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SUPPLEMENT ARTICLE

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Assessing the effect of the Expanding Maternal and Neonatal Survival program on improving stabilization and referral for maternal and newborn complications in Indonesia

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Abstract

Objective: To determine if the Expanding Maternal and Neonatal Survival (EMAS) program was associated with improved effectiveness of the referral system in Indonesia to facilitate timely and effective management of complications experienced by women and newborns.

Methods: Poisson regression using longitudinal monitoring data was used to assess the impact of the EMAS program on stabilization practices prior to referral. Data from a nonrandomized quasi-experimental pre-post evaluation study were used to assess the impact of the EMAS program along the referral pathway using χ^2 analysis.

Results: Monitoring data demonstrated improvements in intervention areas for stabilization of pre-eclampsia/eclampsia (24% vs 61%, incidence rate ratio [IRR] 2.4; 95% confidence interval [CI], 2.3–2.6) and treatment of newborns with suspected severe infection (30% vs 54%, IRR 2.0; 95% CI, 1.6–2.4) prior to referral. The EMAS program was associated with significantly higher levels of communication, advanced notification, back referral, and hospital emergency readiness and staff preparedness compared with the comparison arm.

Conclusion: The EMAS program contributed to improvements in the management of obstetric and newborn complications, including communication, transportation, and preparation of pregnant mothers in need of referral and hospital emergency readiness and staff preparedness.

KEYWORDS
Health facility delivery; Indonesia; Maternal health; Monitoring and surveillance; Referral

1 | BACKGROUND

Indonesia, the world's fourth largest population, continues to struggle with high maternal mortality despite two decades of major investments by government and nongovernment sectors in national programs.[1–7] Disparities exist between different provinces in terms of the proximity to the capital, economy, education, household wealth, and infrastructure, with better availability and access to basic services,

including health, among the most developed provinces of Java and Bali compared with those on islands further away from the capital.[8]

The two most common causes of maternal deaths in Indonesia are hypertensive disorders (pre-eclampsia and eclampsia) and postpartum hemorrhage (PPH), followed by sepsis, obstructed/prolonged labor, and complications of unsafe abortions.[9] Most births in Indonesia are attended by a skilled birth attendant (83%) and the majority (63%) of these births occur in a health facility.[10]

Nevertheless, an assessment in five regions in Indonesia found that 41.9% of maternal deaths occurred at public hospitals and that Eastern Indonesia and Sulawesi provinces reported the second highest maternal mortality rates and lower levels of service coverage, compared with Java and Bali.[11] Persistent high maternal morbidity and mortality are likely linked to the lack of health workers' capacity to provide high-quality care, potentially due to insufficient training, limited experience in managing complications, inadequate infrastructure in which care is provided, and geography.[7,9,12,13] Accordingly, efforts have been focused on improving timely access to care,[14,15] including effective management of complications during labor at community health facilities (*puskesmas*), and, if necessary, timely and effective referral to a hospital for specialist care.[16]

A well-functioning referral system should act as an early warning system for comprehensive emergency obstetric and newborn care (CEmONC) facilities; ideally, ensuring that the necessary staff, supplies, and equipment are fully prepared to provide emergency obstetric and newborn care 24 hours a day, 7 days a week.[16] Previous international studies have identified a number of facility-based factors that slow response times, including ineffective management of complications, a lack of supportive supervision, and unreliable standards of care and monitoring in referral facilities.[17–20] Overall, a lack of readiness to respond to emergency complications at referring facilities contributes to delays in the provision of care. These factors include inadequate transport, poor communication infrastructure, lack of basic equipment, and inadequate skills and knowledge on the part of providers.[17,18,21]

In Indonesia, public health care within districts is provided through a network of *puskesmas* and hospitals. Across the country, PONED (*Pelayanan Obstetri dan Neonatal Esensial Dasar*) *puskesmas* are staffed with a physician and several midwives and nurses who are responsible for providing basic emergency obstetric and newborn care (BEmONC), including making detailed plans for how referrals are to be arranged.[22] While the p*uskesmas* network covers a population of 30 000–50 000, many are located in relatively isolated areas with limited infrastructure, variable quality of services, and a lack of PONED capacity.[22,23] In the event of complications, *puskesmas* staff should refer clients to hospitals, which should be equipped to provide CEmONC.[22]

Previous studies in Indonesia[24,25] identified transport as a major barrier to efficient referral; emergency transport was often unavailable and private transport was unreliable and incurred costs. One study identified patients' and providers' uncertainty about where to seek emergency care, which resulted in patients traveling to several hospitals before receiving treatment, as a source of delay within an ineffective referral system.[12] A reluctance to admit poorer women covered by social health insurance was also found to be the case in some facilities.[13,24] Other barriers include a lack of proper documentation for health insurance registration, the distance to health facilities, shortage of qualified health workers, overcrowded health facilities, and suboptimal health facility accreditation.[26]

Indonesia's highly decentralized health system and a growing private sector, which includes private hospitals and midwives, may also contribute to continuing high maternal morbidity and mortality rates. These may include difficulties in coordination between public and private systems[7,9,27] and a lack of standardized protocols for managing emergency complication and referrals between p*uskesmas* and hospitals.[28]

