summary aggregate form for reporting to the MOH every month. Data quality and use of these registers was monitored by EMAS program staff. District-based quality improvement coordinators, who were medical professionals and trained in clinical governance, also visited facilities to review the use of the registers and assessed quality and completeness, especially as it related to mortality recording and reporting. A provincial-level EMAS monitoring and evaluation (M&E) officer conducted a second level of review to ensure data consistency and accuracy. EMAS M&E data managers at the national program office conducted monthly routine data assessments for completeness and timeliness across all districts and random quality assurance checks.

Aggregate data were collected monthly from health facilities using a routine collection form. Data were initially collected from 101 hospitals and 285 *puskesmas* in 30 districts. Subsequently, the monitoring system added 35 hospitals in an additional 27 districts,

where the EMAS program expanded to provide limited technical supports to provincial governments. Several other district health offices also adapted the standardized registers beyond EMAS program districts.

The first random assessment using the RDQA tool occurred in early 2013. Results revealed many data quality challenges and resulted in significant investments for health information strengthening, including the development, pilot testing and introduction of tools (e.g. standardized registers in June 2013); and trainings and workshops to improve existing data recording, management, and use practices. The findings of the second RDQA in 2015 showed much better results. The discrepancy between data reported in the information system and observed at facility was only 3%. The third RDQA conducted in 2016 also showed very low discrepancy in reporting. Findings from the site visits and the RDQA assessments were also fed back to facilities to help improve data quality and completeness over the life of the program.

The analysis in the present article is limited to 101 hospitals in 30 districts in six provinces. Our preliminary analysis suggests that very few maternal deaths occurred in *puskesmas*; therefore, an effective analysis of mortality trends at *puskesmas* level was not feasible.

2.2 | Analysis

The EMAS program was implemented in three phases: Phase 1 from July 2012 to March 2016 (45 months of exposure); Phase 2 from January 2014 to September 2016 (33 months of exposure); and Phase 3 from April 2015 to December 2016 (21 months of exposure). Consequently, it was difficult to directly assess the overall net changes in the level of mortality and improvement in MNH care indicators between the baseline and endline periods of the EMAS program. Moreover, the facilities were heterogeneous across the six provinces by hospital types, numbers of hospital beds, delivery volumes, and administration type (private versus public). To estimate the rate of changes of MNH indicators (e.g. overall and complication-specific CFRs and changes in coverage for evidence-based practices) between $T=0$ (start date of EMAS monitoring data) and $T=1$ (end date of EMAS monitoring data), we used random-effects Poisson regression models where "EMAS exposure period" was the key variable of interest. Poisson models are suitable for modeling count data as an outcome variable (e.g. number of deaths) where interest is to estimate incidence rate ratios (IRR) for the regressor variables (variables of interest) during an observation period. We used separate models for each outcome related to CFRs, very early neonatal mortality, and MNH care indicators (e.g. uterotonic drug and $MgSO_4$ use).

The EMAS exposure period was rescaled to bound between the values of 0 and 1, irrespective of intervention phases. One key advantage of this model specification was that converting the beta coefficient (β) associated with "EMAS exposure period" variable to exponentiated beta [$\exp(\beta)$] directly estimated the IRR, which was essentially the rate of changes in the model outcomes (mortality indicators and MNH care indicators) between the starting ($T=0$) and end ($T=1$) periods of the EMAS intervention program. All models were

TABLE 1 Incidence rate ratios for overall and cause-specific obstetric CFRs and very early neonatal mortality rates at intervention hospitals in Indonesia by EMAS exposure period and other selected variables.

