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Mobile Obstetrics
Monitoring (MOM)

Pilot study

Mobile Obstetrics Monitoring (MOM)

as a model for community-based
antenatal care delivery in a
low-resource setting

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Philips Mobile Obstetrics Monitoring

(MOM) is a software solution that allows community healthcare workers to perform antenatal risk stratification, receive diagnostic assistance, and assess a patient's progress via a mobile device to enhance maternal care in community settings. With MOM, ObGyns and midwives jointly review and manage each case, facilitating timely referral of the patient to an appropriate healthcare center for further management if needed. All the above analysis and inferences are possible through the review of data made available in MOM.

A pilot study of 656 pregnant women in Padang, Indonesia, assessed the use of MOM to facilitate a public-private partnership of midwives and ObGyns with regard to five aspects: the ability to improve the detection of high-risk pregnancy, appropriate and timely referral of very high-risk pregnancy to an appropriate healthcare center, remote monitoring by ObGyns of high-risk pregnancies facilitated by home visits of midwives, patient engagement in antenatal services, and improved skills and knowledge of midwives.

About Bunda

Bunda Medical Center, Padang, is part of the Bundamedik Healthcare System. Indonesian Reproductive Science Institute is a Bundamedik Healthcare System research affiliate. They are committed to public health and the people of Indonesia. This project was a collaboration between Bundamedik, the city government of Padang, the Ministry of Health, and Philips Healthcare to address increasing concern with maternal mortality in Indonesia.

Background

Addressing high maternal mortality rates

The maternal mortality rate in Indonesia remains among the highest in Southeast Asia, with 190 maternal deaths per 100,000 live births.[1] The World Health Organization estimates that most of these deaths could be avoidable with access to effective antenatal and intrapartum reproductive healthcare services. The Demographic Health Survey of Indonesia 2012 indicates that 82% of the pregnant women in rural and semi-urban areas had at least four antenatal care visits, which indicates that coverage of the services and access to care is fairly well distributed.[2] However, though 98% of the women had an abdominal examination, a blood pressure measurement, and weight assessment, only 53% were informed of pregnancy complications, and less than 50% of the women had a blood or urine examination or had their height measured. Lack of such standard antenatal care services suggests that though Indonesia has made rapid strides in coverage of reproductive healthcare services in urban and rural areas, the country needs to address phase 3 in the Three Delays Model.[3] The Three Delays Model classifies the barriers that women face in achieving the timely and quality healthcare needed to prevent deaths occurring in pregnancy and childbirth. Phase 1 is the delay in the decision to seek care. Phase 2 is the delay in reaching care. Phase 3 is the delay in receiving adequate healthcare. Poor infrastructure, unskilled or unmotivated healthcare workers, and/or a poor referral system each contribute to Phase 3 delays.

Assessing the value of mobile monitoring and a public-private partnership

A 2012 UNICEF report featured several recommendations for the Indonesian Government to improve the quality of care.[4] These recommendations can be generally characterized as the need to increase spending on mother and childcare healthcare infrastructure and focus on quality. Several interventions to reduce the maternal mortality rate have been tested by various

governmental and nongovernmental organizations with varying degrees of success. Two interventions that appear to hold great promise are mobile monitoring and a public-private partnership. These approaches have been shown to improve antenatal care in a cost-effective manner.[5,6] Combining these approaches suggested a hypothesis: can a mobile monitoring solution be offered that leverages a public-private partnership model to address the Phase 3 delay?

Teams from multidisciplinary backgrounds have been effective in hospitals for the past 50 years. Each individual team member brings expertise, knowledge, experience, and perspective to aid patient care and management. Hospital teams have frequently involved patients and their families so that the management can be more patient-centric, and many studies document the effectiveness of this approach.[7] Extension of this concept into the community and into primary care is challenging because of several hurdles in community care that may not be present in a hospital setting. Midwives working in remote geographies frequently find themselves alone in critical decision-making situations. Large patient loads and the difficulties of a poor referral infrastructure, coupled with numerous day-to-day responsibilities, e.g., meticulous recordkeeping, tracking patients, providing health education, and training junior midwives, makes decision-making an arduous task.[8] Various insurance proposals have been implemented to offer underprivileged people access to quality healthcare. The comprehensive justification required for a referral increases the workload of the midwives and a poor decision has consequences for patient health, safety, and healthcare economics.

