ORIGINAL RESEARCH

Delivery as Trauma: A Prospective Time-Cohort Study of Maternal and Perinatal Mortality in Rural Cambodia

Chandy Houy, MPH;[1] Sam Ol Ha, MPH;[1] Margit Steinholt, MD;[2] Eystein Skjerve, DVM;[3] Hans Husum, MD[4]

1. Trauma Care Foundation Cambodia, Battambang, Cambodia
2. Tromso Mine Victim Resource Centre, University Hospital Northern Norway, Department of Community Medicine, University of Tromso, Tromso, Norway
3. Department of Food Safety and Infection Biology, Norwegian University of Life Sciences, Oslo, Norway
4. Department of Community Medicine, University of Tromso, Tromso, Norway

Correspondence:
Hans Husum, MD, PhD
N-9690 Havoysund, Norway
E-mail: husumhans@gmail.com

Conflicts of interest: All authors confirm that there are no conflicts of interest, copyright constraints, or industry funding to report for any of the authors. The views expressed in this article are those of the authors and do not reflect the policy or position of any institution.

Keywords: Cambodia; maternal mortality; prehospital; traditional birth attendant; trauma system

Abbreviations:
DSL: Delivery Life Support
HC: health center
MMR: maternal mortality ratio
ROC: Receiver Operating Characteristics
TBA: traditional birth attendant
VHV: village health volunteer

Received: February 21, 2016
Revised: June 5, 2016
Accepted: June 25, 2016

Online publication: January 26, 2017

doi:10.1017/S1049023X1600145X

Abstract

Objective: The majority of maternal and perinatal deaths are preventable, but still women and newborns die due to insufficient Basic Life Support in low-resource communities. Drawing on experiences from successful wartime trauma systems, a three-tier chain-of-survival model was introduced as a means to reduce rural maternal and perinatal mortality.

Methods: A study area of 266 villages in landmine-infested Northwestern Cambodia were selected based on remoteness and poverty. The five-year intervention from 2005 through 2009 was carried out as a prospective study. The years of formation in 2005 and 2006 were used as a baseline cohort for comparisons with later annual cohorts. Non-professional and professional birth attendants at village level, rural health centers (HCs), and three hospitals were merged with an operational prehospital trauma system. Staff at all levels were trained in life support and emergency obstetrics.

Findings: The maternal mortality rate was reduced from a baseline level of 0.73% to 0.12% in the year 2009 (95% CI Diff, 0.27-0.98; $P < .01$). The main reduction was observed in deliveries at village level assisted by traditional birth attendants (TBAs). There was a significant reduction in perinatal mortality rate by year from a baseline level at 3.5% to 1.0% in the year 2009 (95% CI Diff, 0.02-0.03; $P < .01$). Adjusting maternal and perinatal mortality rates for risk factors, the changes by time cohort remained a significant explanatory variable in the regression model.

Conclusion: The results correspond to experiences from modern prehospital trauma systems: Basic Life Support reduces maternal and perinatal death if provided early. Trained TBAs are effective if well-integrated in maternal health programs.

Houy C, Ha SO, Steinholt M, Skjerve E, Husum H. Delivery as trauma: a prospective time-cohort study of maternal and perinatal mortality in rural Cambodia. ***Prehosp Disaster Med*****. 2017;32(2):180-186.**

Introduction

Efforts to reach the United Nations' Millennium Development Goal of maternal mortality ratio (MMR) reduction by 75% have failed.[1] Despite an annual global reduction in MMR at 2.3 %, still too many die unnecessarily.[2] In 2013, 2.8 million babies (44 % of all "under-five" deaths) never survived their first month of life, and the proportion of neonatal deaths keeps on rising.[3] These children will not survive unless their mothers do, so maternal and neonatal care should be regarded as an integrated challenge. Deliveries in anemic and malnourished women can be compared to rural trauma. The majority of women who die of pregnancy-related complications, as most victims of war and conflict, die before they ever reach appropriate medical care, uncontrolled hemorrhage being the main risk variable. In settings like these, survival is a matter of immediate forward life support and appropriate damage control at an early stage. With a general lack of health professionals in low-income countries, there is no other way than delegating life-saving skills to the best resource persons at hand.