Variables	Overall CFR	PPH CFR	Severe PE/E CFR	Very early neonatal mortality (24 h)
	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)	IRR (95% CI)
EMAS implementation period	0.50 (0.42–0.61)	0.77 (0.49–1.22)	0.80 (0.59–1.08)	0.79 (0.65–0.96)
Type of hospital				
Private hospital	1.0	1.0	1.0	1.0
Public hospital	2.27 (1.63–3.15)	1.11 (0.65–1.88)	1.47 (1.01–2.14)	2.95 (2.18–3.98)
Provinces				
West Java	1.0	1.0	1.0	1.0
Central Java	0.95 (0.64–1.42)	0.80 (0.45–1.44)	1.06 (0.74–1.52)	0.67 (0.46–0.99)
East Java	0.52 (0.34–0.80)	0.51 (0.26–0.98)	0.73 (0.48–1.12)	1.00 (0.67–1.48)
Banten	1.73 (0.88–3.39)	0.53 (0.18–1.57)	1.27 (0.75–2.16)	0.94 (0.47–1.88)
North Sumatra	1.36 (0.78–2.38)	2.22 (0.96–5.13)	2.39 (1.44–3.97)	1.37 (0.81–2.31)
South Sulawesi	1.10 (0.56–2.18)	0.85 (0.33–2.20)	1.47 (0.79–2.73)	0.83 (0.44–1.56)
EMAS implementation phases				
Phase 1	1.0	1.0	1.0	1.0
Phase 2	0.96 (0.66–1.39)	0.58 (0.34–1.00)	0.73 (0.53–1.00)	0.72 (0.50–1.02)
Phase 3	0.49 (0.33–0.74)	0.47 (0.26–0.88)	0.53 (0.36–0.79)	0.84 (0.58–1.21)

Abbreviations: CFR, case fatality rate; PPH, postpartum hemorrhage; PE/E, pre-eclampsia/eclampsia; IRR, incidence rate ratios; CI, confidence interval.

adjusted for hospital facility type (private versus public), province, and EMAS intervention phases.

For graphical presentations of the data, we derived predicted incidence rates at $T=0$ (baseline) and $T=1$ (endline) from the fitted Poisson model estimates.

3 | RESULTS

As of March 2017, the coverage of MNH practices and mortality outcome had been recorded and monitored for over 314 649 deliveries across 101 hospitals. Figure 1 shows the trends in obstetric CFRs among women admitted to hospitals with any maternal complication, whether or not they were referred from another facility. Overall, the trend in all three phases of the EMAS program shows a consistent downward slope, which suggests that reductions in CFR from maternal complications were similar in all EMAS phases after the program was initiated.

The results of the random-effects Poisson model suggest that overall CFR from any obstetric complications decreased significantly by 50% (IRR 0.50; 95% confidence interval [CI], 0.42–0.61) on average during the three phases of the EMAS intervention period, adjusted for type of facilities (private or public), province, and the implementation phases of EMAS program (Table 1). The estimated predicted CFRs for each phase and overall average total at the start (baseline) and end periods (endline) of the EMAS program are shown in Figure 2. The CFR was about 7.8 maternal deaths per 1000 women admitted with obstetric complications at the beginning of monitoring in Phase 1,

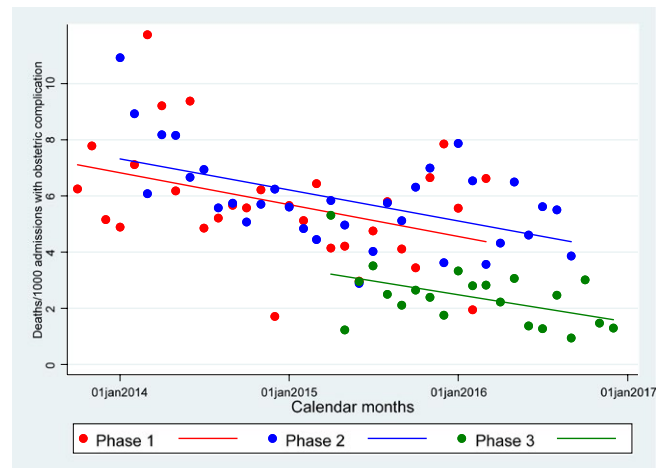


FIGURE 1 Trends in case fatality rate from obstetric complications by EMAS implementation phases.

which declined to 3.9 deaths per 1000 women admitted with obstetric complications by the end of the EMAS program. A similar reduction in the CFRs was observed in Phase 2. CFRs were substantially lower at the Phase 3 hospitals (on average about 2.9 maternal deaths per 1000 women with obstetric complications) when monitoring of the EMAS program was initiated. Nevertheless, the overall CFR was reduced by about 55% to 1.3 deaths per 1000 women with obstetric complications by the end of EMAS program implementation period during this phase. On average, the CFR decreased from 5.4 to 2.6 deaths per 1000 cases of obstetric complications admitted during the EMAS