Changes to the health insurance scheme for pregnant mothers may have also influenced service provision and client care-seeking practices. Between 2011 and 2013, Indonesia provided universal maternal health coverage through several different plans.[22,29] After 2014, a single payer system, *Jaminan Kesehatan Nasional* (JKN), was launched to facilitate achievement of universal health care. Beneficiaries of JKN are entitled to comprehensive maternity benefits, including institutional childbirth coverage for normal births at the *puskesmas* level, however, pregnant women are not allowed to directly seek treatment at a hospital or specialist clinic, except in an emergency situation or with a referral letter.[22,26]

The United States Agency for International Development (USAID) funded the Expanding Maternal and Neonatal Survival (EMAS) program (September 2011 to March 2017) to support the government of Indonesia in reducing maternal and newborn mortality by strengthening the quality of care[30] provided in *puskesmas* and hospitals and in strengthening district-level referral pathways. The EMAS program is fully described in the overview paper published in this Supplement.[31]

The purpose of the present study was to determine whether the EMAS program was associated with improved effectiveness of the referral system to facilitate timely and effective management of pregnant women and newborns with complications. We present an analysis of available monitoring data alongside evaluation data to assess outcomes and impact of the EMAS referral interventions, including indicators assessing the effectiveness, efficiency, and timeliness of the referral system to facilitate the management of women and newborns with complications.

2 | MATERIALS AND METHODS

2.1 | Description of the EMAS program and the referral interventions

EMAS was implemented in over 400 hospitals and community health centers (*puskesmas*) in 30 districts and cities in six provinces in Indonesia: North Sumatra, Banten, West Java, Central Java, East Java, and South Sulawesi. This program was implemented in three phases—Phase 1: July 2012–March 2016; Phase 2: Jan 2014–Sept 2016; and Phase 3: April 2015–Dec 2016.[32] A phased approach presented an opportunity to assess progress and identify lessons to improve implementation strategies and approaches as the program expanded into additional districts. A new facility-based monitoring system was developed and implemented in 2013 to track key maternal and newborn

evidence-based practices and a formal impact evaluation study was conducted in the last 2 years of the program (2015 and 2016) to assess the two main program objectives related to strengthening the referral system and improving quality of care.[30,31]

The overall objective of the EMAS referral component was to increase the efficiency and effectiveness of referral pathways for emergency complications. The EMAS program employed a district-wide approach to improving the referral system. All facilities (*puskesmas* and hospitals) in a given district were formally networked to all of the surrounding facilities, including private hospitals. Interventions to maximize the effectiveness of the referral network included:

1. *Referral network memoranda of understanding (MOUs)* that strengthened linkages and formalized referral networks between BEmONC (*puskesmas*) and CEmONC (hospital) facilities within a given district. The MOUs also formally integrated private facilities and providers into the district referral system for the first time.
2. *Referral performance standards and tools*, adapted from Ministry of Health guidelines, were introduced along with a comprehensive set of performance monitoring tools and implementation plans. These were augmented with job aids and clinical mentoring sessions. Performance standards were regularly monitored both at the facility level and at the district level to assess facility- and district-level readiness to manage obstetric and newborn emergencies, identify health system weaknesses, and craft action plans to help address the weaknesses.
3. *An automated electronic referral exchange system*, SijariEMAS, enabled *puskesmas* and private midwives to send a two-way message (via phone/call center, SMS, or mobile or web application) to a central server prior to referral that would automatically route that referral to the most appropriate hospital using a pre-specified algorithm per the agreed MOU referral flow. The selected hospital could then choose to accept or reject the referral case depending on their capacity and capabilities at the time. In addition, *puskesmas* staff could receive messages through the system from the referral hospital about how to stabilize and prepare the patient prior to referral.

2.2 | Assessment design

Designing interventions and evaluations that aim to address a multitude of factors that may impact on something as complex as maternal and newborn mortality is challenging.[33] This study aims to assess the outcomes and impact of the EMAS referral interventions utilizing available monitoring and evaluation data to present two separate assessments: (1) A longitudinal analysis to assess the impact of the overall EMAS referral system on improving stabilization practices for emergency complications prior to referral, and identifying facility and geographical characteristics that are associated with improved stabilization practices; and (2) a quasi-experimental analysis to compare improvements in the referral system following the introduction of the electronic automated referral system (SijariEMAS), the primary referral intervention, using evaluation data. These methods are described separately below.

2.2.1 | Routine maternal and newborn health monitoring system—assessment of improvements in stabilization practices for emergency complications prior to referral

Procedures

Under the EMAS program, a facility-based maternal and newborn health (MNH) monitoring system was implemented in early 2013 to routinely compile data on facility-level MNH-related process and impact indicators. Aggregate data were collected monthly from health facilities using a routine data collection form. Data were initially collected from 101 hospitals and 285 *puskesmas* in 30 EMAS project-focus districts. Subsequently, the monitoring system added 35 hospitals in an additional 27 districts, where the EMAS program expanded to provided limited technical support to provincial governments.

Sample

Data from 101 hospitals within the 30 EMAS-focus districts were available. A total of 314 649 births were recorded between 2013 and March 2017. Cases were included in this analysis if a pregnant mother was registered as a "referral" case, defined as being referred from any facility (i.e. hospital, *puskesmas*, midwife). A total of 28 340 maternal referral cases were included from 97 hospitals and 3799 newborn referral cases from 98 hospitals were reported during the observation period—all were included in this analysis.

