Can people-centered community-oriented interventions improve skilled birth attendance? Evidence from a quasi-experimental study in rural communities of Cambodia, Kenya, and Zambia
KEYWORDS

Skilled Birth Attendance, Community Health Workers, Social Accountability Mechanisms, Community Scorecard
Abstract

Background Skilled attendance at delivery is a key marker for reducing maternal mortality. Effective community engagement strategies complemented by community health worker (CHW) services can improve access to maternal health services in areas with limited health infrastructure or workforce. Methods A quasi-experimental study with matched comparison groups was conducted in Cambodia, Kenya and Zambia to determine the effect of integrated community investments on SBA. In each country, communities in two districts/sub-districts received a package of community-oriented interventions comprised of timed CHW household health promotion for maternal, newborn and child health complemented by social accountability mechanisms using community scorecards. Two comparison districts/sub-districts received ongoing routine interventions. Data from the final evaluation were examined to determine the effect of community-oriented interventions including timed CHW services and SBA. Results Over 90% of the 3,037 women in Cambodia, 2,805 women in Kenya and 1,171 women in Zambia reported SBA. Women in intervention sites who received timely CHW health promotion and social accountability mechanisms in Cambodia and Kenya showed significantly higher odds of SBA (Cambodia, aOR=7.48; 95% CI: 3.87, 14.5, Kenya, aOR=0.60; 95% CI: 0.41, 0.85). The findings also indicated that older women (>24 years), in Cambodia, women with primary or secondary education in Cambodia and Kenya, women from higher wealth quintiles in Cambodia, and women with four or more ANC visits in all countries reported significantly higher odds of SBA. Inclusion of family members in pregnancy-related discussions (aOR=1.69; 95% CI: 0.92, 3.13 in Cambodia; aOR=2.12; 95% CI: 1.06, 4.26 in Kenya; aOR=6.78; 95% CI: 1.15, 13.9 in
Zambia), follow up visits from the CHW following a referral or health facility visit (aOR=2.44; 95% CI: 1.30, 4.60 in Cambodia; aOR=2.17; 95% CI 1.25, 3.75 in Kenya; aOR=1.89; 95% CI: 1.05, 2.02 in Zambia) also showed significantly greater odds of SBA. Conclusions Enhancing people-centered care through culturally appropriate community-oriented strategies integrating timely CHW health promotion and social accountability mechanisms shows some evidence for improving SBA during delivery and accelerating the sustainable development goals for maternal child and newborn health.

Background

Recent evidence from the World Health Organization indicates that globally almost 80% of births are now assisted by skilled personnel during delivery [1]. However, inequities exist as low- and middle-income countries (LMICs) accounted for approximately 99% (302,000) of the global maternal deaths, with sub-Saharan Africa accounting for approximately 66% (201,000) of these deaths [2]. Economic and ethnic disparities were also evident in poorer countries based on the progress reports for the Millennium Development Goals [3]. Maternal mortality reduction remains a priority under the Sustainable Development Goal 3.1 with a target of less than 70 deaths per 100,000 live births by 2030 [2].

The majority of maternal deaths are preventable even in LMICs, as 75% of all maternal deaths are caused by postpartum hemorrhage, hypertensive disorders of pregnancy (pre-eclampsia/eclampsia), infections, unsafe abortions and other delivery-related complications [4, 5]. High maternal mortality rates in LMICs have been associated with poor access to quality healthcare services during the
antenatal, delivery and postnatal periods [6]. Accessible and quality antenatal care (ANC) and SBA during delivery have been shown to improve survival and health outcomes of women in sub-Saharan Africa and Southeast Asia [7]. The presence of SBA at delivery has been shown to be a critical factor for reducing maternal mortality as about 16-33% of maternal deaths could be averted with SBA [4, 8-10].

In a recent systematic review of studies in LMICs, health facility deliveries were found to have resulted in a 29% reduction in the risk of neonatal mortality; however, these results were found only within a conducive environment with skilled staff and emergency obstetrical facilities [11]. Several studies have shown that health facility deliveries may not be realistic for women living in rural and remote areas of LMICs due to poor physical access, long distances to facilities, and poor quality of services [11]. Furthermore, large proportions of unskilled deliveries still occur within health facilities [12]. Hence, facility deliveries within the contexts of LMICs may not always be attended by an SBA and are therefore unlikely to lead to the desired maternal outcomes expected from skilled assistance at birth.

Several individual and contextual factors influence SBA during delivery. These include maternal age, parity, socio-economic status, education, cultural beliefs, access to quality and affordable care, and overall trust in the local healthcare system [13-16]. There is strong evidence that health promotion provided by CHWs in the household, behavior change communication campaigns, early recognition of obstetrical complications, and prompt referral can reduce delays in care-seeking and promote SBA during delivery [17]. Strengthening community engagement through social accountability mechanisms using community scorecards has also
shown to improve health service utilization in some contexts [18-21].

CHWs perform a wide range of health promotion activities during home visits, which include treatment support, home-based care, promotion and facilitation of ANC attendance, use of culturally-acceptable educational strategies, engagement of family members in pregnancy-related care, and planning for a facility delivery [22]. However, few studies have explored the effect of various components of CHW service delivery on maternal care-seeking practices.