In 1997, a three-tier prehospital trauma system was set up in the vast minefields of Cambodia and North Iraq. The systems comprised thousands of layperson first helpers providing Basic Life Support; a few hundred health center (HC) paramedics trained in

Advanced Trauma Life Support; and hospital emergency room staff trained in damage-control interventions. The intervention reduced trauma mortality rate from 40% to 10%.[4,5] Later studies of the chain-of-survival model in Iraq confirmed that immediate life support by trained laypersons was the single most important factor for survival in rural trauma with long transit times outside hospital.[6,7] In the 1990s, delegating life-saving skills to non-doctors was controversial; however, today most rescue systems are founded on forward trauma and cardiac life support, emphasizing the role of immediate interventions.[8,9] Despite these evidence-based advances, the role of traditional birth attendants (TBAs) in maternal health care remains controversial.[10-12]

The aim of this study was to examine the effect on maternal and perinatal mortality rates of merging providers of maternal care with an existing Cambodian rural prehospital trauma system.

Material and Methods

The Delivery Life Support (DLS) program was implemented as a five-year prospective interventional study with time-cohort design. The study areas were selected inside the minefields of Northwestern Cambodia in cooperation with the health authorities in the provinces of Battambang and Pailin. The total population in the two provinces is 1.1 million people. Both provinces have urban referral hospitals where medical care is available if the patient can pay for it. However, the vast majority of the rural population have little or no access to basic and necessary treatment due to financial, cultural, or geographical barriers. The study population was defined by purposive sampling based on criteria of remoteness, poverty, and poorly developed medical infrastructure. Consequently, the intervention was carried out in a remote rural population of 200,000 inhabitants in 266 villages.

Intervention

Each village had at least one TBA, and normally one village health volunteer (VHV) previously trained in Basic Trauma Life Support. The HCs were staffed by paramedics with extensive trauma experience and two to four professional midwives. The training program was implemented at 17 HCs and three referral hospitals from December 2004 through December 2005. The teaching focused on resuscitation of blue babies and obstetric emergencies such as hemorrhage, eclampsia, and prolonged labor. A core group of 27 experienced midwives and trauma paramedics were trained as instructors to conduct two-day courses for 337 TBAs and 150 VHVs in the villages. The surgeons at three hospitals were upgraded in emergency operative obstetrics and surgical skills. Throughout the five-year study period, the local TBAs with HC midwives conducted one-day antenatal classes for pregnant women in all 266 villages with emphasis on danger signs before and during delivery. To enhance the cooperation and performance within the chain-of-survival system, the TBAs met four times yearly with their midwife supervisor to audit cases managed in the previous period. Each year, rehearsal class was arranged for the midwives and paramedics to audit critical cases throughout the study period. The curricula and treatment protocols for the formal training are described in Table 1.

Data Management

All deliveries were registered consecutively in case record forms: simple charts for TBAs and more comprehensive ones for HC staff. The program coordinator collected the forms, validated entries, and collected missing information. The main outcome variable for the maternal study was the death of a woman while pregnant after 22 weeks of gestation or within four weeks after delivery. The International Classification of Diseases/ICD criteria define maternal death as all pregnancy-related complications within 42 days postpartum. However, in an area of high internal migration and difficult travel conditions, it was not feasible to track the study subjects for more than four weeks postpartum. The main outcome variable for the babies was perinatal mortality defined as stillbirth or death within one week after birth. Explanatory variables included demographic factors, maternal age, and number of previous deliveries.

The DLS network had a vast outreach and it took two years to achieve adequate interaction between the three tiers of the system and to establish reliable systems for data gathering. For this reason, the cohort of 2005 and 2006 patients was used as baseline for the time controls. Miscarriages and deliveries before gestational week 22 were excluded. The women in the study areas seldom attended more than one antenatal visit, so for most of the patients, there was little or no information recorded before gestational week 22. This left a study population of 10,540 women. The World Health Organization (WHO; Geneva, Switzerland) definition of stillbirths excludes miscarriages before week 28.[13] Consequently, 10,491 babies were included for study.