Instruments and measures

The MNH monitoring system utilized a standardized set of registers in EMAS facilities, four designed for use in hospitals and three designed for use in *puskesmas*. Staff at both hospitals and *puskesmas* routinely entered data into the facility register. The registers were in turn used to complete a summary aggregate form for reporting to the Ministry of Health every month. Data quality and use of these registers was monitored by EMAS program staff, who conducted routine data assessments for completeness and timeliness across all districts and a random quality assurance check each month.

Two indicators from the hospital register that relate to the effectiveness of the referral system were selected for this analysis:

1. *Proportion of mothers* who were referred to hospital owing to severe pre-eclampsia/eclampsia who received magnesium sulphate ($MgSO_4$) to stabilize their condition before referral.
2. *Proportion of newborns* with suspected severe infection who received an antibiotic before referral.

Information about these two indicators was verified through an accompanying referral letter or information from the midwife who accompanied the mother when referred to a hospital.

Statistical analyses

To estimate the rate of change in the two referral indicators between the start date of EMAS monitoring data (T=0) and end date of EMAS monitoring data (T=1), we used random-effects Poisson regression

models where "EMAS exposure period" was the key independent variable and each facility served as its own intercept in the model. As the performance of the facilities was heterogeneous across the six provinces and hospital types by size of hospital beds, delivery volumes, and administration (private and public), the model calculated the difference between T=0 and T=1 by facility, adjusted by hospital facility type (public vs private) and province (West Java, Central Java, East Java, Banten, North Sumatera, and South Sulawesi). Data were analyzed using Stata version 14 (StataCorp LLC, College Station, TX, USA). Results are presented stratified by the three EMAS implementation phases. Significance was set at P<0.05.

One key advantage of this model specification was that the exponentiated beta exp(β) associated with "EMAS exposure period" directly estimated the incidence rate ratio (IRR), which was essentially the rate of change of the indicators ($MgSO_4$ and antibiotic use).

Overall, this analysis included data from 45 months of exposure for Phase 1, 33 months of exposure for Phase 2, and 21 months for Phase 3; however, the first few months of data collection at the start and at the end of each phase were excluded owing to instability of key maternal mortality indicators (e.g. some health facilities reported unusually high case fatality rates).

2.2.2 | EMAS evaluation study—assessment of the referral system following the introduction of an electronic automated referral system (SijariEMAS)

Procedures

An evaluation study of EMAS was conducted in the last 2 years of the EMAS program (Phase 3 of the program), which employed a quasi-experimental pre-post control trial design. This study was conducted in six Phase 3 intervention and six comparison districts selected from the six EMAS-focus provinces. Data were collected at two time periods (2015 and 2016) from a total of 13 hospitals and 24 *puskesmas*, and included 2100 clinical observations of obstetric and newborn patients. The study sites, selection, and data collection processes are described in detail in companion articles.[30,31]

Sample

A total of 1609 clinical observations, excluding low birth weight cases, were conducted. Referral cases were included in this study if they were considered an "eligible" referral case, defined as any referral that was received at a participating EMAS evaluation study hospital from a *puskesmas* within the same district and that could be tracked during a specified 4-week observation period. A total of 180 referral cases were included in this analysis.

Instruments and measures

Data collection focused on observations of care provided for women who presented for delivery at each study hospital. Observations were conducted in the labor and delivery room and the emergency room and began at either the active stage of labor and proceeded until the end of the pregnancy or began at the onset of a prioritized obstetric or newborn emergency complication. Data were collected using a structured clinical observation checklist accompanied by a follow-up referral case tracking tool that collected retrospective information about the referral process. Each instrument contained a unique set of indicators relating to the referral interventions.

Direct clinical observations: Clinical observations of labor and childbirth practices were conducted in hospitals within each district over a 4-week period. Hospital staff was asked to inform clinical observers when a woman arrived with PPH, sepsis, or severe pre-eclampsia/eclampsia to facilitate observation of as many cases as possible. Each clinical observer completed a week-long training in data collection methods. Samsung (Samsung, Seoul, South Korea) tablets were used to collect clinical observation data in real time. Medical record review was not part of the process nor was verbal communication with providers or patients during the delivery process, although providers were consulted for clarification of some items, if necessary, following the birth. Two indicators from these clinical observations that related to the effectiveness of the referral system were selected for this analysis:

1. *Hospital emergency readiness and staff preparedness* at the hospitals in preparation for the arrival of the referral case, including: (1) hospital emergency staff coordination (emergency team coordinated activities, doctor called, lab called, support units mobilized); (2) supplies/equipment arranged on trolley; and (3) emergency staff roles clearly designated.
2. *Appropriate management of complications* at the *puskesmas* prior to referral including: (1) initial treatment of PPH cases at *puskesmas*; and (2) initial stabilization of pre-eclampsia/eclampsia cases at *puskesmas*.

Referral case studies: A subset of direct clinical observation cases that were referred from within the same district as the hospital was selected and retrospectively tracked back to their original referral *puskesmas* within a three- to 4-day period. A referral case tracking tool was then completed at the referring *puskesmas* to capture information at both *puskesmas* (prior to referral) and the hospital (post-referral) about the referral decision, timing, and process. Data sources included a review of medical records, documentation related to the referral (including SijariEMAS data, when applicable), and interviews with facility staff.