World Vision, a Christian relief and development organization, has made substantial investment globally in community-based healthcare for economically disadvantaged communities. These programs are implemented through comprehensive Area Development Programs (ADPs) to provide a wide range of services, including safe water and sanitation, health and nutrition education, child protection, food security and livelihood improvements. This study examines the associations between World Vision’s integrated community-based interventions, including frequency and type of CHW services and community oriented social accountability mechanisms and the likelihood of delivery in the presence of a skilled birth attendant.

Methods

The multi-country research study was conducted in Cambodia, Kenya, Guatemala and Zambia by the Johns Hopkins University, the National Institute of Public Health in Cambodia, the Institute of Nutrition of Central America and Panama in Guatemala, Moi University School of Public Health in Kenya, and the Institute of Economic and Social Research at the University of Zambia. This analysis does not include results
from the Guatemala study sites.

Study Design

The research was designed as a two-arm quasi experimental study in 12 World Vision ADPs between September 2013 and September 2017. In each country, four ADPs representing districts, sub-districts, counties or municipalities with a population ranging from 19,000 to 25,000 were selected based on disease burden, accessibility, and other population characteristics. Two sites in each country were assigned to the intervention arm and two matched sites to the comparison arm (Table 1).

**INSERT TABLE 1: Table 1: Selected Study Sites in Each Country**

All selected study sites received regular programming from World Vision in the areas of water and sanitation, child protection, livelihood and economic development, and education. The research intervention was designed for a period of 24-36 months to enhance maternal, newborn, and child health. In the intervention sites, two strategies were launched; 1. Existing CHWs (and those newly recruited under the Ministry in Cambodia) received a multi-phase training to provide targeted household health promotion and behavior change counseling at strategic stages during the pregnancy, the post-partum period, and early childhood. 2. Social accountability mechanisms using Community Voice and Action and Community Scorecards were established to foster community governance and accountability and support health facility operations. Additional details on the mechanisms for
social accountability for World Vision’s Community Voice and Action and Community Scorecards can be found elsewhere [23]. In both the intervention and comparison sites, World Vision facilitated the formation of facility management committees and community councils or strengthened existing councils to support CHWs and improve the delivery and utilization of facility-based services, using the Global Fund’s Community Systems Strengthening Framework [24]. The comparison sites continued to receive health services from the local district, and other development organizations including routine government supported CHW services.

We performed a multi-stage sampling strategy to select communities as sampling units in proportion to their population size. Households meeting the eligibility criteria were randomly selected for the interviews from each sampling unit. One eligible woman aged 15-49 years who was pregnant or had delivered in the previous two years and one child younger than 5 years of age were selected randomly from each eligible household. Sample size estimates were based on expected increase in skilled birth attendance. A two-sided alpha of 0.05 and power of 0.80 was used to determine the required sample size, with adjustments for non-response rate (5%) and a design effect of 1.2.

Interviewers with household survey experience received training on survey field procedures, ethics and informed consent. Appropriate quality control measures were employed for translation and field testing of instruments, data collection, and participant confidentiality. Structured household surveys, modified from the Demographic Health Surveys, were administered to all heads of households to obtain socio-demographic, food security, water and sanitation and wealth asset
information. A separate survey, also modified from the Demographic Health Surveys and focused on reproductive history, care-seeking behaviors, and utilization of health services for maternal, child and newborn health was administered to the eligible women. Johns Hopkins University and local Institutional Review Board approved informed written consent was obtained from all study participants in Kenya and Zambia, and verbal consent in Cambodia.

Facility-based ANC was defined as pregnancy-related care at a government or private hospital or clinic. A composite ANC Services Index (based on the WHO recommendations) was computed with a score of 0-12, with equal weight for the individual ANC services the woman received [25]. The ANC Services Index included: two doses of tetanus toxoid vaccine, iron or folate pills, antimalarial medications (in accordance with country policies), pregnancy-related nutrition counseling, counseling about the importance of danger signs in pregnancy, information on where to access care for antenatal or obstetrical complications, HIV testing, counseling on prevention of mother-to-child transmission of HIV, weight and blood pressure measurements, and testing of urine and blood.

To assess the degree and quality of pregnancy-related care provided by CHWs, we determined the number of CHW visits a woman received from the time of conception to delivery for her most recent pregnancy and other CHW service delivery quality indicators (CHW being courteous and respectful, woman’s satisfaction with CHW care, use of counseling aids or illustrated storybooks, pregnancy-related CHW counseling at home, inclusion of influential family members in pregnancy-related
discussions, provision of information on pregnancy complications, discussion of solutions for any pregnancy-related problems, assistance with access to ANC, and follow up visits if the woman was referred to or visited a health center during her pregnancy). SBA was defined as deliveries that occurred in the presence of a doctor, clinical officer, nurse or trained midwife.

Ethical clearance was obtained from the institutional review boards at Johns Hopkins Bloomberg School of Public Health, National Institute of Public Health in Cambodia, Moi University School of Public Health in Kenya, Institute of Nutrition of Central America and Panama in Guatemala, and the Institute for Economic and Social Research at the University of Zambia.