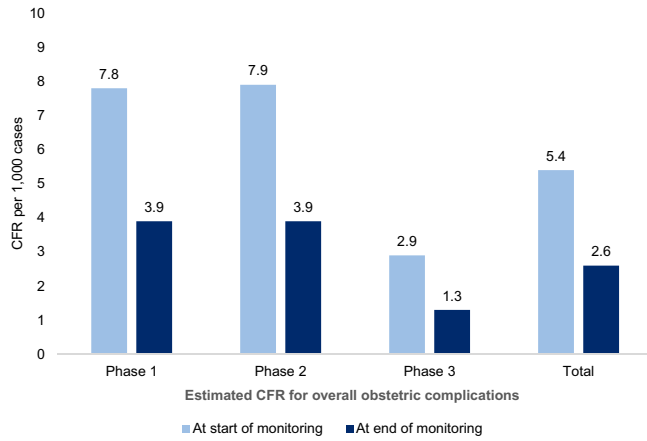


FIGURE 2 Estimated case fatality rate (CFR) for overall obstetric complications by EMAS implementation phase.

program period, adjusted for the differences in province, type of hospitals (private and public), and the EMAS implementation phases.

The CFRs from postpartum hemorrhage (PPH) and severe pre-eclampsia/eclampsia decreased modestly by about 23% (IRR 0.77; 95% CI, 0.49–1.22) and 20% (IRR 0.80; 95% CI, 0.59–1.08), respectively, during the EMAS program period. However, the reductions were not statistically significant ($P>0.05$); the confidence interval values inclusive of value 1.0 suggest that the IRRs are not significantly different from the null hypothesis of no difference between two time points: endline and baseline. The changes in estimated CFRs for PPH and severe pre-eclampsia/eclampsia complications, adjusted for province and type of hospitals, in each phase and for the overall EMAS program period are shown in Figure 3. Note that the routine use of uterotonic drugs during the third stage of labor immediately after the birth of the infant but before the expulsion of the placenta, which is used for the prevention of PPH, and the use of MgSO₄ for pre-eclampsia/eclampsia were already very high in the study hospitals when the EMAS program was initiated (about 95% and 81%,

respectively; data not shown). The use of uterotonic drugs increased about 5% (IRR 1.05; 95% CI, 1.04–10.06) and the use of MgSO₄ by 18% (IRR 1.18; 95% CI, 1.14–1.23) during the EMAS program period (Table 2). The use of these drugs almost reached 100% by the end of the EMAS program (data not shown).

The very early neonatal mortality rate (deaths within 24 hours) decreased by 21% (IRR 0.79; 95% CI, 0.65–0.96) during the EMAS program period. A similar reduction in the mortality rate was observed for early neonatal mortality (deaths within first 7 days after birth; data not shown). Figure 4 shows the changes in the estimated very early and early neonatal mortality rates, adjusted for province and type of hospitals, in each phase and for the overall EMAS program. During the EMAS program, the very early neonatal mortality rate declined from 4.8 to 3.3 deaths per 1000 live births (estimates adjusted for other covariates). The early neonatal mortality rate was substantially higher at about 33.6 deaths per 1000 live births, but decreased to about 23.9 deaths per 1000 live births.

Overall, the obstetric CFRs and early neonatal mortality rates were significantly higher in public hospitals. East Java had the lowest obstetric CFRs and early neonatal mortality rates among the six provinces included in this study.

4 | DISCUSSION

Our analysis suggests that overall obstetric CFR and very early and early neonatal mortality rates decreased significantly after the implementation of the EMAS intervention program at hospitals in the selected program districts of Indonesia. The reductions of the cause-specific CFRs due to PPH and severe pre-eclampsia/eclampsia, however, were modest and not significant. This finding, however, was not unexpected because the use of uterotonic drugs and MgSO₄ for the treatment and prevention of PPH and eclampsia, respectively, was already very high. Due to the small number of cases, separate analyses of case-specific CFRs due to other direct