The intervention was approved by the National Committee for Research Ethics in Cambodia (NECHR Ref. No. 2004/045) and the Regional Committee for Research Ethics in Norway (REK Vest No.199.04).

Statistical Methods

Proportions are reported with confidence intervals and are considered significantly different when the 95% confidence interval for the difference between two proportions (95% CI Diff) does not contain zero.[14] Logistic regression models were used in time cohort analysis to adjust for confounding variables. All assumed predictors of death were included using a backward selection process with inclusion at significance level of five percent. The logistic model was evaluated by Receiver Operating Characteristics (ROC) analysis. A predictor is considered "fair" if the area under the ROC curve is 0.7-0.8 and "good" if larger than 0.8.[15] The data were processed in Excel (Microsoft Corporation; Redmond, Washington USA) and then transferred to Stata (12/SE for Windows; College Station, Texas USA) and JMP (SAS; Cary, North Carolina USA) for statistical analyses.[16]

Results

Maternal Mortality

The mean age of the women included in the study was 27 years, 20% being 20 years or younger. There were 25% first-time mothers; 60% gave birth for the second, third, or fourth time; and 15% had five or more previous deliveries. A steep decline in TBA-assisted deliveries was observed in the 2008 and 2009 cohorts. There were 40 maternal deaths among the 10,540 women included in the study (0.38 %). The proportion of births with a fatal maternal outcome was significantly lower in the three intervention cohorts as compared to the baseline (Table 2). The most profound reduction was observed in TBA-assisted deliveries (Figure 1). Out of the 40 fatalities, 24 died of postpartum hemorrhage, three women died of eclampsia, and three from malaria. Only one woman was recorded as dead before giving birth. Her diagnosis was "bleeding combined with transverse position of the fetus." In nine fatalities, the cause of death was not noted. For 73 deliveries,

https://doi.org/10.1017/S1049023X1600145X Published online by Cambridge University Press

Target Groups	Teachers	Duration of Instruction	Main Focus in Pregnancy	Main Focus at Delivery	Practical Techniques
District Hospital Doctors [n = 15]	Surgeon (HH) and obstetrician from Norway (MS).	Introduction course 3-days. One-day rehearsal yearly.	Diagnose and treat preeclampsia and eclampsia.	Surgical techniques. Diagnose and treat obstructed labor, prolonged labor, and postpartum hemorrhage.	Diazepam and magnesium-sulfate. Vacuum extraction. Animal models: caesarean section, B-Lynch suture. Intrauterine condom tamponade for post-partum hemorrhage.
Midwives + Paramedics [n = 16 + 10]	Midwife and obstetrician (MS) from Norway. Cambodian midwife (HC, project head).	Introduction course 10-days. Two-days rehearsal twice yearly.	Diagnose and treat preeclampsia and eclampsia, malnutrition, and malaria. Birth control.	Diagnose and treat obstructed labor, prolonged labor, and postpartum hemorrhage. Advanced CPR of mother and infant. Skin-to-skin warming and immediate breast feeding of baby.	Diazepam and magnesium-sulfate. Use of partogram, syntocinon, and vacuum extractor. Misoprostol, intrauterine condom tamponade, and aorta compression. Manual removal of placenta. Training delivery techniques on mannequin.
Traditional Birth Attendants + Village Health Volunteers [n = 337 + 150]	Local midwives and paramedics.	Introduction course 3-days. One-day meeting with midwives four times yearly.	Danger signs in pregnancy and during delivery. Nutrition and breastfeeding.	Diagnose eclampsia, obstructed labor, prolonged labor, and postpartum hemorrhage. Basic CPR of mother and infant. Skin-to-skin warming and immediate breast feeding of baby.	Identification of high risk pregnancies for referral to health center or hospital. Condom tamponade and aorta compression. Training with mannequins.
Pregnant Women [n = 2,000/year]	Local traditional birth attendants with midwife.	One-day courses in each village. One or two times per year.	Danger signs in pregnancy and delivery. Nutrition. Planning for delivery, nutrition, breastfeeding.	Premature rupture of membranes. Abnormal position of the baby. Prolonged labor.	Practical organization of referrals. In-field communication.