This study teams ObGyns from the private sector with midwives from government health services to provide antenatal care to the community, not only leveraging the team-based approach to care but also exploring the possibility of improving quality

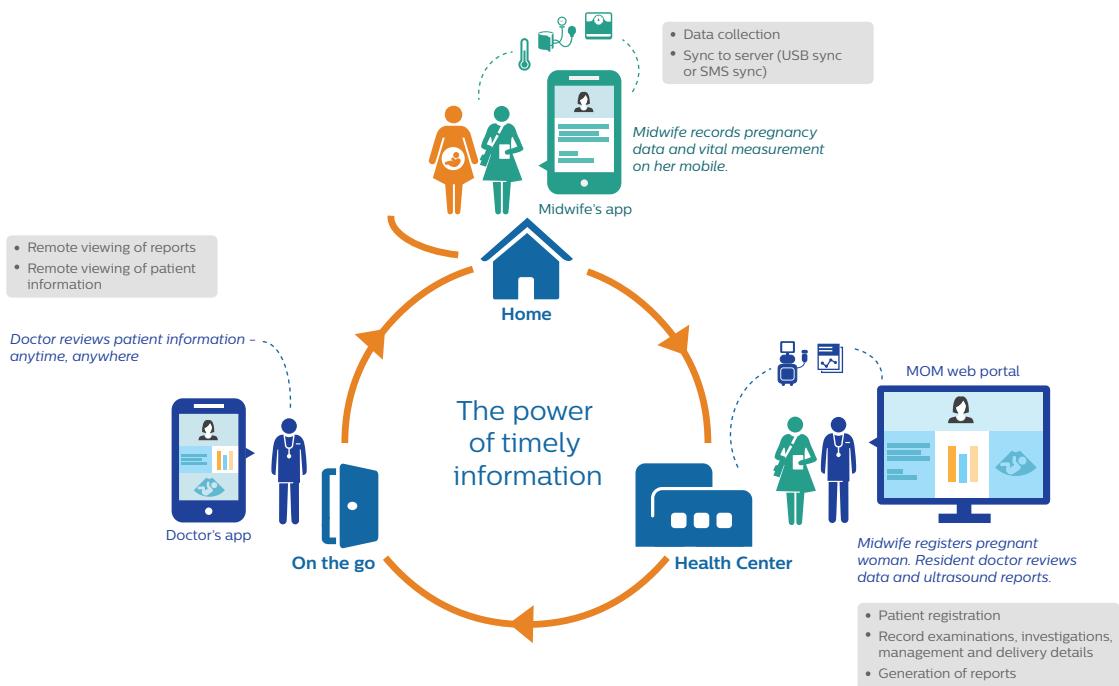
of care through a unique public-private partnership. The ObGyns provide much-needed help in decision-making and also effective and timely referral advice. The team-based approach has certain fundamental requirements, e.g., bonding, clearly defined objectives for each team member, accountability, and adherence to working protocols. These requirements can be facilitated by the MOM application, which can be accessed by both midwives in remote geographies and their respective ObGyns. Midwives access the MOM application via mobile phone; ObGyns access the application with either a laptop or cell phone. MOM allows ObGyns and midwives to review patient files together and decide on an appropriate course for management of each case, not only easing the decision-making process of patient management but also encouraging timely referral to appropriate healthcare centers for further management if needed.

Incorporating ultrasound into antenatal care

The team-based approach allowed for incorporation of antenatal ultrasound examinations into the services offered. The Indonesian healthcare system does

not mandate the use of ultrasound during antenatal care at the primary care level. Only high-risk cases referred to more advanced healthcare centers receive an ultrasound examination. This meant that women with no obvious risk factors or signs (using the Poedji Rochatji score) and with normal blood and urine tests might not receive an ultrasound examination. Placenta previa, twins, intrauterine growth restriction, and problematic placement and presentation of the fetus may be missed because these conditions are best diagnosed through ultrasound. That ultrasound examination is excluded from mandatory antenatal services provided at the primary care level is probably due to the paucity of skilled manpower to do ultrasound examinations. Some provinces have provided ultrasound machines to primary care centers but the skill required to use them is often lacking and many of these systems remain unused. Our study integrated the use of the ultrasound system in primary care, performed by ObGyns. Ultrasound images were integrated with the MOM application.