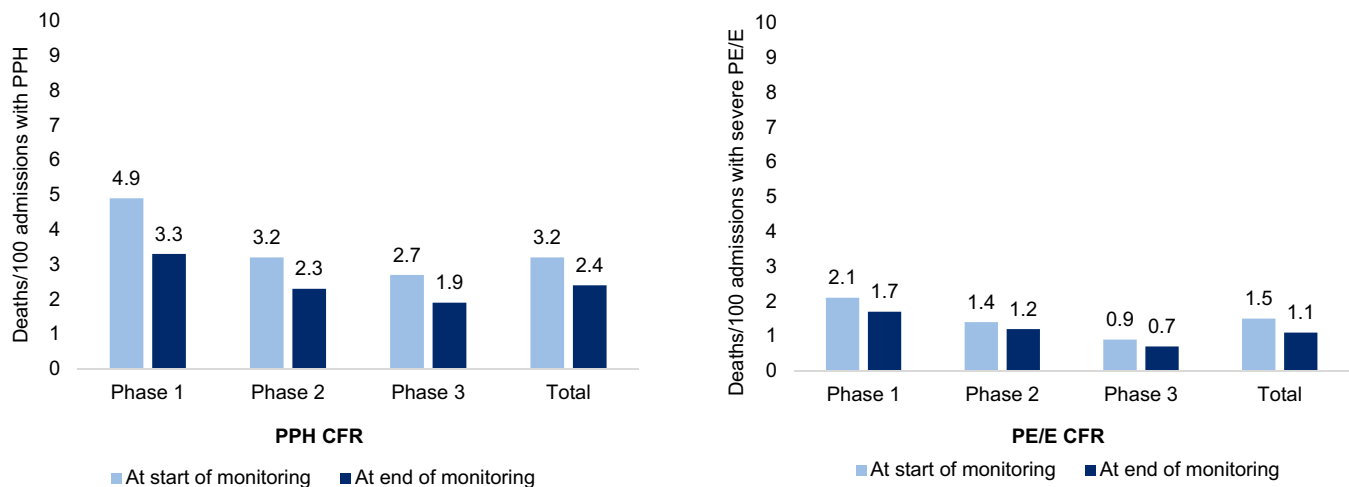


FIGURE 3 Estimated case fatality rate (CFR) for postpartum hemorrhage (PPH) and severe pre-eclampsia/eclampsia (PE/E) by EMAS implementation phase.

TABLE 2 Incidence rate ratios for the uses of uterotonic drug in the third stage of labor and MgSO₄ among severe PE/E cases at intervention hospitals in Indonesia by EMAS exposure period and other selected variables.

Variables	Use of uterotonic drug in the third stage of labor	Use of MgSO ₄ among severe PE/E cases
	IRR (95% CI)	IRR (95% CI)
EMAS implementation period	1.05 (1.04–1.06)	1.18 (1.14–1.23)
Type of hospital		
Private hospital		
Public hospital	1.00 (0.99–1.01)	1.02 (0.98–1.06)
Provinces		
West Java	1.0	1.0
Central Java	1.01 (0.99–1.02)	1.11 (1.06–1.16)
East Java	1.01 (0.99–1.02)	1.12 (1.07–1.17)
Banten	0.99 (0.96–1.01)	1.01 (0.94–1.08)
North Sumatra	1.01 (0.99–1.03)	1.03 (0.96–1.11)
South Sulawesi	1.01 (0.99–1.04)	0.98 (0.90–1.07)
EMAS implementation phases		
Phase 1	1.0	1.0
Phase 2	1.01 (1.00–1.02)	1.01 (0.97–1.06)
Phase 3	1.01 (1.00–1.02)	1.00 (0.95–1.05)

Abbreviations: MgSO₄, magnesium sulfate; PE/E, pre-eclampsia/eclampsia; IRR, incidence rate ratios; CI, confidence interval.

causes of maternal mortality (e.g. obstructed labor, sepsis) were not feasible.

An earlier analysis of the causes of maternal deaths based on the Population Census 2010 data suggests that about 38% of maternal deaths in Indonesia were primarily due to puerperium complications (the first 6 weeks after childbirth) and other conditions not included in

the direct causes of maternal mortality categories.¹⁰ It is possible that improvement in labor management, resuscitation management, and appropriate stabilization of patients before referral may have contributed to the reductions of obstetric CFR and early neonatal mortality in hospitals supported by the EMAS program.