Standard quality control procedures were employed to clean, verify and analyze data using STATA 14 [26]. A principle components analysis using 12 household assets (television, radio, bicycle, etc.) and household type (type of roof, drinking water source, type of sanitation, etc.) were used to construct wealth quintiles. A descriptive analysis was performed by computing frequencies across the Intervention and Comparison sites, and t tests and chi-squared tests were performed to determine differences between intervention and comparison sites. Univariate logistic regressions were constructed to determine factors associated with SBA for maternal deliveries. The presence of collinearity among the independent variables used in the regression models was tested. Analyses were conducted separately for each country as contextual factors would inherently vary among the countries. Final models providing estimates of odds ratios for SBA were
adjusted for: mother’s age, education, parity, wealth quintile, treatment arm, receiving 4 or more facility-based ANC visits, and ANC index score. Results from the final evaluation are presented in this study due to minor variations in the baseline instruments.

Results

Sociodemographic Characteristics

Table 2 provides selected sociodemographic characteristics of women who were included in the study; 3,037 in Cambodia, 2,805 in Kenya and 1,171 women in Zambia. More than 85% of households were headed by a male across all sites in both Cambodia and Kenya. In Zambia, less than 50% of households were headed by males in the intervention sites, compared to 70% in the comparison sites. In all three countries, most of the women were 20-36 years of age. More than 80% of the women were married in Cambodia and Kenya, while 70 to 75% of the women were married in Zambia.

**INSERT Table 2: Sociodemographic characteristics of study population by country**

In all three countries, more than 75% of the women had completed primary education, although women in Kenya had a higher proportion that had completed primary education overall compared to the other two countries. More than 60% of the women including in the study were multiparous. While the miscarriage or stillbirth rates were less than 7% among women in Kenya and Zambia, more than 20% of women reported a miscarriage or stillbirth in Cambodia. Approximately one-fourth
of the women had access to health insurance in Cambodia, but this was not reported for Kenya or Zambia. Significant differences were apparent between comparison and intervention sites for male headed households (Kenya and Zambia), mean family size (Cambodia and Kenya), marital status (Kenya), education (Cambodia, Kenya and Zambia), health insurance (Cambodia) and wealth quintile (Cambodia, Kenya and Zambia).

_Antenatal and Delivery Care_

Characteristics of ANC and delivery care are shown in Table 3. The WHO standard of receiving at least 4 or more facility-based ANC visits was significantly higher in the intervention sites for Cambodia (81.2% vs 58%, p<0.001) and Kenya (70.5% vs 62.7%, p<0.001) but was significantly higher in the comparison sites in Zambia (59.6% vs 73.2%, p<0.001). In Cambodia, the mean month of women’s first ANC visit was the first trimester, whereas women in Kenya and Zambia tended to access ANC during the second trimester.

A composite ANC services index score (maximum score=12) was computed based on the quality of ANC services women received. The average score in all sites in all countries was above 9, except in the comparison site in Cambodia, where the average ANC index score was 7.8. In each country, women had significantly higher ANC services index scores in the intervention compared to the comparison sites. Table 3 shows the various individual ANC services received by women in each country, with significant differences between intervention and comparison sites for some services.
SBA during delivery was significantly higher in the intervention sites in Cambodia (99.1% vs 84.8, p<0.001). While over 90% of women reported SBA during delivery in Kenya and Zambia, there were no significant differences between the intervention and comparison sites. In Cambodia, most women received SBA from a trained midwife, while in Kenya and Zambia, most women received SBA from a nurse. Among the women who did not receive SBA, the majority had a traditional birth assistant for delivery in Cambodia while in Kenya and Zambia, most of those who did not receive SBA obtain care from a relative, friend or neighbor.

**INSERT Table 3: Characteristics of Antenatal Care and Skilled Birth Attendance of Study Population by Country**

*Community health worker services*

In all three countries, a significantly greater proportion of women in the intervention sites compared to comparison sites received at least one visit from a CHW during their last pregnancy (Table 4). The total number of CHW visits varied between countries. In Zambia, majority of the women did not receive any visit from a CHW (76% in intervention sites and 89.9% in comparison sites, p<0.001), while in Cambodia, 70% of the women in intervention sites reported at least 1-2 CHW visits, and 65.5% reported no CHW visits in the comparison sites. In all three countries regardless of treatment site, less than one-fourth of women received 3-4 CHW visits, and less than 5% of women received more than 4 CHW visits during their last pregnancy, except for the intervention sites in Kenya (10.5%). Across all countries, about one third of the CHW visits occurred during the 1st trimester.
Over 95% of women in all sites reported that the CHW was courteous and respectful and were satisfied with the CHW services. There were no significant differences between intervention and comparison sites, except in Kenya in terms of CHW service satisfaction, where women from intervention sites reported slightly higher levels of satisfaction (97.9% vs 93.6%). A majority of the women reported that CHWs provided counseling during home visits, with significant differences between intervention and comparison sites for Cambodia (94.9% vs 69.8%, p<0.001) and Zambia (99.3% vs. 88.7%, p<0.02). For Kenya, more than 90% of women reported CHW counseling during home visits in both intervention and comparison sites. CHWs in intervention sites were significantly more likely to use counseling aids and storybooks during their visits, discuss pregnancy complications and danger signs with the woman, provide solutions to concerns, and include influential family members in the discussions compared to comparison sites in all three countries. For Cambodia and Kenya, over 90% of women reported that CHWs facilitated their access to ANC, but this percentage was less in Zambia (53.3% in intervention sites and 84.6% in comparison sites). Approximately 90% of the women in Kenya reported that CHWs made a follow-up visit after they were referred to or visited a health center, whereas in Cambodia and Zambia, approximately 75% of women in the intervention sites and 50% in the comparison sites reported follow up visits from a CHW after referral to or visit to the health facility (p<0.05).
Regression Analysis