MOM offers the power of timely information



Methodology

The objective of the study was to see if the team-based approach could be leveraged to effectively address Phase 3 of the Three Delays Model. While several provinces in Indonesia are still addressing the first and second phases of the Three Delays Model, the Padang province was chosen for its high literacy, a mix of ethnic groups, network of puskesmas (government-mandated community health clinics), and positive indices on the first two phases of the Three Delays Model.[2]

The cohort prospective study registered and followed 656 pregnant women from the first trimester until delivery. The team was formed by ObGyns from the Bunda Medical Center, Padang, and six midwives, each from a different Padang puskesmas. The study included ObGyns from the Jamil District Hospital who could evaluate whether the referrals to them were timely and appropriate.

The study period was from December 2013 until December 2014, allowing a thorough evaluation of the team-based approach facilitated by the MOM application.* Each of the 656 women was assigned to a midwife from a puskesmas in the vicinity of their residence. The study was approved by the Bunda Medical Center, Jakarta, and the women were registered into the study after their approval on the informed consent form. Selection of the study participants into the trial was random. After registration, each woman underwent the 1-1-2 pattern of antenatal examination as mandated by the Indonesian government. Each midwife used the MOM application to enter patient history and other clinical parameters as recorded during the antenatal examination, including a risk level based on the scoring system of Poedji Rochatji.[8] Once a trimester, study participants also underwent an ultrasound (USG) examination by the ObGyn, which was conducted at the Bunda Medical Center with transport provided to the study participants.

The ObGyn reviewed the risk level assigned by the midwife and then, if necessary, modified the risk level based on patient history, the examination and USG evaluation. The modified risk level was sent to the cell phone of the midwife by the MOM application to not only aid the midwife in benchmarking her assessment with that of the ObGyn but also to give insight into the application of USG examination in antenatal care. All high-risk cases were referred to a more advanced healthcare center for further management.

Midwives in the study carried backpacks that included a doptone, testing kit for hemoglobin, urinary proteins, and blood glucose, a scale to measure weight, and a tape measure. These home visits were in addition to the routine antenatal visits at the puskesmas and helped to increase the touch points between the pregnant women and the antenatal care delivery system, increasing the ability to screen early for high-risk cases and to refer high-risk cases if necessary.

We evaluated whether the use of MOM was effective with regard to:

1. Improving the efficacy of detection of very high-risk and high-risk pregnancies
2. Appropriate and timely referral of very high-risk pregnancies to more advanced healthcare centers
3. Remote monitoring of high-risk pregnancies by the ObGyn facilitated by home visits of the midwives
4. Patient engagement in attending and utilizing antenatal services
5. Improving skills and knowledge of the midwives

*MOM, Trial Protocol, 20 September 2013

Observations and results

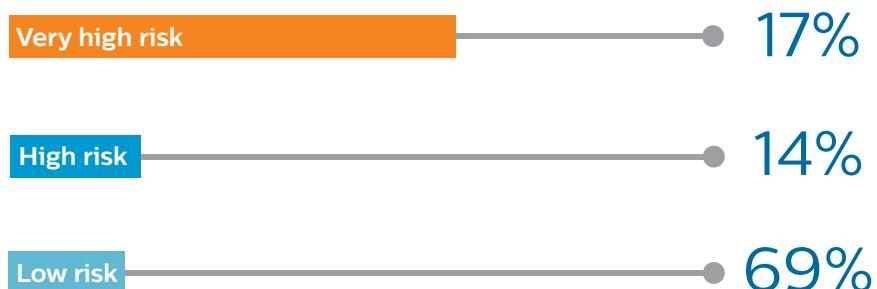
1. Efficacy of detection of very high-risk and high-risk pregnancies

Historically, three main causes of maternal mortality in Indonesia are preeclampsia, hemorrhage, and infection. Our study found the rate of postpartum hemorrhage to be 1.07% (7 patients) compared to an average of 3-10% and the rate of preeclampsia of 1.6% (11 patients), which was lower than the average of 5-15%. [9,10] After the initial risk assessment by midwives followed by ObGyn review, the detection of high-risk and very high-risk pregnancies were 14% and 17% respectively, using the MOM application and antenatal ultrasound (**Figure 1**). This significant increase in detection efficacy was primarily due to

the use of ultrasound, which aided in identifying several cases of multiple pregnancies, placenta previa, congenital malformations, and intrauterine growth restriction that would be difficult to ascertain by physical examination alone and which prompted immediate action to change the plan of pregnancy care (**Table 1**). Apart from the use of ultrasound scans, the ObGyn review of pregnancy profiles using the MOM application detected cases in which the midwife had misclassified the risk level, most likely due to variances in skill levels of the midwives in using the Poedji Rochatji scoring.