Well-performing HISs are crucial for monitoring progress toward development goals and serve as a foundation for continuous quality improvement.^{23,24} In Indonesia, studies on MNH outcomes and quality improvement measurements have been limited mostly to special studies and country-level surveys; it was difficult to assess the effectiveness of subnational policy and public health programming efforts from these studies. EMAS HIS strengthening activities in facilities demonstrated that, with sufficient inputs and support, routine data collection can be strengthened to record key outcomes of interest, including measures of quality such as obstetric CFRs. Investing in routine systems to measure what matters versus what is expedient may be less costly than large surveys, and routine systems can produce data most relevant for local programming and policy decisions.²⁵ Several district health offices have expanded use of the standardized registers beyond EMAS-supported facilities using their own funding.

We recognize that our study had a few limitations. To assess the overall impact of the EMAS project we utilized data from the routine MNH monitoring data system that was set up by the EMAS project. This limits the ability to compare data from EMAS-focused districts with other comparison districts. The routine MNH monitoring data system also did not collect data on other interventions or policy changes (e.g. universal health insurance policy) that may have impacted MNH outcomes over the life-course of the program; thus, any changes in outcomes presented in this paper cannot necessarily confer attribution. However, the ability to triangulate data from 101 hospitals across the three different phases of the EMAS program provides consistencies in the impact assessment of the EMAS program on key MNH outcomes. The consistency of EMAS effects during all three phases in most MNH indicators that we examined strongly suggests that overall CFRs and very early and early neonatal mortality

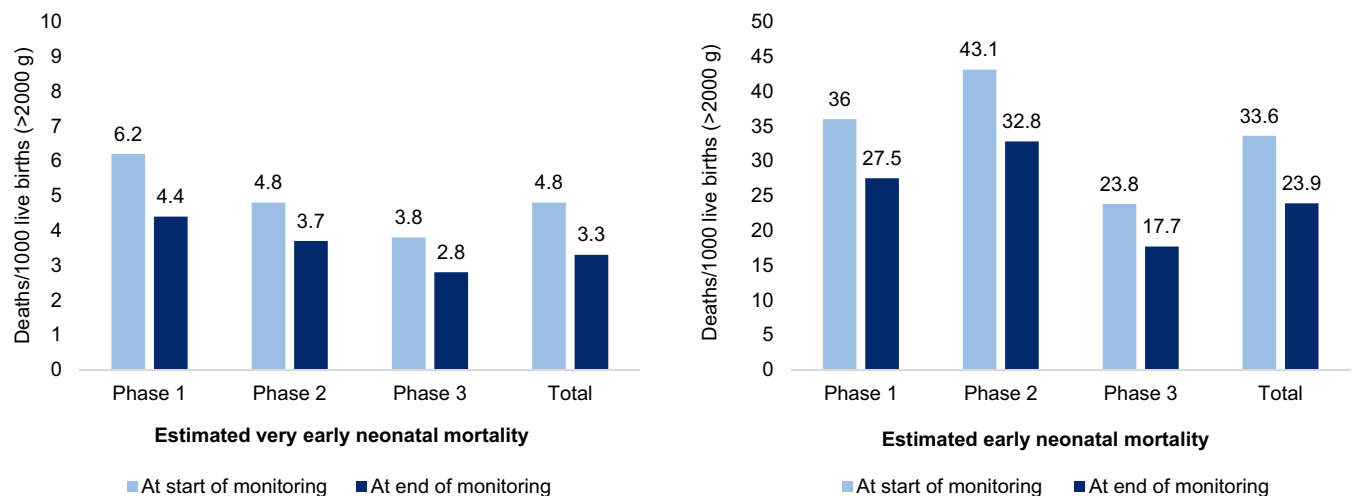


FIGURE 4 Estimated very early (<math><24\text{ h}</math>) and early (<math><7\text{ d}</math>) neonatal mortality rates by EMAS implementation phase.

decreased significantly in EMAS facilities. Similarly, evidence-based healthcare practices (uterotonic drug and MgSO₄ use) increased significantly to reach almost 100% use.

It is well recognized in the literature that after the implementation of an HIS for tracking mortality, the reporting of deaths may increase because of improvement in mortality reporting. So, it is often difficult to ascertain trends of mortality from a routine data monitoring system. This may also attenuate the estimation of true changes in mortality reduction. Cause-specific maternal mortality reporting is also challenging for routine facility data collection when deaths occur immediately after admission. The main direct causes of maternal death that are recommended for the inclusion in the calculation of the direct obstetric CFR are: hemorrhage, prolonged/obstructed labor, postpartum sepsis, complications of abortion, pre-eclampsia/eclampsia, ectopic pregnancy, and ruptured uterus.²⁶ It is difficult to ascertain the accuracy of the causes that were included in the reporting of all “obstetric/maternal complications” in the MNH monitoring system.