Table 1. The Delivery Life Support Training Program
Abbreviation: CPR, cardiopulmonary resuscitation.

the category of birth attendant was not known and in this group, six women died. A subset of 75 patients were diagnosed with circulatory shock. Among these there were two fatalities. No trauma-related deaths were recorded. Of all demographic factors and presumed death predictors entered into the regression model, age, parity, and TBA-assisted delivery remained predictors of maternal death (P values < .005). The regression model had a ROC area of 0.83. The time cohorts remained a significant explanatory variable when adjusted for the risk factors.

Perinatal Mortality

The perinatal mortality rate in the study period was 2.1%. The overall death rate did not differ significantly between the subsets of TBA and midwife/doctor-assisted deliveries (Table 3). There was a significant reduction by year of mortality rates in babies suffering early deaths, 50% of fatalities occurring in TBA-assisted deliveries (Figure 2). The prevalence of stillbirths and late neonatal deaths did not change significantly during the study period. In the subset of babies delivered by professional midwives, the mean Apgar Scores improved during the intervention period. Especially the score registered after five minutes showed a significant improvement by year (Figure 3). Birth weight was a significant Apgar Score predictor; however, adjusted for this variable, the time cohort effect on Apgar Score outcomes was still significant. Caesarean section was done in 164 cases. In this subset, one woman and 14 babies died. Of all demographic factors and presumed death predictors included in the regression model, the significant risk factors for perinatal mortality were birth weight, twins, eclampsia, blood loss, which year the delivery took place, and maternal death (P values < .001). Adjusted for these risk factors, the year of delivery and birth weight remained significant explanatory variables. The regression model had a fair fit with an ROC area of 0.73.

https://doi.org/10.1017/S1049023X1600145X Published online by Cambridge University Press

Year	Traditional Birth Attendant	Midwife/Doctor	Category of Attendant Unknown	Total	95% CI Diff
Baseline	14/1,160 1.21% (0.72-2.02)	4/1,932 0.21% (0.08-0.53)	5/66	23/3,158 0.73% (0.49-1.09)	–
2007	7/1,707 0.41% (0.20-0.84)	2/1,536 0.13% (0.04-0.47)	1/4	10/3,247 0.31% (0.17-0.57)	0.07-0.81
2008	3/593 0.51% (0.17-1.48)	1/1,088 0.09% (0.02-0.52)	0/1	4/1,682 0.24% (0.09-0.61)	0.05-0.88
2009	1/614 0.16% (0.03-0.92)	2/1,837 0.11% (0.03-0.40)	0/2	3/2,453 0.12% (0.04-0.36)	0.27-0.98
Total	25/4,074 0.61% (0.42-0.90)	9/6,393 0.14% (0.07-0.27)	6/73	40/10,540 0.38% (0.28-0.52)	

Table 2. Number of Maternal Deaths and Births by Year and Category of Birth Attendant
Note: The proportions are expressed with 95% confidence intervals in brackets. Mortality rates per year are compared to the baseline by 95% confidence intervals for the difference (95% CI Diff).

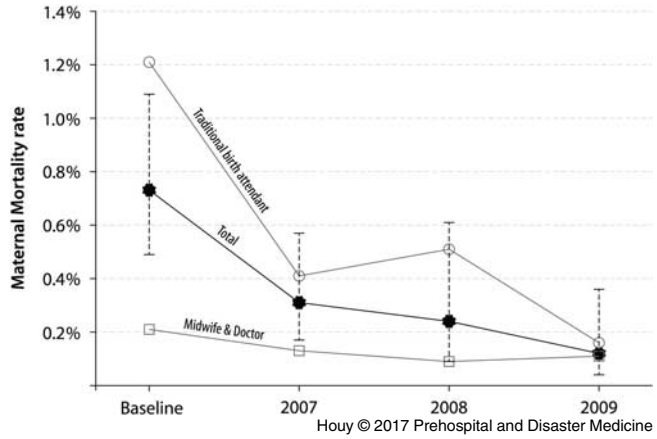

Figure 1. Maternal Mortality Rates by Year and Category of Birth Attendant.
Note: The vertical bars represent 95% confidence intervals of the total mortality estimates.