Detected risks

Figure 1. Risks detected by midwives and ObGyns using the MOM application and antenatal ultrasound.



Advantages of ultrasound by trimester

Table 1. Advantages offered due to antenatal ultrasound examination in various trimesters.

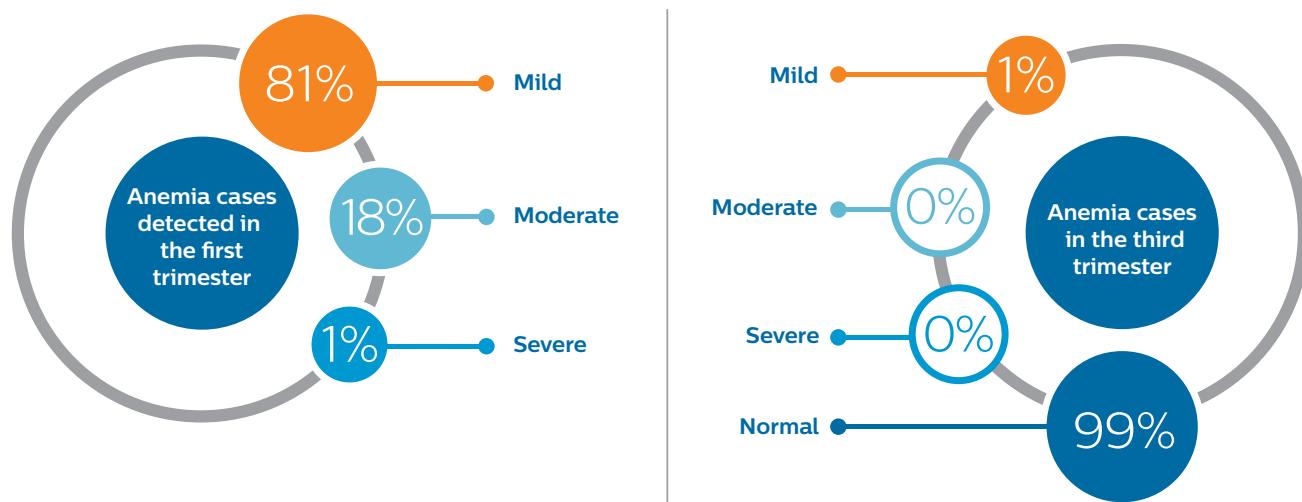
First trimester	Second trimester	Third trimester
<ul style="list-style-type: none">One case of anencephaly detected and advised accordinglySeveral cases of twins diagnosedTwo cases of fetal demiseTwo cases of hydatidiform mole	<ul style="list-style-type: none">Several cases of placenta previaSeveral patients followed up for Doppler ultrasound due to intrauterine growth restriction, eclampsia, or any other parameter affecting fetal wellbeing	<ul style="list-style-type: none">Advised cases of expected post-term deliveries based on placenta grade on ultrasoundSeveral cases in which time of delivery could be advised based on the colon grade

Management of anemia

In the first five months of pregnancy 64% of women were identified as having anemia ($\text{Hb} < 10 \text{ g/dl}$). **Figure 2** shows the percentage of anemia cases detected in the first trimester. The hemoglobin levels of the women were tracked using MOM and the women were treated with iron and/or folic acid tablets or injections, depending on severity of the condition. In the third trimester it was observed that only 1% of the women had anemia. Noncompliant patients were tracked and visited at home by the midwives to administer treatment.

Anemia management

Figure 2. Anemia cases in the first trimester and the same cases in the third trimester illustrate proper management of anemic cases.