Table 5 shows results from the univariate and multivariate logistic regression analysis. Women with some education had greater odds of receiving SBA compared to women with no education in all three countries, but these findings were significant only for Cambodia and Kenya. Multiparous women compared to primiparous women and those in the wealth quintile equal to or above the 40\textsuperscript{th} percentile compared to women whose wealth was less than the 40\textsuperscript{th} percentile, who were otherwise similar on controlled factors, were more likely to receive SBA. Again, these findings were significant only for Cambodia and Kenya. Older women had significantly greater odds (aOR=1.65; 95\% CI: 1.14, 2.39, \(p<0.01\)) of receiving SBA in Cambodia. There was no significant association between age and SBA in Kenya and Zambia. Women in the intervention sites in Cambodia had 7.5 times greater odds (aOR=7.48; 95\% CI: 3.87, 14.5) of receiving SBA compared to women in the control sites. Though there was a significant difference for women in Kenya, it was not as pronounced (aOR=0.60; 95\% CI: 0.41, 0.85). There was no significant association between the intervention and comparison sites for SBA in Zambia.

\textbf{INSERT Table 5: Multivariate Logistic Regression of Factors Associated with Skilled Birth Attendance by Country}

The odds of SBA were significantly higher for women who received four or more facility-based ANC visits for all three countries controlling for other factors. For
Cambodia and Kenya, for every additional ANC service received (i.e., a one-point increase in the ANC Index Score), women were 1.13 times (95% CI: 1.08, 1.19) more likely to receive SBA in Cambodia and 1.19 times (95% CI: 1.13, 1.24) more likely to receive SBA in Kenya. The results from Zambia showed no significant association when controlled for other factors.

Though there was a significant positive dose-effect between the number of CHW visits and delivery with SBA in the univariate analysis for Cambodia and Kenya, this significance was no longer evident in the multivariate analysis. For women in Kenya and Zambia, women had a greater odds of being delivered by a SBA if the CHW included influential family members in discussions after controlling for other factors (Kenya aOR=2.12; 95% CI: 1.06, 4.26; Zambia, aOR=6.78; 95% CI: 1.15, 13.9) and if the CHW conducted a follow up visit after a referral to a health care center (Cambodia, aOR=2.44; 95% CI: 1.30, 4.60; Kenya, aOR=2.17; 95% CI 1.25, 3.75; Zambia, aOR=1.89; 95% CI: 1.05, 2.02). Other components of CHW pregnancy-related services were not significantly associated with presence of SBA at delivery in the multivariate analyses carried out in the three countries.

Discussion

It is postulated that more than 80% of maternal deaths can be prevented with supervision by a skilled professional at delivery [9, 27]. The findings from this study provide some evidence of the effectiveness of integrated community interventions with the deployment of trained CHWs to conduct timed and targeted household visits and the institution of social accountability mechanisms using community voice and action, community scorecards in the intervention sites and community councils
to promote appropriate care-seeking in all study sites. Reported SBA was significantly higher for the intervention sites only for Cambodia (99.1% Intervention vs 84.9% Comparison, p<0.001), though over 90% reported SBA during delivery in both intervention and comparison sites for Kenya and Zambia. The type of SBA varied by country, as in Cambodia where most women reported receiving SBA from a trained midwife while in Kenya and Zambia, SBA was mostly by nurses indicating the different cadres providing these services. Women who did not seek skilled attendance sought care from traditional birth attendants in Cambodia while in Kenya and Zambia, women who did not seek SBA received assistance from relatives, friends or neighbors. These findings necessitate the need for additional health promotion interventions to be targeted to women and their families to access SBA for delivery.

The key predictors of SBA, which varied across countries, were woman’s educational status, women aged 24 or more years, multiparity, higher wealth quintiles, four or more ANC visits, and number of ANC services, similar to findings reported in other studies [13-16]. CHW-related factors that showed a significant effect on likelihood of SBA, were the inclusion of other family members in the decision making by CHWs and CHW follow up visits after referral or visit by the mother to the health facility. Though the frequency of home visits by CHWs was significant in the univariate model, it was no longer significant when controlled for other factors. Women in the intervention sites in Cambodia had 7.5 greater odds of being delivered by an SBA, than those in the comparison sites (95% CI:0.41,0.85). A study in Kenya on intent of SBA at ANC also showed similar predictors, as 94.8% of the women were likely to seek SBA. In that study, cost, educational level, number of ANC visits, and provider gender were significantly associated with women’s intent to deliver with an
As education was a significant predictor in all contexts, it is imperative to provide appropriate household-level health promotion interventions through CHWs to vulnerable populations to encourage SBA during delivery and facility deliveries. The number and type of ANC visits were also key predictor of SBA. Women with 4 or more ANC visits had significantly higher odds of delivery with SBA, and ANC service index was significantly associated with the interventions in both Cambodia and Kenya. ANC also ensures the maternal care continuum as women who obtain ANC are more likely to access facility services for delivery and post-natal care [28]. Though several studies have shown strong associations between ANC visits and SBA, the type of ANC services received was not considered in these studies [29-31]. The differences in SBA during delivery also showed economic inequities, as women from lower wealth quintiles reported lower presence of SBA during delivery. One multi-country analysis indicated that absolute household income was a better predictor of SBA wealth indices [32]. Though the information on household income was collected, it was not considered in the model. Rather, we included only income quintile. A selected review of studies showed that differences in the extreme wealth deciles (as opposed to quintiles) were much larger than between the quintiles [33], highlighting the need to target additional support and CHW visits to these economically vulnerable households.