Discussion

The authors report a new approach to avoidable maternal and perinatal deaths in low-resource communities. Like the understanding of trauma care, also in obstetric critical care, the mother and the baby start dying at the time of delivery, especially so when the patient is fragile with poor pre-event physiological capacity. In the actual study, the most profound decline in mortality was observed in deliveries assisted by trained non-professional attendants. This corresponds to results from trauma system studies in war; immediate Basic Life Support by trained bystanders was the most significant risk variable in a large cohort of war injured in Iraq.[6,7] Also, recent studies in emergency obstetrics document the effect of forward care. In Bangladesh, TBAs were successfully trained to use misoprostol in postpartum hemorrhages.[17,18]

The Cambodian study was implemented under rough conditions; consequently, there are several poorly controlled variables. Firstly, some maternal and perinatal deaths may have passed unrecorded in the study period. Most women left HCs and hospitals with their babies just days after delivery, so late deaths may therefore have escaped registration. In addition, close to 40% of the study population delivered at home in remote villages where there is no formal system for referral and documentation. Among these TBA-assisted deliveries, some fatal outcomes probably went unregistered, especially during the baseline period of 2005-2006 when deep distrust was observed between TBAs and HC staff, villagers fearing condemnation, and abusive behavior from professional health workers.[19] Secondly, like any study with historical controls, the epidemiology of the study population may change during the study period. A marked decrease in TBA-assisted deliveries was observed in 2008 and 2009, which could reflect at least two factors. As an effect of the antenatal classes in the villages, more high-risk cases were probably transferred for delivery at HCs and hospitals (Table 2). Also, political factors should be considered. In 2009, the Cambodian government passed a law to ban home deliveries. This had a clear negative impact in areas where professional health care is unavailable due to geographical and financial reasons. Most likely, dedicated TBAs continued to assist clandestine deliveries in the remote villages, efforts going unreported due to fear of sanctions from the authorities. Despite these methodological challenges, the decline in maternal and perinatal mortality is presumably real. The DLS network was well-embedded at local level, and data were scrutinized during verbal autopsies in the villages by trained midwives during the entire study period.

Due to ethical reasons, the study had to be conducted without controls: "Members of any control group should be provided with an established effective treatment, whether or not such treatment is available in the host country."[20] Designs with historical controls require validation of both the baseline and contextual changes. In 2004, a pre-intervention household survey was conducted in the actual study area documenting a MMR of 20/4,482 (0.45%). This is similar to the 2005-2006 baseline used in the time cohort study (95% CI Diff, 0.06-0.68). The survey identified a perinatal mortality rate of 209/4,180 (5.0%), which is higher than the actual

https://doi.org/10.1017/S1049023X1600145X Published online by Cambridge University Press

Year	Traditional Birth Attendant	Midwife/Doctor	Category of Attendant Unknown	Total	95% CI Diff
Baseline	37/1,160 3.19% (2.32-4.37)	72/1,932 3.73% (2.97-4.67)	2/66	111/3,158 3.51% (2.93-4.22)	–
2007	19/1,707 1.11% (0.71-1.73)	33/1,503 2.20% (1.57-3.07)	1/4	53/3,214 1.57% (1.20-2.06)	1.16-2.72
2008	10/593 1.69% (0.92-3.08)	20/1,068 1.87% (1.22-2.88)	0/5	30/1,666 1.78% (1.25-2.53)	0.75-2.60
2009	9/614 1.47% (0.77-2.76)	15/1,837 0.82% (0.50-1.34)	0/2	24/2,453 0.98% (0.66-1.45)	1.78-3.31
Total	75/4,074 1.94% (1.47-2.30)	140/6,340 2.21% (1.87-2.60)	3/77	217/10,491 2.07% (1.81-2.36)	

Table 3. Number of Perinatal Deaths and Deliveries by Year and Category of Birth Attendant
Note: The proportions are expressed with 95% confidence intervals in brackets. Mortality rates per year are compared to the baseline by 95% confidence intervals for the difference (95% CI Diff).