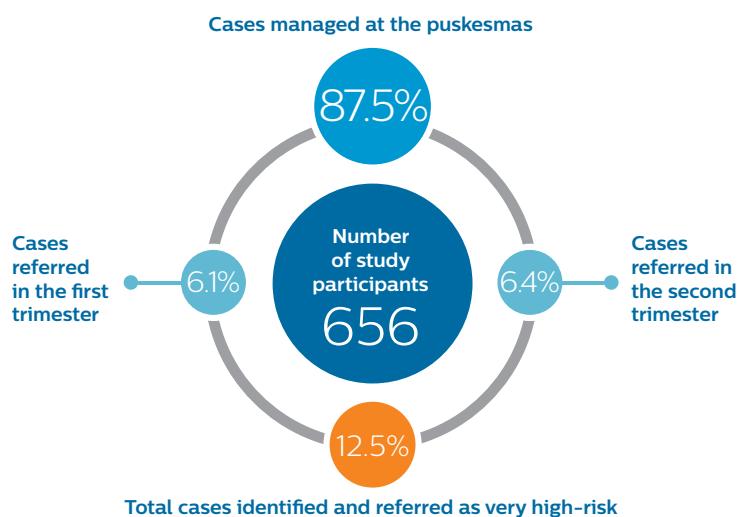


2. Appropriate referrals of very high-risk pregnancies to more advanced healthcare centers

Appropriate referrals have been shown to significantly reduce maternal morbidity.[11] A total of 82 participants screened were identified as very high-risk pregnancies and referred to more advanced healthcare centers. Of the 82 cases (12.5%), 40 (6.1%) were identified in the first trimester and 42 (6.4%) in the second trimester, as shown in **Table 2**.

High-risk referrals

Table 2. Percentage of very high-risk cases referred to more advanced healthcare centers for further management.



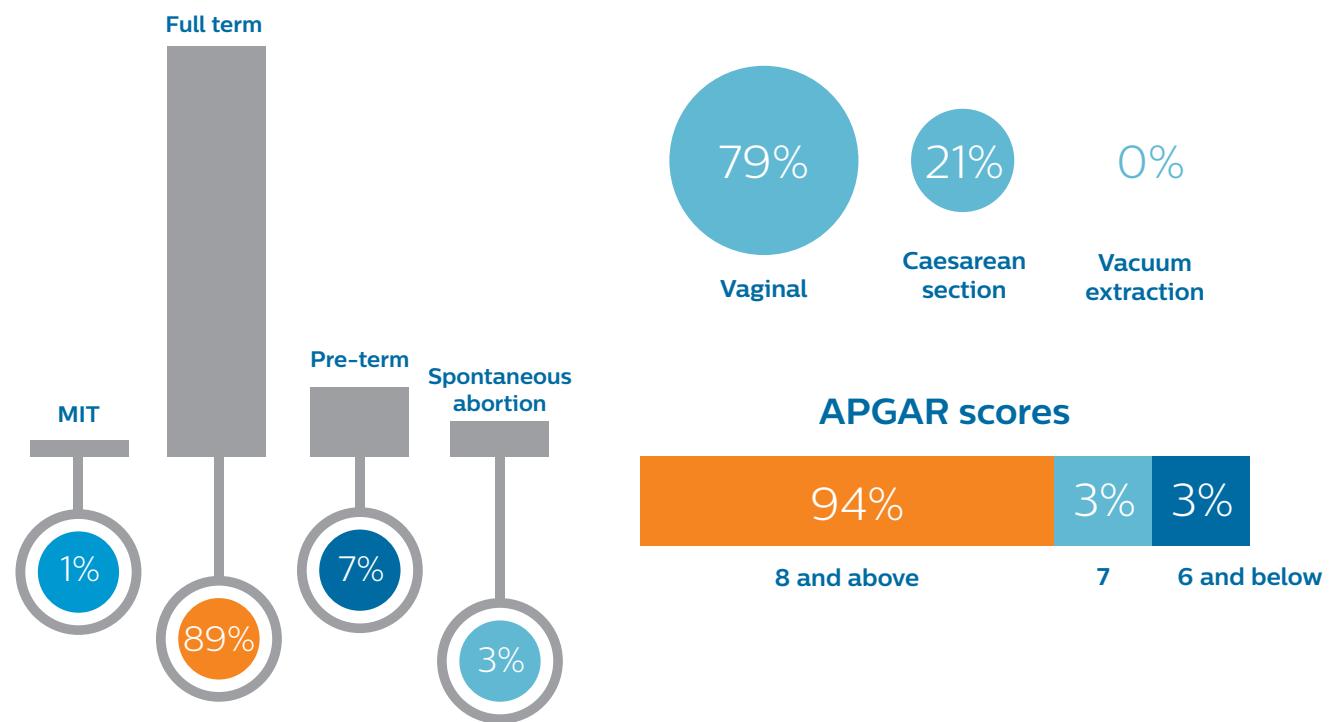
At the earliest sign of fetal distress or worsening of maternal health study participants were referred to a more advanced healthcare center. Doctors at the referral hospitals indicated appreciation that patients were referred in time and that their management resulted in favorable outcomes. Care was also taken to refer the case to the right referral center with specific infrastructure and skills necessary to treat the women.