Reductions in maternal mortality remain a key priority under the Sustainable Development Goal (SDG) 3, which aims to ensure healthy lives and promote well-being for all. The national-level SDG 3 target is that, by 2030, no country should have an MMR greater than 140 maternal deaths per 100 000 live births, which is twice the global target of MMR less than 70.²⁷ Lessons learned from the EMAS and other MNH interventions and their appropriate replications of successful interventions will likely help Indonesia reduce maternal and neonatal mortality and promote achievement of SDG 3.

AUTHOR CONTRIBUTIONS

SA conceptualized the study, conducted the analyses, and wrote the preliminary draft. MT, AP, and RS contributed to analyses, interpretations of the results, and in finalizing the manuscript. AZ, NP, and AR contributed to finalizing the manuscript. All authors approved the final version of the manuscript.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

REFERENCES

1. Statistics Indonesia (Badan Pusat Statistik—BPS), National Population and Family Planning Board (BKKBN), and Kementerian Kesehatan (Kemenkes—MOH) and ICF International. *Indonesia Demographic and Health Survey 2012*. Jakarta, Indonesia: BPS, BKKBN, Kemenkes, and ICF International; 2013. <https://dhsprogram.com/pubs/pdf/fr275/fr275.pdf>. Accessed November 26, 2018.
2. Alkema L, Kantorova V, Menozzi C, Biddlecom A. National, regional, and global rates and trends in contraceptive prevalence and unmet need for family planning between 1990 and 2015: A systematic and comprehensive analysis. *Lancet*. 2013;381:1642–1652.
3. United Nations. World Contraceptive Use 2018. [WHO website, dataset]. 2018. <http://www.un.org/en/development/desa/population/publications/dataset/contraception/wcu2018.shtml>. Accessed September 19, 2018.
4. UNICEF. *Committing to Child Survival: A Promise Renewed – Progress Report 2015*. New York: UNICEF; 2015. https://www.unicef.org/publications/files/APR_2015_9_Sep_15.pdf. Accessed September 19, 2018.
5. United Nations. *World Population Prospects: The 2017 Revision. Key Findings and Advance Tables*. New York: United Nations; 2017. https://population.un.org/wpp/Publications/Files/WPP2017_KeyFindings.pdf. Accessed September 19, 2018.
6. World Bank. *Poverty & Equity Data Portal* [World Bank website]. 2017. <http://povertydata.worldbank.org/poverty/country/IDN>. Accessed November 26, 2018.
7. Statistics Indonesia (Badan Pusat Statistik—BPS). *Profil Penduduk Indonesia Hasil SUPAS*. Jakarta: BPS; 2015. <https://www.bps.go.id/publication/2016/11/30/63daa471092bb2cb7c1fada6/profil-penduduk-indonesia-hasil-supas-2015.html>. Accessed November 26, 2018.
8. United Nations. *Trends in Maternal Mortality: 1990 to 2015. Estimates by WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division*. Geneva: WHO; 2015.
9. Joint Committee on Reducing Maternal and Neonatal Mortality in Indonesia; Development, Security, and Cooperation; Policy and Global Affairs; National Research Council; Indonesian Academy of Sciences. *Reducing Maternal and Neonatal Mortality in Indonesia: Saving Lives, Saving the Future*. Washington: National Academies Press; 2013. https://sites.nationalacademies.org/cs/groups/pgasite/documents/webpage/pga_178872.pdf. Accessed November 26, 2018.
10. Ministry of Health Republic of Indonesia, United Nations Population Fund (UNFPA). *Disparity of Access & Quality Review of Maternal Mortality in Five Region in Indonesia*. Jakarta, Indonesia: National Institute of Health Research and Development and UNFPA; 2012. https://indonesia.unfpa.org/sites/default/files/pub-pdf/Disparity_of_Access_Quality_Review_of_Maternal_Mortality_in_5_Regions_in_Indonesia.pdf. Accessed November 26, 2018.
11. Mahmood MA, Mufidah I, Scroggs S, et al. Root-cause analysis of persistently high maternal mortality in a rural district of Indonesia: Role of clinical care quality and health services organizational factors. *Biomed Res Int*. 2018;2018:3673265.
12. Mawarti Y, Utarini A, Hakimi M. Maternal care quality in near miss and maternal mortality in an academic public tertiary hospital in Yogyakarta, Indonesia: A retrospective cohort study. *BMC Pregnancy Childbirth*. 2017;17:149.
13. Dettrick Z, Gouda HN, Hodge A, Jimenez-Soto E. Measuring quality of maternal and newborn care in developing countries using demographic and health surveys. *PLoS ONE*. 2016;11:e0157110.
14. Rosales A, Sulistyono S, Miko O, et al. Recognition of and care-seeking for maternal and newborn complications in Jayawijaya district, Papua province, Indonesia: A qualitative study. *J Health Popul Nutr*. 2017;36(Suppl.1):44.
15. Kobewka DM, van Walraven C, Turnbull J, Worthington J, Calder L, Forster A. Quality gaps identified through mortality review. *BMJ Qual Saf*. 2017;26:141–149.
16. World Health Organization. *Monitoring Emergency Obstetric Care: A Handbook*. Geneva: WHO; 2009. <http://apps.who.int/iris/bitstream/>