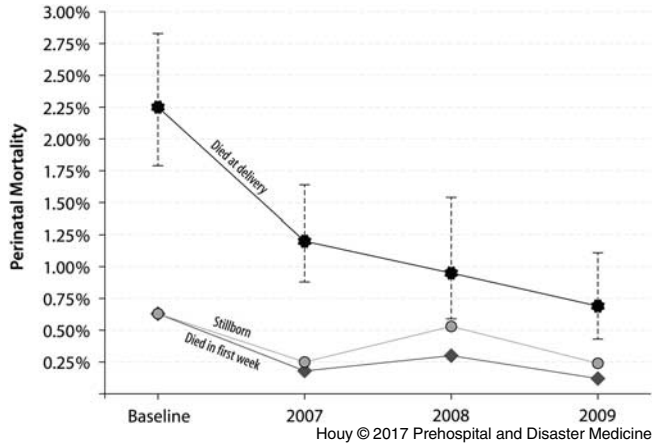

Figure 2. Perinatal Mortality Rates by Year for the Three Fatality Subsets.
Note: The vertical bars represent 95% confidence intervals of the died-at-delivery estimates.

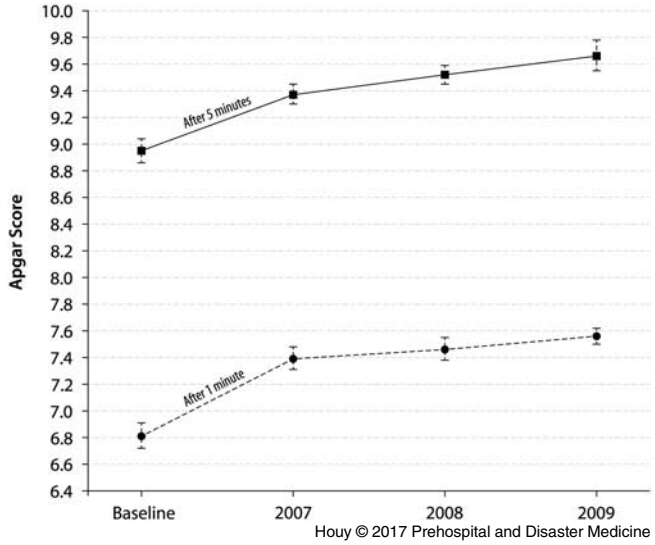

Figure 3. Mean Apgar Scores by Year in the Subset of Deliveries with Skilled Attendants.
Note: The vertical bars express the 95% confidence intervals of the estimates.

time-cohort baseline (95% CI Diff, 0.06-0.24).[19] Hence, the time cohort comparisons under the DLS intervention are acceptable. During the study period, the officially reported MMR in Cambodia declined from 4.7 per 1,000 live births in 2005 to 2.1 per 1,000 live births in 2010.[21,22] However, crude national figures on MMR in Cambodia are based on secondary data gathering in remote areas and also include urban center deliveries. They may not therefore be comparable to the low-resource settings of the DLS program. The 500 rural health workers who participated in the study confirmed that the catchments areas did not achieve much of the reported improvements. Except for mobile phones and motorbikes, contextual changes were few. The cost for medical treatment, one of the main reasons for not using professional maternal health services, remained the same throughout the study period.

The regression models of this study had modest explanatory power. This reflects the complexity of the study context. Especially for perinatal mortality, the ROC value is low, indicating that the model poorly explains variations of mortality patterns due to inadequate explanatory information. Recent studies in the DLS catchments area indicate a prevalence of anemia in pregnant women at 50% in rural remote areas (personal communication; midwives Leang Ladat and Loeur Pyrun) and more than 40% of mothers being underweight (personal communication; Khay Rattana, MD). Poverty has a negative effect on health, but quantitative indicators cannot fully measure the hardship of poverty, landlessness, oppression, and infectious diseases. It is also difficult to estimate the

https://doi.org/10.1017/S1049023X1600145X Published online by Cambridge University Press

adverse effects of traditional medicine, which still stands strong in the study area: mothers being urged to drink rice wine postpartum and newborn being washed in cold water.