Figure 3 shows pregnancy outcomes, including rate of Caesarean section and infant APGAR scores. Caesarean section rate was 21%, with the most common indication mal-presentation and obstructed labor. An APGAR score greater than

8 was demonstrated by 94% of the infants, with only 3% having a score less than 6 and needing NICU admission. Low-birth-weight babies (less than 2500 g at birth) accounted for approximately 7% of the births, and a large majority of them were premature. Each premature delivery was performed at an institution, having already been referred to a more advanced center for management. There were four neonatal deaths reported and the causes were due to sepsis, head injury, and one death in the NICU due to birth asphyxia. The deaths due to sepsis and injury occurred at home and indicate there is a potential to extend support to pregnant women in the postnatal period.

Perinatal outcomes

Figure 3. Perinatal outcomes of women registered in the MOM study.



3. Remote monitoring of high-risk pregnancies by ObGyns facilitated by midwives

ObGyn review of case records facilitated by MOM provided a form of ObGyn remote monitoring. Home visits of the midwives to the residences of women classified as high-risk and those who could not travel to the puskesmas provided additional touch points between the pregnant women and the healthcare system. **Table 3** compares several parameters of the current study with data from previous years by puskesmas, illustrating that increased touch points between the pregnant women and health services have resulted in improved monitoring and consequently better screening and referral of very high-risk pregnancies. Approximately 47 of the pregnant women had at least two home visits by the midwives. The home visits were made to recommended patients based on increased frequency of follow-up due to certain risk factors such as pallor, pre-existing hypertension, abnormal glucose tolerance tests, or non-compliance with taking iron and/or folic acid tablets.

MOM benchmarks

Table 3. MOM benchmarked with the previous year 2011–2012 performance on several parameters.

	Puskesmas 1	Puskesmas 2	Puskesmas 3	Puskesmas 4	Puskesmas 5	Puskesmas 6
2011-2012 mother and child data						
Total number of pregnant patients	996/963	406/391	1389/1373	856/811	1219/595	2726/2215
Total number of normal deliveries	729 (73.19%)/ 750 (77.88%)	305 (75.12%)/ 339 (86.7%)	1314 (94.6%)/ 1282 (93.37%)	753 (87.97%)/ 733 (90.38%)	1274 (104.5%)/ 531 (89.24%)	2388 (87.6%)/ 2029 (91.6%)
Number of maternal mortalities	1/0	0/0	2/0	0/0	3/3	2/2
Cause of maternal death	Eclampsia	–	Preeclampsia, late postpartum hemorrhage		Postpartum hemorrhage	Preeclampsia, trauma
Number of very high risk	0/6 (3.8%)	8/7 (2%)	3/0	0/49 (6%)	190/45 (8%)	101/61 (3%)
Cause of maternal morbidity (complication of pregnancy)		Hypertension in pregnancy	Hypertension, asthma	Multiparity, anemia, malnutrition, DM	Hypertension, antepartum hemorrhage	Hypertension in pregnancy
Number of home visits per month	–	10	60	6	–	10
Maternal obstetric monitoring						
Total number of pregnant patients	132	76	92	68	136	152
Total number of normal deliveries	100	67	71	64	96	121
Number of maternal mortalities	0	0	0	0	0	0
Cause of maternal death	NA	NA	NA	NA	NA	NA
Number of very high risk	12 (9%)	18 (23%)	7 (8%)	7 (10%)	21 (15%)	25 (16%)
Cause of maternal morbidity (complication of pregnancy)	PIH, various	PIH, various	Preeclampsia PPH, various	APH, DM, various	DM, anemia, APH, various	PROM, retesio placenta, cord around the neck, PPH, preeclampsia, various
Number of home visits per month	43	28	7	25	37	79

In the year of 2011–2012 in the same demographic population the mortality rate was 114 and 72 per 100,000 deliveries respectively. The 2013–2014 study group experienced no maternal deaths.