Despite the expansion of primary health care systems, CHW activities and service delivery varies greatly across and even within countries [22, 34]. Location and frequency of CHW visits during the antenatal period and the number and content of
counseling messages delivered can vary even with large-scale integrated CHW programs in place [22, 35]. This is likely due to the lack of standardization and sparse data on optimizing CHW service delivery. One study conducted in Nigeria showed that there was a positive dose-effect on several maternal and child health indicators from the intensity of CHW services delivered, measured by the number of one-on-one advice and assistance sessions provided in addition to standard pregnancy-related education and counseling [36]. Other studies have also looked at the dose-effect of CHW services on maternal care seeking practices but focused mostly on CHW program intensity. Karim et al. illustrated that a composite measure of time spent with the woman and number of counseling messages delivered was associated with improvements in ANC, iron supplementation, birth preparedness measures, and postnatal care, but no evidence on facility deliveries or SBA [37].

In our study population across three countries, we observed that a significantly higher proportion of women in the intervention sites reported CHW visits than women in comparison sites. Comparing intervention sites across countries, a greater proportion of women in Cambodia received CHW visits (71.8%) compared to Kenya (55.1%) and Zambia, where only one quarter of women (24.8%) received at least one CHW visit. Explanations for these differences are likely context-specific. In Zambia, for instance, the CHWs were volunteers who had been initially recruited and trained by the ministry as Safe Motherhood Action Groups. Evidence from qualitative findings from this study which are not included here showed that the major challenges in the implementation of timed and targeted counseling by CHWs in Zambia was the lack of transport to reach remote households. High CHW attrition rates and low levels of satisfaction among CHWs were also reported. In Cambodia,
the national policy of 2 CHWs per village was a major barrier, as the CHWs felt too overwhelmed meet the demands and expectations for service delivery. Data from the CHW qualitative findings (not reported here) showed that the support systems for CHW supervision and oversight were also suboptimal, which may have resulted in the lack of a dose-effect between the number of CHW visits and SBA.

For Kenya and Zambia, women were significantly more likely to have SBA at delivery if the CHW had involved influential family members in discussions with the woman. While this finding was not significant in Cambodia in multivariate analysis, there was a positive association in the univariate analysis. Our findings are supported by studies from various countries that have demonstrated that a key component to establishing this trust was ensuring male involvement in the woman's care [34, 38]. In Uganda, this was most pronounced in terms of birth preparedness, as men still dominate economic power and related decision making in many households [34]. However, when the husband was part of counselling during pregnancy, decision making around saving money to pay for delivery care and seeking care was perceived to be easier for the woman and family in general [34]. In Ethiopia, participation in family meetings was significantly associated with an increase in the reported completeness of maternal and newborn health care that women received during birth and the early postnatal period, even after controlling for sociodemographic characteristics and maternal and newborn health service use factors [38]. Furthermore, while ANC utilization is positively associated with SBA, women who had both antenatal care and family meeting participation were most likely to have SBA for delivery[38]. In many LMIC, especially in sub-Saharan Africa and Southeast Asia, women often do not have decision-making power with regard to
health service utilization [16, 34, 39]. Thus, the involvement of other key household members such as husbands and mothers-in-law is beneficial for effective CHW health promotion.

The sociocultural environment was another critical factor for optimizing CHW functionality. In Cambodia, kinship, social hierarchical structures, religion, patron-client relations and collectivism were shown to impact the ability of CHWs to form relationships and influence decision-making for service utilization [40]. The CHW system in Cambodia fosters a strong identity with a structured induction training and support led by local government bodies that includes basic skills, such as communication and behavior change technique [40]. Furthermore, literature on the impact of CHW use of support tools demonstrates that having culturally appropriate tools, such as narratives available through videos and storybooks, can be an important, cost effective aid to CHWs, as illustrated in a study from Pakistan, where such tools facilitated dialogue between men and women to create greater awareness of maternal care [41,42]. This is important to understand because while our study did not show a significant association between the use of counseling aids and storybooks and SBA, this aspect of CHW services may still be paramount for their ultimate impact on maternal care.

Women were also significantly more likely to deliver with SBA if a CHW had conducted one or more follow-up visits after a referral or visit the woman after a health center visit. This finding is supported by a study from Uganda where follow-up and feedback of mothers who had been referred was perceived to be important in creating accountability for referral compliance and fostering confidence in the
CHW service, and this enabled them to successfully complete the maternal and newborn care practices recommended by the CHW [34]. Effective and formal integration of CHWs into the healthcare system is of importance to improve maternal and child care seeking as demonstrated by the Family Health Program in Brazil, for example [43].

Most CHW studies involve interventions with many components of service delivery, making it difficult to isolate the effects of individual performance improvement interventions [44]. Thus, it is also challenging to determine whether a CHW program did not achieve a statistically significant effect due to lack of implementation fidelity of the CHW program design or the CHW program design was not yet optimized to achieve maximum effect [44]. The mechanisms for CHW recruitment, training, management and support is central to the quality of services that they deliver.