Four indicators from the referral case tracking tool that related to the effectiveness and timeliness of the referral system were selected for this analysis:

1. *Communication and advanced notification* between the *puskesmas* and the hospitals prior to referral, including (1) advance notification of the referral case; and (2) the provision of critical heath information about the referral case.
2. *Preparation and transportation* of the referral case between *puskesmas* and hospitals, including: (1) the use of an ambulance for transporting the pregnant woman; (2) accompaniment during transfer by a health worker; (3) whether or not the insurance status had been checked prior to referral; (4) the use of a referral slip; and (4) the occurrence of delays in the referral process.

3. *Provision of a back referral* from the hospitals to the *puskesmas* regarding the outcome of the referral and any further follow-up, including: (1) the use of a back-referral slip; (2) whether information about the patient's diagnosis was transmitted back to the *puskesmas*; and (3) whether information about any follow-up required was also transmitted.
4. *Timeliness and efficiency of the referral* from the *puskesmas* to the hospital, including: (1) time from decision made to refer to time of departure (*puskesmas*); and (2) time between referral and arrival at hospital.

Statistical analyses

The evaluation study was designed as a quasi-experimental pre-post assessment, allowing for a difference-in-difference (DID) analysis, comparing changes between EMAS intervention and comparison facilities at baseline (2015) compared with endline (2016). However, the limited number of referral cases captured over the observation period, particular at endline, precluded a DID analysis (Table 1). In addition, SijariEMAS was not implemented universally across all EMAS interventions sites by the endline period, which would have significantly biased the DID analysis. Instead, a modified analysis was conducted that collapsed data from 13 hospitals and 24 *puskesmas*, combining the two data collection periods (2015 and 2016) to allow for comparison of referral cases that utilized SijariEMAS with referral cases that did not utilize the SijariEMAS system.

The impact of the EMAS program was subsequently assessed by comparing differences in each outcome indicator, comparing referral cases that utilized SijariEMAS with referral cases that did not use SijariEMAS. We used a χ^2 analysis for dichotomous variables; for continuous time variables, we compared the mean differences in response times of referral cases that used SijariEMAS with those that did not use SijariEMAS.

2.3 | Ethics

This project received approval from the Indonesia Ministry of Health, National Institute of Health Research and Development #LB.02.201/5.2/KE/213/2015 and was deemed exempt by the Johns Hopkins Bloomberg School of Public Health institutional review board (IRB No: 00005912).

3 | RESULTS

3.1 | Routine MNH monitoring system—assessment of improvements in stabilization practices for emergency complications prior to referral

A total of 28 340 maternal referral cases were registered over the study period, with an average of 12.35 pre-eclampsia/eclampsia referral cases per phase. Use of $MgSO_4$ for the treatment of pre-eclampsia/eclampsia cases at *puskesmas* prior to referral was lower (24%) at the start of monitoring, than at the end (61%) (Fig. 1). In all EMAS phases, $MgSO_4$ use prior to referral increased significantly over time, from 20% to 55% in Phase 1, 22% to 64% in Phase 2, and 32% to 60% in Phase 3. Improvements in $MgSO_4$ use for the treatment of pre-eclampsia/eclampsia was significantly associated with the EMAS implementation period (IRR 2.4; 95% CI, 2.3–2.6), public hospital (IRR 1.7; 95% CI, 1.3–2.2), and occurring in Central Java (IRR 3.8; 95% CI, 2.6–5.5), Banten (IRR 3.5; 95% CI, 1.8–6.7), and South Sulawesi (IRR 2.5; 95% CI, 1.3–3.6) (Table 1).

TABLE 1 Factors associated with stabilization of maternal and newborn complications prior to referral among EMAS intervention districts.

Variables	Adjusted IRR (95% CI)	*P* value[a]
$MgSO_4$ provision for referred PE/E cases prior to referral (n=28 340)		
EMAS implementation period	**2.4 (2.3–2.6)**	**<0.01**
Type of hospital		
Private hospital	1.0	
Public hospital	**1.7 (1.3–2.2)**	**<0.01**
Province		
West Java	1.0	
Central Java	**3.8 (2.6–5.5)**	**<0.01**
East Java	1.1 (0.7–1.6)	0.64
Banten	**3.5 (1.8–6.7)**	**<0.01**
North Sumatra	1.0 (0.6–1.9)	0.89
South Sulawesi	**2.5 (1.3–3.6)**	**<0.01**
EMAS implementation phase		
Phase 1	1.0	
Phase 2	1.1 (0.8–1.6)	0.65
Phase 3	1.4 (0.9–2.0)	0.09
Newborns with suspected severe infection who received antibiotics prior to referral (n=3799)		
EMAS implementation period	**2.0 (1.6–2.4)**	**<0.01**
Type of hospital		
Private hospital	1.0	
Public hospital	**2.0 (1.2–3.4)**	**<0.01**
Province		
West Java	1.0	
Central Java	1.1 (0.6–2.1)	0.83
East Java	0.84 (0.4–1.6)	0.63
Banten	**3.6 (1.3–10.6)**	**0.02**
North Sumatra	0.63 (0.3–1.5)	0.30
South Sulawesi	1.1 (0.4–3.1)	0.87
EMAS implementation phase		
Phase 1	1.0	
Phase 2	0.8 (0.4–1.4)	0.41
Phase 3	1.0 (0.5–1.9)	0.96

Abbreviations: IRR, incidence rate ratio; CI, confidence interval; $MgSO_4$, magnesium sulphate; PE/E, pre-eclampsia/eclampsia.
[a]The *P* values in bold denote significant results based on a significance level of 0.05.