Despite methodological challenges, it is apparent that the improvement in indicators to a large extent was the result of the intervention. The marked reduction in maternal and perinatal deaths observed in TBA-assisted deliveries should be emphasized. This is an indication of better individual skills, but probably also an effect of closer networking between the TBAs and the local HC improving timely referrals of risk patients. Many TBAs told the authors they felt relieved just by having their work acknowledged by professional health staff. Being part of the DLS network made the TBAs more confident when advising young women to go to a HC or hospital, especially if they knew the staff working there. The TBAs in this study were all highly respected members of their villages, and most of them had decades of experience as birth attendants. During the intervention period, the number of TBA-assisted deliveries declined substantially. For most of the TBAs, this was a welcomed development as they were all aware of the risks of childbirths. A preliminary survey of the DLS intervention in 2007 documented improved confidence and networking between the village and professional care providers.[23] During the intervention, parts of the study area got access to mobile phone networks. This represented a huge improvement for counseling and emergency referrals. There are no data gathered on this variable in this study; however, a recent controlled trial from Zanzibar shows that mobile phone advising of pregnant women significantly reduced perinatal mortality.[24]

The Cambodian intervention had positive effects beyond reducing death counts. One of the most striking changes observed during the study period was a change in attitudes among professional health staff towards poor women. During the initial study years, several families and village care providers reported to be blamed if a delivery had an adverse outcome. Over time, this attitude changed as hospital and HC staff gained insight and understanding in the patients' harsh lives and the difficult working conditions for the TBAs. Regular antenatal classes conducted by the TBA-midwife teams in the remote villages are not only a tool for more accurate identification of danger signs, but also a method of rooting and improving of the entire chain of emergency care.[25]

Conclusion

Based on the Cambodian experience, alternative approaches to reduce maternal and perinatal mortality in low-resource settings are recommended. There are lessons to learn from years of evidence-based trauma system intervention. Basic obstetric care and life support reduces the risk of maternal and perinatal death if provided timely and appropriately. Traditional birth attendants are life-savers if well-integrated in the chain-of-survival. Moreover, the study illustrates that it is possible to conduct major interventional studies in remote and rough scenarios. This is vital in order to scientifically identify key factors for better survival systems.

Acknowledgements

The authors want to thank the care providers in rural Cambodia who readily participated in the study collecting data under challenging conditions. Professional advice from the Provincial Health Directorates in Battambang and Pailin and the Department of Mother and Child Health in Battambang is acknowledged. Battambang Central Blood Bank and the blood banks in Sompouv Lun and Pailin gave generous support in emergencies. The authors also want to thank Professor of International Health Staffan Bergström, Karolinska Institutet, Stockholm and Professor Ellen Blix, Oslo University College of Applied Sciences, who helped design and initiate the intervention. Professor Anne Eskild, University of Oslo, advised in writing up the findings. The study was sponsored by The Norwegian Research Council (Oslo, Norway) and humanitarian grants from The Norwegian Ministry of Foreign Affairs (Oslo, Norway).

Authors' Contribution

The study was conceived by HH and implemented by CH, MS, and HH. CH and SOH gathered the data and undertook the analysis together with ES and HH. CH, MS, and HH drafted the manuscript. All authors read and approved the final edition.