To complement the contribution of CHW services, social accountability mechanisms have been shown to enhance maternal and health outcomes in Malawi and India [20,45]. These strategies provide a forum to address the social determinants and positively influence the utilization of healthcare services by creating effective accountability structures and fostering transparent dialogues with the community entities and health providers at the primary care facilities and enhance performance of providers and equitable quality of care. Though this study did not explore the effects of the integrated approach of CHW home visits and social accountability mechanisms independently, use of services improved significantly in the intervention sites for number of ANC services received, though SBA at delivery was
only significant for Cambodia. Further investigation of the independent and combined effects of the social accountability mechanisms and CHW services is warranted to enhance and optimize CHW services.

We report several potential study limitations. The quasi experimental cross-sectional design does not allow for causal inferences about the effectiveness of the integrated interventions on maternal care seeking practices. Recall bias on timing and number of CHW visits by the women may be another factor for bias in this study, as the woman’s recall was not corroborated with the CHW visit records. Thirdly, the dose effect of CHW visits can only be ascertained with additional data on the time spent during home visits, content covered and the quality of the visits. Lastly, the broad spectrum of health and developmental activities, including the establishment or strengthening of community councils and ongoing CHW services in the comparison sites, also contributed to increased SBA utilization for delivery care, which was not independently examined with a difference in difference analysis.

Conclusions

This study provides some evidence of community-oriented initiatives that address number and nature of CHW service delivery components for household health promotion to enhance the likelihood of SBA during delivery. A standard minimum number of CHW visits, while considering the unique sociocultural contexts of different LMICs, should be evidenced-based, and CHW communication skills to build rapport and trust with mothers and families should be paramount in promoting appropriate care seeking. The complementary community level interventions to enhance social accountability to ensure equitable access and utilization of quality
services at the primary care level, need to be empirically explored in the future. Despite the limitations, the study findings provide some evidence that effective engagement of CHWs and social accountability mechanisms with community entities can enhance access to safe delivery care in these rural communities.

**Abbreviations**

CHW Community Health Worker, SBA Skilled Birth Attendance, ANC Antenatal Care

**Declarations**

**Ethics Approval and Consent to Participate**

The study was part of a larger research trail that was conducted in Cambodia, Guatemala, Kenya and Zambia. Ethical clearance was obtained from the Johns Hopkins Bloomberg School of Public Health Institutional Review Board (IRB # 00004986), and the Institutional Review Boards of the local research institutions (National Institute of Public Health in Cambodia, Moi University School of Public Health in Kenya, Institute of Nutrition of Central America and Panama in Guatemala, and the Institute for Economic and Social Research at the University of Zambia. Based on the country ethical protocols, written informed consent in the local language was obtained from all study participants in Guatemala (Spanish), Kenya (Swahili) and Zambia (Tonga, Nyanja, Lozi), and verbal informed consent was obtained from all study participants in Cambodia (Khmer), prior to administering the surveys and privacy and confidentiality was ensured. The consent procedures were approved by the institutional review boards in all countries and the Johns Hopkins Bloomberg School of Public Health.
Consent for Publication

Not applicable

Competing Interests

The study was conducted through a research grant (#113543) to Johns Hopkins University. AE, YJ, HP and GE were partially funded by the grant to conduct the research. JC and AHG were employed by World Vision. We declare no other competing interests.

Availability of data and materials

Data sets used for analysis for the current research are not publicly available as the research was performed under a contractual agreement, but available from the corresponding author upon reasonable request.

Funding

The study was conducted through a research grant # 113543 to Johns Hopkins University from World Vision. The funding organization was not involved in the data collection, analysis or interpretation of the findings.

Author’s Contributions

AE, GE, and HP designed and conducted the research study. AE and AK wrote the
original manuscript and conceptualized the analysis. AK and YJ performed the analysis. HP, JC, AHG and YJ, reviewed and contributed to the final draft. All authors read and approved the final manuscript.

Acknowledgements

The authors would like to acknowledge the contributions of the research and survey teams in Cambodia, Zambia and Kenya, and the support received from the Ministry of Health and World Vision staff in each country. We would also like to thank the study participants for their time. We are also grateful for the valuable insight and feedback from the reviewers and the editorial team.

References

[1] World Health Organization. Skilled attendants at birth; 2018 [Available from: https://www.who.int/gho/maternal_health/skilled_care/skilled_birth_attendance_text/en/.

[2] World Health Organization, Unicef. Trends in maternal mortality: 1990-2015: estimates from WHO, UNICEF, UNFPA, World Bank Group and the United Nations Population Division. 2015.

[3] Team UST. Review of the contributions of the MDG Agenda to foster development: Lessons for the post-2015 UN development agenda. UN System Task Team 2012.

[4] Crowe S, Utley M, Costello A, Pagel C. How many births in sub-Saharan

26
Africa and South Asia will not be attended by a skilled birth attendant between 2011 and 2015? BMC Pregnancy and Childbirth. 2012;12(1):4.

[5] World Health Organization. Strategies toward ending preventable maternal mortality (EPMM). 2015. World Health Organization: Geneva. 2015.

[6] McDonagh M. Is antenatal care effective in reducing maternal morbidity and mortality? Health policy and planning. 1996;11(1):1-15.