- handle/10665/44121/9789241547734_eng.pdf?sequence=1. Accessed September 19, 2018.
17. Paxton A, Bailey P, Lobis S. The United Nations Process Indicators for emergency obstetric care: Reflections based on a decade of experience. *Int J Gynecol Obstet.* 2006;95:192–208.
 18. Fauveau V, Donnay F. Can the process indicators for emergency obstetric care assess the progress of maternal mortality reduction programs? An examination of UNFPA Projects 2000–2004. *Int J Gynecol Obstet.* 2006;93:308–316.
 19. Mahendradhata Y, Trisnantoro L, Listyadewi S, et al. *The Republic of Indonesia Health System Review.* Vol. 7, No. 1. New Delhi: WHO, Regional Office for South-East Asia; 2017. http://www.searo.who.int/entity/asia_pacific_observatory/publications/hits/Indonesia_HIT/en/. Accessed November 26, 2018.
 20. Campbell OM, Graham WJ; Lancet Maternal Survival Series steering group. Strategies for reducing maternal mortality: Getting on with what works. *Lancet.* 2006;368:1284–1299.
 21. Hyre A, Caiola N, Amelia D, Gandawidjaja T, Markus S, Baharuddin M. Expanding Maternal and Neonatal Survival in Indonesia: A program overview. *Int J Gynecol Obstet.* 2019;144(Suppl.1):7–12.
 22. The Global Fund to Fight Aids, Tuberculosis and Malaria; Office of the Global AIDS Coordinator; PEPFAR; USAID, WHO; UNAIDS; MEASURE Evaluation. *Routine Data Quality Assessment Tool (RDQA): Guidelines for Implementation for HIV, TB, & Malaria Programs.* 2008. https://www.fsnnetwork.org/sites/default/files/rdqa_guidelines-draft_7.30.08.pdf. Accessed November 26, 2018.
 23. Aiga H, Kuroiwa C, Takizawa I, Yamagata R. The reality of health information systems: Challenges for standardization. *Biosci Trends.* 2008;2:5–9.
 24. AbouZahr C, Boerma T. Health information systems: The foundations of public health. *Bull World Health Organ.* 2005;83:578–583.
 25. Ronsmans C, Achadi E, Sutratikto G, Zazri A, McDermott J. Use of hospital data for Safe Motherhood programmes in south Kalimantan, Indonesia. *Trop Med Int Health.* 1999;4:514–521.
 26. MEASURE Evaluation. Family Planning and Reproductive Health Indicators Database: Case fatality rate (CFR) – all complications [MEASURE Evaluation website]. https://www.measureevaluation.org/prh/rh_indicators/womens-health/sm/case-fatality-rate-cfr-all-complications. Accessed September 25, 2018.
 27. United Nations General Assembly. Transforming our world: the 2030 Agenda for Sustainable Development (UN website). 2015. <https://www.unfpa.org/resources/transforming-our-world-2030-agenda-sustainable-development>. Accessed September 19, 2018.