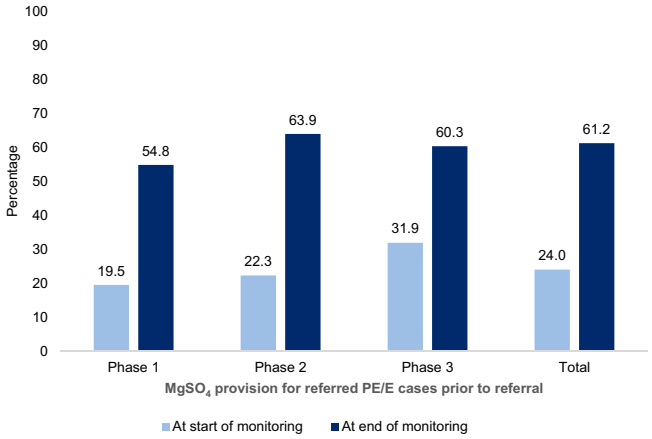

FIGURE 1 Magnesium sulphate ($MgSO_4$) provision for referred pre-eclampsia/eclampsia (PE/E) cases prior to referral. For graphical presentations of the data, we derived predicted incidence rates at *T*=0 (start of monitoring) and *T*=1 (end of monitoring) from the fitted Poisson model estimates.

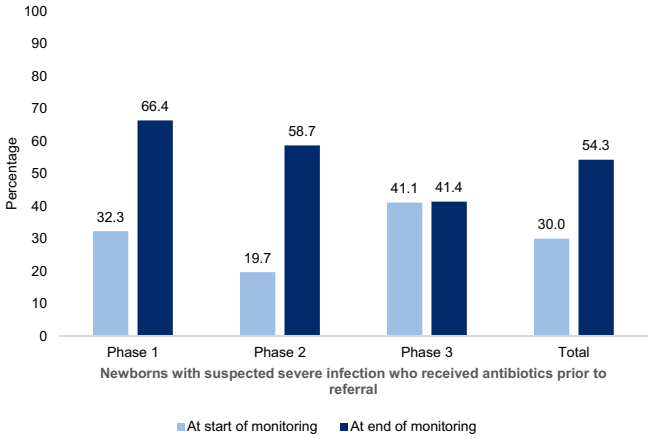

FIGURE 2 Newborns with suspected severe infection who received antibiotics prior to referral. For graphical presentations of the data, we derived predicted incidence rates at *T*=0 (start of monitoring) and *T*=1 (end of monitoring) from the fitted Poisson model estimates.

A total of 3799 newborn referral cases were registered over the study period. Use of antibiotics for treatment of newborns with suspected severe infection prior to referral was quite low at (30%) at the start the EMAS project (Fig. 2). Use almost doubled to 54% (IRR 2.0; 95% CI, 1.6–2.4) during the EMAS intervention period. In EMAS Phase 1, antibiotic use increased significantly from 32% to 66%, and almost three-fold in Phase 2 sites (from 20% to 59%). There was no change in antibiotic use before referral in suspected cases of severe infection in Phase 3 in referring facilities (41% in both). Improvement in antibiotic use for the treatment of suspected severe infection was significantly associated with the EMAS implementation period (IRR 2.0; 95% CI, 1.6–2.4), public hospital (IRR 2.0; 95% CI, 1.2–3.4), and occurring in Banten province (IRR 3.5; 95% CI, 1.3–10.6) (Table 1).

3.2 | EMAS evaluation study

Among all cases of obstetric complications (n=434) whose management was directly observed in hospitals, a total of 180 eligible pregnant women who were referred to hospitals were included in this analysis (Table 2). The total number of clinical observations in both comparison and intervention arms declined between baseline and endline time points, particularly for cases without obstetric or newborn complications. In contrast, the number of obstetric or newborn complications increased or remained stable over the same period in both arms. However, the number of referral cases that were eligible and captured at endline diverged between arms, declining between baseline and endline in the comparison arms, and increasing or holding stable between baseline and endline in the EMAS intervention arm. Interestingly, East Java province reported no referrals at endline in both comparison and EMAS intervention districts. In total, 71 (39.5%) pregnant women were referred through SijariEMAS compared with 109 (60.5%) referrals that did not use SijariEMAS (standard of care) (Table 2).

Of obstetric referral cases, among facilities using SijariEMAS, a significantly higher proportion were severe pre-eclampsia/eclampsia cases (83.1%) compared with those that did not use SijariEMAS (62.4%). Conversely, a significantly lower proportion of cases were PPH (16.9%) at facilities using SijariEMAS compared with those that did not (32.1%). No maternal sepsis and newborn referral cases were referred using SijariEMAS (Table 3). All cases were referred to public hospitals. PONED *puskesmas* had significantly higher proportions of referral cases using SijariEMAS, but there was no significant difference for non-PONED *puskesmas*. No differences were seen by province in the proportion of referral cases both using or not using SijariEMAS, except in East Java where no referral cases were reported in intervention districts. The most common reasons for a *puskesmas* to refer a case included "service required was not appropriate to be delivered at the *puskesmas* (e.g. cesarean delivery)," "no equipment to manage complication," "no staff with the clinical skills/capacity to manage complication," and "not enough staff to manage complication." These were similar across cases that did and did not use SijariEMAS, except for a higher proportion of cases that reported "not enough staff to manage complication" used SijariEMAS (*P*<0.01) and a higher proportion of cases that reported "no staff with the clinical skills or capacity to manage complication" did not use SijariEMAS. Referral outcomes were similar across cases that did and did not use SijariEMAS.