[7] Graham WJ, Bell JS, Bullough CH. Can skilled attendance at delivery reduce maternal mortality in developing countries? Safe motherhood strategies: a review of the evidence. 2001.

[8] Safer MP. Making pregnancy safer: the critical role of the skilled attendant. World Health Organization: Geneva. 2004.

[9] Ronsmans C, Graham WJ, group LMSSs. Maternal mortality: who, when, where, and why. The lancet. 2006;368(9542):1189-200.

[10] Ross JA, Blanc AK. Why aren’t there more maternal deaths? A decomposition analysis. Maternal and child health journal. 2012;16(2):456-63.

[11] Tura G, Fantahun M, Worku A. The effect of health facility delivery on neonatal mortality: systematic review and meta-analysis. BMC pregnancy and childbirth. 2013;13(1):18.

[12] Biemba G, Yeboah-Antwi K, Semrau K, Hammond E, Hamer D. Who is Assisting Women to Deliver Babies within Health Facilities. An Analysis of Deliveries in Four Provinces in Zambia Austin J Public Health Epidemiol. 2014;1(2):1007.

[13] Mengesha ZB, Biks GA, Ayele TA, Tessema GA, Koye DN. Determinants of skilled attendance for delivery in Northwest Ethiopia: a community based nested case control study. BMC Public Health. 2013;13(1):130.

[14] Dickson KS, Amu H. Determinants of skilled birth attendance in the
Northern Parts of Ghana. Advances in Public Health. 2017;2017.

[15] Gitimu A, Herr C, Oruko H, Karijo E, Gichuki R, Ofware P, Lakati A, Nyagero J. Determinants of use of skilled birth attendant at delivery in Makueni, Kenya: a cross sectional study. BMC pregnancy and childbirth. 2015;15(1):9.

[16] Nyongesa C, Xu X, Hall JJ, Macharia WM, Yego F, Hall B. Factors influencing choice of skilled birth attendance at ANC: evidence from the Kenya demographic health survey. BMC pregnancy and childbirth. 2018;18(1):88.

[17] Perry HB, Sacks E, Schleiff M, Kumapley R, Gupta S, Rassekh BM, Freeman PA. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 1. rationale, methods and database description. Journal of global health. 2017;7(1).

[18] Ho LS, Labrecque G, Batonon I, Salsi V, Ratnayake R. Effects of a community scorecard on improving the local health system in Eastern Democratic Republic of Congo: qualitative evidence using the most significant change technique. Conflict and health. 2015;9(1):27.

[19] Edward A, Osei-Bonsu K, Branchini C, shah Yarghal T, Arwal SH, Naeem AJ. Enhancing governance and health system accountability for people centered healthcare: an exploratory study of community scorecards in Afghanistan. BMC health services research. 2015;15(1):299.

[20] Hamal M, de Cock Buning T, De Brouwere V, Bardají A, Dieleman M. How does social accountability contribute to better maternal health outcomes? A qualitative study on perceived changes with government and civil society actors in Gujarat, India. BMC health services research. 2018;18(1):653.

[21] Mafuta EM, Dieleman MA, Essink L, Khomba PN, Zioko FM, Mambu TN,
Kayembe PK, de Cock Buning T. Participatory approach to design social accountability interventions to improve maternal health services: a case study from the Democratic Republic of the Congo. Global health research and policy. 2017;2(1):4.

[22] Perry H, Zulliger R. How effective are community health workers. An overview of current evidence with recommendations for strengthening community health worker programs to accelerate progress in achieving the health-related Millennium Development Goals Baltimore: Johns Hopkins Bloomberg School of Public Health. 2012.

[23] Schaaf M, Topp SM, Ngulube M. From favours to entitlements: community voice and action and health service quality in Zambia. Health policy and planning. 2017;32(6):847-59.

[24] The Global Fund. Community systems strengthening framework. Geneva: The Global Fund,; 2010.

[25] World Health Organization. WHO recommendations on antenatal care for a positive pregnancy experience. World Health Organization,; 2016.

[26] StataCorp. Stata 14. 14.2 ed. Texas, USA2015.

[27] World Health Organization, UNICEF. Reduction of maternal mortality: a joint WHO/UNFPA/UNICEF/World Bank Statement. 1999.

[28] Edward A, Jung Y, Ettyang G, Chege J, Ghee AE. Applying an Equity Lens to Maternal Health Care Continuum in Rural Communities of Cambodia, Guatemala, Kenya, and Zambia. Internal Medicine Review Vol 4, No 2 (2018)

[29] Abou-Zahr CL, Wardlaw TM, Organization WH. Antenatal care in developing countries: promises, achievements and missed opportunities: an analysis of trends, levels and differentials, 1990-2001. 2003.
[30] Amoakoh-Coleman M, Ansah EK, Agyepong IA, Grobbee DE, Kayode GA, Klipstein-Grobusch K. Predictors of skilled attendance at delivery among antenatal clinic attendants in Ghana: a cross-sectional study of population data. BMJ open. 2015;5(5):e007810.

[31] Nair M, Ariana P, Webster P. What influences the decision to undergo institutional delivery by skilled birth attendants? A cohort study in rural Andhra Pradesh, India. Rural & Remote Health. 2012;12(4).

[32] Joseph G, da Silva IC, Fink G, Barros AJ, Victora CG. Absolute income is a better predictor of coverage by skilled birth attendance than relative wealth quintiles in a multicountry analysis: comparison of 100 low-and middle-income countries. BMC pregnancy and childbirth. 2018;18(1):104.