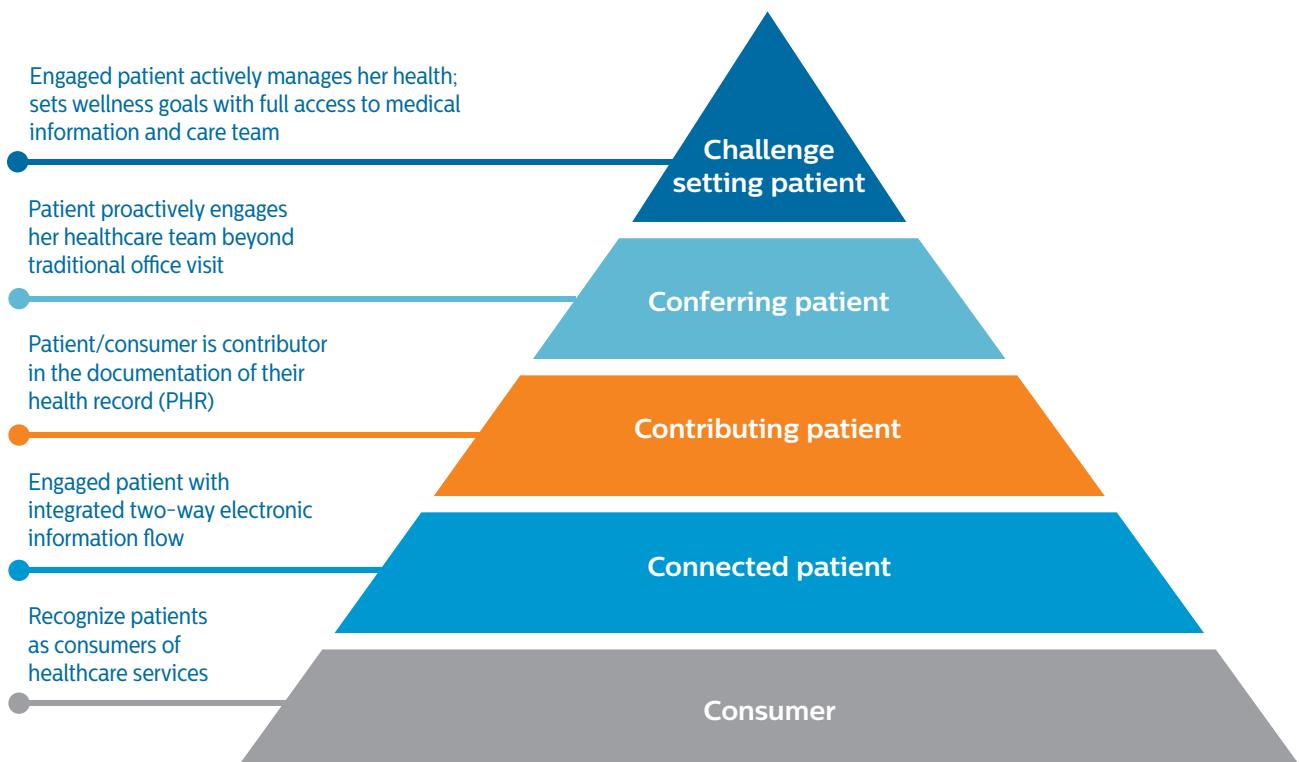
4. Engagement of pregnant women in attending and utilizing antenatal services

There was a demonstrable increase in patient engagement during the MOM study. Participants had an opportunity to meet with their midwives and the ObGyns during the ultrasound examination. This provided an opportunity to answer questions and to tailor antenatal care management to best suit patient requirements. When asked what they considered the most important difference between the team approach compared to their previous experiences,

study participants almost unanimously replied about the feeling of safety of being remotely monitored by the ObGyns and also that they had more time for discussion with the ObGyns. An improvement in engagement has been proven to result in improved outcomes by several studies in the past.[12,13] Study participants moved up the patient engagement pyramid shown in **Figure 4** and demonstrated the results shown in **Figure 5**.

Patient engagement pyramid

Figure 4. The patient engagement pyramid shows increasing levels of commitment.



Results of MOM intervention

Figure 5. Results of the pregnant women engagement survey.



5. Improvement of skills and knowledge of midwives

The midwives in the study considered teaming with ObGyns a positive step that resulted in a more efficient detection of high-risk and very high-risk pregnancies. The midwives also had regular classes on antenatal sonography at the Bunda Medical Center. The classroom sessions were very helpful in clarifying and updating their knowledge, as evaluated by their ability to prioritize care and take action in an emergency. Traditional risk-scoring systems can result in overloading referral centers, with the result that many women who needed referral have been missed in the past. In the current model, the team adopted an approach in which all women are considered to have normal pregnancies until evidence to the contrary.