3.2.1 | Referral effectiveness

When pregnant women were referred using SijariEMAS, there were consistently higher levels of effective communication (*P*<0.01) and advanced notification (*P*<0.01) between the *puskesmas* and hospital compared with pregnant women who were referred without using SijariEMAS (Table 4). Pregnant women who were referred using SijariEMAS were also more likely to have been transported to the hospital in ambulance, accompanied by a health worker, had their health

TABLE 2 Characteristics of all clinical observational cases and referral cases by EMAS intervention and data collection round (n=180).

Type of observation	Comparison		EMAS intervention	
By EMAS intervention	**Baseline**	**Endline**	**Baseline**	**Endline**
Total direct clinical observations (n=1609)	**n=379**	**n=314**	**n=552**	**n=364**
Cases without an obstetric or newborn complication	276	158	341	163
Obstetric complication cases[a]	76	94	137	131
Postpartum hemorrhage cases	34	54	45	28
Severe pre-eclampsia/eclampsia cases	42	40	89	102
Maternal sepsis cases	0	0	3	1
Newborn complication cases	19	56	51	59
Newborn sepsis/severe infection cases	0	1	1	2
Newborn resuscitation cases	19	55	50	57
Total referral cases (n=180)	**n=43**	**n=16**	**n=56**	**n=65**
Obstetric referral cases	42	16	54	63
Postpartum hemorrhage cases	16	9	12	10
Severe pre-eclampsia/eclampsia cases	26	7	41	53
Maternal sepsis cases	0	0	1	0
Newborn referral cases	1	0	2	2
Newborn sepsis cases	1	0	1	1
Newborn resuscitation cases	0	0	1	1
Province				
West Java	13	6	9	11
Central Java	8	4	15	25
East Java	7	0	5	0
Banten	10	6	20	23
North Sumatra	1	0	4	4
South Sulawesi	4	0	2	2
SijariEMAS used in referral process	**0**	**0**	**21**	**50**

[a]Some obstetric cases included multiple complications within individuals; in such cases, each complication was counted separately.

insurance checked prior to referral, and had a referral slip. SijariEMAS also provided a mechanism to support information exchange back to the *puskesmas* following treatment at the hospital, with significantly higher levels of information provided about diagnosis sent back to the *puskesmas*. Cases referred using SijariEMAS had consistently higher levels of stabilization for pre-eclampsia/eclampsia prior to referral to the hospital, with limited improvement to the appropriate stabilization of PPH cases, and higher levels of hospital readiness, including proportions of hospital emergency staff coordination, supplies/equipment arranged on a trolley, and emergency staff roles clearly designated and in preparation to receive the referral (Table 4).

3.2.2 | Referral efficiency

The time that *puskesmas* staff took between when the decision was made to refer a pregnant woman to when she actually departed the *puskesmas* was similar among cases that used SijariEMAS compared with those that did not use SijariEMAS (approximately 30 minutes each, P=0.32) (Table 5). However, the elapsed time between the woman leaving the *puskesmas* and arriving at hospital was slightly shorter among cases that used SijariEMAS compared with those that did not (75 minutes vs 60 minutes), although this was not significant (P=0.36).

4 | DISCUSSION

Findings from these two analyses indicate that positive improvements occurred at different points along the referral pathway within EMAS-focused districts over the study period. The longitudinal assessment of the monitoring data, which included over 45 months of data exposure time, clearly shows improvements in the appropriate stabilization of both obstetric and newborn complications at *puskesmas* prior to referral, across all three phases of the EMAS program, with the exception of Phase 3 newborn outcomes. Because the monitoring system was implemented as part of

TABLE 3 Characteristics of referral cases that used SijariEMAS compared with those that did not use SijariEMAS (n=180).

	SijariEMAS not used		SijariEMAS used		
By SijariEMAS use	n=109	%	n=71	%	*P* value[a]
Obstetric referral cases[b]	104	95.4	71	100.0	
Postpartum hemorrhage cases	38	32.1	15	16.9	**0.03**
Severe pre-eclampsia/eclampsia cases	68	62.4	59	83.1	**0.01**
Maternal sepsis cases	1	1.0	0	0.0	–
Newborn referral cases	5	4.6	0	0.0	
Newborn sepsis cases	3	2.8	0	0.0	0.27
Newborn resuscitation cases	2	1.8	0	0.0	0.52
Hospital type					
Public	109	100.0	71	100.0	–
Private	0	0.0	0	0.0	
Type of *puskesmas*					
PONED[c]	51	46.8	58	53.5	**<0.01**
Non-PONED[d]	38	53.2	33	46.4	0.16
Province					
West Java	22	20.2	17	23.9	0.58
Central Java	31	28.4	21	29.6	0.87
East Java	12	11.0	0	0.0	**<0.01**
Banten	31	28.4	28	39.4	0.15
North Sumatra	4	3.7	3	4.2	1.00
South Sulawesi	9	8.3	2	2.8	0.21
Reason for referral					
No equipment to manage complication	25	25.8	22	31.0	0.30
Not enough staff to manage complication	5	4.6	15	21.1	**<0.01**
No staff with clinical skills/capacity to manage complication	24	22.0	6	8.5	**0.02**
Staff did not feel confident in managing complication	9	8.3	7	9.9	0.79
Service required was not appropriate to be delivered at *puskesmas* (e.g. cesarean)	48	44.0	18	25.4	**0.01**
Not enough space to manage complication	0	0.0	3	4.2	0.06
Outcomes of complications					
Complication managed	90	82.6	56	78.9	1.00
Referred to another hospital	1	1.0	1	1.4	0.28
Death	3	2.8	0	0.0	1.00
Patient discharged without approval	3	2.8	2	2.8	0.27
Other	12	11.0	12	16.9	0.06