References

1. The World Health Organization. Maternal Mortality, Fact Sheet No. 348. Updated May 2014. http://www.who.int/mediacentre/factsheets/fs348/en/. Accessed December 19, 2015.
2. Kassebaum NJ, Bertozzi-Villa A, Coggeshall MS, et al. Global, regional, and national levels and causes of maternal mortality during 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;384(9947): 980-1004.
3. United Nations Children's Fund. UNICEF Data: Monitoring the Situation of Children and Women. http://data.unicef.org/child-mortality/neonatal. Accessed January 10, 2016.
4. Husum H, Gilbert M, Wisborg T, Heng YV, Murad M. Rural prehospital trauma systems improve trauma outcome in low-income countries: a prospective study from North Iraq and Cambodia. *J Trauma*. 2003;54(6):1188-1196.
5. Wisborg T, Murad MK, Edvardsen O, Husum H. Prehospital trauma system in a low-income country: system maturation and adaptation during eight years. *J Trauma*. 2008;64:1342-1348.
6. Murad KM, Husum H. Trained lay first responders reduce trauma mortality: a controlled study of rural trauma in Iraq. *Prehosp Disaster Med*. 2010;25 (6):533-539.
7. Murad KM, Larsen S, Husum H. What makes a survivor? Ten-year results from a time-cohort study of prehospital trauma care in Iraq. *Scand J Trauma Resusc Emerg Med*. 2012;20:13.
8. ATLS Subcommittee, American College of Surgeons' Committee on Trauma, International ATLS Working Group. Advanced Trauma Life Support: the ninth edition. *J Trauma Acute Care Surg*. 2013;74:1363-1366.
9. Field JM, Hazinski MF, Sayre MR, et al. American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Part 1: Executive Summary. *Circulation*. 2010;122(18 Suppl 3):S640-S656.
10. Kwast B, Bergström S. "Training professionals for safer motherhood." In: Lawson JB, Harrison KA, Bergström S, (eds.). *Maternity Care in Developing Countries*. London, United Kingdom: RCOG Press; 2003: 46-62.
11. Bergstrom S, Goodburn E. "The role of traditional birth attendants in the reduction of maternal mortality". In: De Brouwere V, Van Lerberghe W, (eds.). *Safe Motherhood Strategies: A Review of the Evidence*. Antwerp, Belgium: ITG Press; 2001: 77-96.
12. Prata N, Passano P, Rowen T, Bell S, Walsh J, Potts M. Where there are (few) skilled birth attendants. *J Health Popul Nutr*. 2011;29:81-91.
13. The World Health Organization. Maternal, newborn, child and adolescent health http://www.who.int/maternal_child_adolescent/epidemiology/stillbirth/en/. Accessed September 19, 2014.
14. Altman DG, Machin D, Bryant TN, Gardner MJ, Gardner S. (eds). *Statistics with Confidence: Confidence Intervals and Statistical Guidelines*. 2nd ed. London, United Kingdom: BMJ Books; 2000.
15. Zweig MH, Campbell G. Receiver-Operating Characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. *Clin Chem*. 1993;39(4):561-577.
16. JMP Version 9. Cary, North Carolina USA: SAS Institute Inc; 2010.
17. Bell S, Passano P, Bohl DD, Islam A, Prata N. Training traditional birth attendants on the use of misoprostol and a blood measurement tool to prevent postpartum hemorrhage: lessons learnt from Bangladesh. *J Health Popul Nutr*. 2014;32(1): 118-129.

18. Prata N, Quaiyum MA, Passano P, et al. Training traditional birth attendants to use misoprostol and an absorbent delivery mat in home births. *Soc Sci Med*. 2012; 75(11):2021-2027.
19. Chandy H, Ol HS, Heng YV, Husum H. Comparing two survey methods for maternal and neonatal mortality in rural Cambodia. *Women Birth*. 2008;21:9-12.
20. National Bioethics Advisory Commission. *Ethical and Policy Issues in International Research: Clinical Trials in Developing Countries*. Maryland USA: NBAC; 2001: iii-vi.
21. Cambodia Demographic and Health Survey 2005. Phnom Penh, Cambodia; 2006.
22. Cambodia Demographic and Health Survey 2010. Phnom Penh, Cambodia; 2011.
23. Chandy H, Steinholt M, Husum H. Delivery Life Support: chain-of-survival for complicated deliveries in rural Cambodia, a preliminary report. *Nurs Hlth Sci*. 2007; 9(4):263-269.
24. Lund S, Rasch V, Hemed M, et al. Mobile phone intervention reduces perinatal mortality in Zanzibar: secondary outcomes of a cluster randomized controlled trial. *JMIR Mhealth Uhealth*. 2014;2(1):e15.
25. Byrne A, Morgan A. How the integration of traditional birth attendants with formal health systems can increase skilled birth attendance. *Int J Gyn Obs*. 2011;115(2): 127-134.