Discussion

Obstetrics has made several advances in tertiary care but providing a similar standard of care at a primary care level is a challenge. In this study, the team-based model, facilitated by the MOM software solution, allowed the team to:

- Focus on the requirements of the pregnant women and tailor management based on their needs
- Review pregnancy records and take appropriate decisions in a timely manner
- Facilitate appropriate referrals
- Standardize antenatal care across various puskesmas

From the clinical outcomes it is clear that this model demonstrated an improvement in various parameters, reducing the maternal mortality rate. The reduced incidence of hemorrhage was most likely due to improved management of anemia in pregnancy. Study parameters allowed anemia to be detected very early in pregnancy. The reduction in the anemia-related cases was dramatic and we consider it due to a multiplicity of factors such as educational backgrounds, effective health education by midwives, and targeted home visits by midwives to women suspected of non-compliance to treatment.

Incorporating routine ultrasound scans in antenatal care has shown improved detection of various pregnancy-related complications, allowing early referral. The authors have justified the same in a health-economy analysis as how much investment is required to reduce maternal deaths overall.[14]

Patients, midwives, and physicians were able to successfully engage in the overall activities of this study. Response to the post-pilot survey indicated high satisfaction and motivation among healthcare professionals with a feeling of empowered by being able to provide a high standard care found in the tertiary center.

The team-based approach has the potential to offer the entire continuum of care from antenatal care until the postnatal care. While many women and infants have access to care in Padang, there is concern about the over-use of treatments that were originally designed to manage complications, with the consequence that many healthy women and newborns become exposed to the adverse effects of unnecessary interventions used routinely, including limited mobility in labor, episiotomy, and Caesarean section. Thus quality of care extends beyond resources and from "what" needs to be done, to include also "how", "where", and by "whom" it needs to be done. The intention is to promote the natural process of childbirth accompanied by early and efficient management of complications and emergencies, while making the care as patient-centric as is possible. MOM also can be used to review decisions retrospectively on whether interventions such as induction of labor and Caesarean section were needed or could have been avoided. Striking the right balance between the support needed during pregnancy care and childbirth and intervening at the right moment and to the right extent is important in all healthcare settings, but especially so in rural and semi-urban areas and low-resource settings.

The study shows that the delivery of optimum maternal care is possible through the team-based approach by leveraging software solutions such as MOM. There is potential to improve the outcome of maternity care through the collaborative practice of healthcare professionals working along the continuum of care.

Sustainability

Though the study was able to show the potential of improving the standard of care through a collaborative approach, there have been some limitations.

1. The study has been done on a small sample of patients. Since the study was exploring public-private collaboration between the midwives in the public sector and private ObGyns, it was thought prudent to test the outcomes on a limited group of patients rather than covering large populations. Since the outcomes are positive, we are confident that the study and its outcomes are scalable.
2. The study focused only on antenatal care. The focus of the study was to improve the quality of antenatal care. However, a significant contribution to maternal and neonatal mortality and morbidity also occurs during labor, delivery, and in the postnatal period. The success of the collaborative approach is most likely to be repeated in the intrapartum and postnatal period as well, however, this was beyond the scope of the study.
3. The collaborative team-based approach is new and the teams need to evolve over time. One of the evolutionary milestones is that the team members hold each other accountable to the tasks that need to be done and this has to be done without the erosion of trust. Some of the fields were not entered into the MOM software application, especially the “reason for referral.” This has left certain gaps in the data, which could have made the analysis more insightful.

The team-based model is potentially sustainable because insurance provides special provisions for claims where the antenatal visits number greater than four. Claims can be made for maternal complications detected in the antenatal period. The more efficient the team-based approach is in screening, management and referrals, the more sustainable it will be.

Conclusions

The main insights from the study are:

- a. A collaborative approach between ObGyns and midwives to offer antenatal services in the community can be leveraged to improve the quality of care with a focus on making care more patient-centric, helping to bridge the gap of Phase 3 of the Three Delays Model.
- b. The utility of antenatal ultrasound is clear.
That this also serves as an opportunity for valuable contact between the ObGyn, midwife, and the patient is a new insight. Many of the decisions on tailoring the management to patient needs were a result of this contact.
- c. The review of the case records by the ObGyns and midwives using the MOM software solution improved decision-making and increased the skills and knowledge of the midwives.
- d. The study is scalable from its potential to be replicated across geographies and to include intrapartum and postpartum care.
- e. This approach can be used to standardize antenatal care, making primary care accreditation worthy.
- f. The MOM software solution worked satisfactorily throughout the one-year study period, indicating that the ecosystem is mature enough to be successfully deployed into the community.

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