[a]*P* value for χ^2 tested with significance level 0.05. Bold values are statistically significant.
[b]Some obstetric cases included multiple complications within an individual; in such cases, each complication was counted separately.
[c]PONED (*Pelayanan Obstetri dan Neonatal Esensial Dasar*) *puskesmas* responsible for providing basic emergency obstetric and newborn care (BEmONC).
[d]Non-PONED *puskesmas*, where health workers have not undergone additional training and support for providing BEmONC.

the EMAS program to monitor and track progress, which did not include any control sites, our ability to attribute changes in stabilization practices directly to the EMAS program is limited. While it is possible that improvements in stabilization practices seen in this study may have been due to other possible factors outside of EMAS interventions, such as changes in the health insurance scheme *JKN*, consistency in the effects seen in stabilization practices for both obstetric and newborn complications during all three phases, from

TABLE 4 Referral effectiveness outcomes among referral cases that used SijariEMAS compared with referral cases that did not use SijariEMAS (n=175, obstetric cases only).

Type of observation	SijariEMAS not used		SijariEMAS used		*P* value[a]
Communication and advanced notification	n=104	%	n=71	%	
Puskesmas provided advance notification to the hospital	37	35.6	65	91.6	**<0.01**
Puskesmas provided key health information to the hospital	25	22.9	50	70.4	**<0.01**
Transportation and preparation	n=104	%	n=71	%	
Ambulance	63	60.6	63	88.7	**<0.01**
Accompanied by health worker	73	70.2	64	90.1	**<0.01**
Health insurance status checked	51	49.0	63	88.7	**<0.01**
Referral slip prepared	72	69.2	65	91.6	**<0.01**
No delays in the patient receiving care at the hospital	94	86.2	64	90.1	0.47
Back referral and information exchange	n=104	%	n=71	%	
Use back referral	38	35.9	47	66.2	**<0.01**
Information provided about diagnosis	35	39.8	42	59.2	**0.03**
Information provided about any follow-up	32	36.4	21	29.6	0.27
Hospital readiness	n=104	%	n=71	%	
Emergency coordinated activities implemented	58	55.8	62	87.3	**<0.01**
Supplies on a trolley[b]	25	34.3	33	76.7	**<0.01**
Staff have clear roles and responsibilities	36	34.6	48	67.6	**<0.01**
Stabilization of PPH prior to referral	n=38	%	n=15	%	
Provide oxygen	9	23.7	5	33.3	0.47
Provided intravenous fluids	33	86.8	13	86.7	0.99
Information provided about diagnosis	27	71.1	10	66.7	0.75
Stabilization of PE/E prior to referral	n=68	%	n=59	%	
Received magnesium sulphate	31	45.6	48	81.4	**<0.01**
Received anti-hypertensives	30	44.1	39	66.1	**0.01**
Protein in urine checked	47	69.1	53	89.8	**<0.01**

Abbreviations: PE/E, pre-eclampsia/eclampsia.
[a]*P* value for χ^2 tested with significance level 0.05. Bold values are statistically significant.
[b]Banten province was excluded as there was a misinterpretation of the question relating to trolley supplies.

over 30 000 cases, provides some confidence that the EMAS program contributed to these positive outcomes. Similar results are reported in a more in-depth analysis of the monitoring data, which show improvements in obstetric case fatality rates and very early newborn mortality rates at hospitals following the implementation of the EMAS intervention program.[32]

The quasi-experimental pre-post assessment of the referral system following the introduction of SijariEMAS system, provided evidence for the utility and impact of an electronic automated referral system to improve both the effectiveness and efficiency of the referral system and also the overall referral-related EMAS interventions, including the district-wide referral MOU. SijariEMAS appeared to be beneficial for the effective transfer of pregnant women in need of referral by providing an actionable information system that links *puskesmas* and hospitals. This enabled staff to appropriately stabilize, prepare, and transport pregnant women to a referral hospital and, at the same time, allow the referral hospital to appropriately prepare and coordinate activities prior to the arrival of the pregnant woman.

The evaluation data clearly highlighted an overall decline in the total number of cases observed at hospitals between baseline and endline time points, yet a stable or increased proportion of complications being managed at the hospitals (Table 2). This pattern may be indicative of more efficient management of noncomplicated cases at the *puskesmas* level and better decision making about referring only complicated cases to hospitals to alleviate overcrowding.[22] This in line with national health insurance scheme *JKN* polices, which mandate that all pregnant mothers requiring a referral must first present at a *puskesmas* to receive a referral slip prior to attending a hospital within the same district.[23] The high numbers of referral cases that were observed in the EMAS intervention arm compared with the comparison arm at

TABLE 5 Referral efficiency outcomes comparing referral cases that used SijariEMAS with those that did not use SijariEMAS.

Intervention	SijariEMAS not used, median time (IQR)	SijariEMAS used, median time (IQR)	*P* value[a]
	n=72	n=64	
Time from decision made to refer to time of departure (*puskesmas*)	30 min (15–50)	30 min (25–60)	0.32
	n=68	n=64	
Time between referral (departure from *puskesmas*) and arrival at hospital	75 min (46–120)	60 min (41–80)	0.36

Abbreviation: IQR, interquartile range.
[a]Test of means was calculated and *P* value reported as significance level <0.05.

endline (Table 2), supports the impact of the overall EMAS program on improving the efficiency and effectiveness of the referral system to facilitate timely and effective management of complications experienced by women. These findings also highlight the unique challenges with designing evaluations for complex and large-scale intervention studies in real-world settings, but these challenges do not diminish the findings, as this analysis was focused on the management of complications, and the numbers of complications remained stable or increased over time within the EMAS interventions sites.

There was limited evidence for the impact of SijariEMAS on improving the timeliness of the referral, with significant variations in response times from when the decision was made to refer the pregnant women in need to time of departure from the *puskesmas*, and the time between leaving the *puskesmas* and arriving at the hospital. Reducing delays in pregnant women receiving CEmONC is critical in reducing risks, but ensuring effective stabilization of complications prior to referral is also key.[22] One potential explanation for these findings is that facilities that used SijariEMAS were also more likely to appropriately stabilize pregnant mothers with pre-eclampsia/eclampsia with $MgS0_4$ or provide antibiotics to newborns with suspected severe infection prior to referral compared with cases that did not use SijariEMAS, which may have subsequently increased their response times. These additional processes for preparing a patient for referral may take longer, but could arguably result in better quality of care and appropriate management of emergency complications overall. Response times between the pregnant women departing the *puskesmas* and arriving at the hospital may also be dependent on factors not captured in this evaluation, including variation in distances between *puskesmas* and hospitals.

A systematic review of emergency obstetric referral interventions in low-resource settings identified similar challenges in addressing the delays in referral pathways for obstetric and immediate newborn care.[25] The review highlighted that while transport and communication interventions were becoming more popular and evidence is building for their effectiveness, it is difficult to measure the impact of referral interventions, which often included multiple interventions designed to reduce delays at several stages of the referral process. These factors make it hard to disentangle the contribution of each component of the intervention. A recent study in Bangladesh,[34] also highlighted that important factors in a successful referral included early detection of complications experienced by mothers, quality support by a midwife, and quick transfer to the referral center. Our study findings were consistent with these findings and provide further evidence for the utility of an automated electronic communication system to serve as an assist in the timely referral and management of obstetric and newborn complications along with the overall positive impact of the EMAS-related referral interventions.

4.1 | Limitations

We recognize that our study has a few limitations. We utilized data from the MNH data monitoring system that was set up by the EMAS project to assess the overall effect of the EMAS program, thus limiting the ability to compare data from EMAS-focused districts with nonprogram comparison districts. In addition, the EMAS program began in July 2012, but the monitoring system was not implemented until 2013; therefore, it was difficult to directly assess the overall improvement in MNH care indicators between the baseline and endline periods of the EMAS program. The system did not collect additional data regarding other potential interventions that may have impacted MNH outcomes over the course of the program, thus attributions for any changes in outcomes presented in this analysis cannot be conferred. The ability to triangulate data from 101 hospitals across the three different phases and the consistency of effects on the two indicators we examined during all three phases provides some confidence in the impact assessment of the EMAS program. The limited number of referral cases observed in the comparison districts at endline (n=16) limited our ability to perform a DID analysis, comparing intervention and comparison districts as planned, and prevented any analysis of associates with referral outcomes. However, the modified analysis, which utilized SijariEMAS as a proxy measure for "exposure," did enable additional analysis providing evidence for the impact of SijariEMAS, and potentially demonstrated the broader strengthening of the referral system that the EMAS program provided through introduction of a referral MOU and the referral performance standards. While it is unclear why some EMAS intervention districts did not consistently use the SijariEMAS for all referral cases, a source of potential bias, the limited sample size prohibited a DID analysis that could control for such factors. It was noted that in South Sulawesi and North Sumatra internet reception can be poor, which may have prevented providers from using the SijariEMAS system, and it was noted by project staff that providers preferred to use cell phones to communicate about referrals cases.

The timing of the evaluation study allowed us only to include data from Phase 3 intervention districts in this analysis. This is likely to attenuate the EMAS effectiveness, which shows the EMAS effect for 1 year only, rather for 5-years—the total program period. The small number of overall referral cases tracked within the evaluation study prevented complication-specific referral and case-management analyses.

5 | CONCLUSION

Notwithstanding the limitations, we believe that the findings from this study indicate that the EMAS program contributed to improvements in the overall management of emergency obstetric and newborn complications at different points along the referral pathway. The use of SijariEMAS, in combination with other referral interventions, was associated with enhanced communication, transportation, and preparation of pregnant mothers in need of referral, and also increased the hospital emergency readiness and staff preparedness to effectively manage obstetric and newborn complications. These steps should help to reduce the delays in access to care for pregnant women and newborns with complications and reduce the high levels of maternal mortality across Indonesia—a key aim of the EMAS program.

AUTHOR CONTRIBUTIONS

AP, SQ, MA, MT, SS, AZ, BW, DA, and TW contributed to the design, planning, and/or oversight of the article. SA, AP, MT, ME, and SS contributed to data collection and/or conducted statistical analyses. All authors contributed to manuscript writing or review.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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