[33] Wong KL, Restrepo-Méndez MC, Barros AJ, Victora CG. Socioeconomic inequalities in skilled birth attendance and child stunting in selected low and middle income countries: Wealth quintiles or deciles? PloS one. 2017;12(5):e0174823.

[34] Okuga M, Kemigisa M, Namutamba S, Namazzi G, Waiswa P. Engaging community health workers in maternal and newborn care in eastern Uganda. Global health action. 2015;8(1):23968.

[35] Jennings MC PS, Schleiff M. Comprehensive review of the evidence regarding the effectiveness of community-based primary health care in improving maternal, neonatal and child health: 2. maternal health findings. Journal of global health. 2017;7(1).

[36] Findley SE, Uwemedimo OT, Doctor HV, Green C, Adamu F, Afenyadu GY. Comparison of high-versus low-intensity community health worker intervention to promote newborn and child health in Northern Nigeria. International journal of women's health. 2013;5:717.
[37] Karim AM, Admassu K, Schellenberg J, Alemu H, Getachew N, Ameha A, Tadesse L, Betemariam W. Effect of Ethiopia’s health extension program on maternal and newborn health care practices in 101 rural districts: a dose-response study. PLoS One. 2013;8(6):e65160.

[38] Barry D FA, Mohammed H, Desta BF, Tadesse L, Aklilu Y. The Effect of Community Maternal and Newborn Health Family Meetings on Type of Birth Attendant and Completeness of Maternal and Newborn Care Received During Birth and the Early Postnatal Period in Rural Ethiopia. Journal of Midwifery & Women’s Health. 2014;59:S44-S54.

[39] King R JR, Dietsch E. Barriers and facilitators to accessing skilled birth attendants in Afar region, Ethiopia. Midwifery 2015;31:540–6.

[40] Ozano K, Simkhada P, Thann K, Khatri R. Improving local health through community health workers in Cambodia: challenges and solutions. Human resources for health. 2018;16(1):2.

[41] Hargraves JL, Bonollo D, Person SD, Ferguson WJ. A randomized controlled trial of community health workers using patient stories to support hypertension management: Study protocol. Contemporary clinical trials. 2018;69:76-82.

[42] Omer K, Mhatre, S, Ansari, N, Laucirica, J, Andersson, N. Evidence-based training of frontline health workers for door-to-door health promotion: A pilot randomized controlled cluster trial with Lady Health Workers in Sindh Province, Pakistan. Patient Educ Couns. 2008;72:178-85.

[43] Lassi ZS, Kumar R, Bhutta ZA. Community-based care to improve maternal, newborn, and child Health. Disease Control Priorities. 2016;2:263-84.

[44] Ballard M, Montgomery P. Systematic review of interventions for
improving the performance of community health workers in low-income and middle-income countries. BMJ open. 2017;7(10):e014216.

[45] Lodenstein E, Ingemann C, Molenaar JM, Dieleman M, Broerse JE. Informal social accountability in maternal health service delivery: A study in Northern Malawi. PloS one. 2018;13(4):e0195671.

Tables

Table 1: Selected Study Sites in Each Country

| Study Sites | Intervention | Comparison |
|-------------|--------------|------------|
| Cambodia    | Chulkiri     | Comapa     |
|             | Prasath Balang | Tbeng Meanchey |
| Kenya       | Karemo       | Katito     |
|             | Kegonga-Ntimaru | Magunga |
| Zambia      | Luampa       | Magoye     |
|             | Choongo      | Nyimba     |

Table 2: Sociodemographic characteristics of study population by country

| Characteristics          | Cambodia N=3,037 | Kenya N=2,805 | I N=634 |
|--------------------------|------------------|---------------|---------|
|                          | I N=1261         | C N=1776      |          |
|                          | n(%)             | n(%)          | n(%)    |
| Male-headed household    | 1130 (89.8)      | 1584 (89.5)   | 1360    |
|                          | 1076 (89.3)      | 0.022         | 288     |
|                          | 1590 (86.4)      | 0.815         | 100     |
|                          | 1040 (85.6)      | 0.000         | 455     |
| Mean family size         | 5.1              | 4.8           | 5.3     |
| Mother’s age (in years)  |                  |               |         |
| 15-19                    | 49 (3.9)         | 81 (4.6)      | 49      |
|                          | 140 (8.8)        | 100 (8.2)     | 140     |
|                          | 1334 (83.9)      | 1040 (85.6)   | 1334    |
|                          | 1121 (92.6)      | 0.000         | 1121    |
|                          | 438 (69.4)       | 0.000         | 438     |
| 20-36                    | 1113 (88.3)      | 1536 (86.5)   | 1113    |
|                          | 1334 (83.9)      | 1040 (85.6)   | 1334    |
|                          | 1121 (92.6)      | 0.000         | 1121    |
|                          | 438 (69.4)       | 0.000         | 438     |
| 37-49                    | 99 (7.8)         | 159 (8.9)     | 99      |
|                          | 116 (7.3)        | 75 (6.2)      | 116     |
|                          | 1121 (92.6)      | 0.000         | 1121    |
|                          | 438 (69.4)       | 0.000         | 438     |
| Marital status           |                  |               |         |
| Married                  | 1239 (98.3)      | 1744 (98.2)   | 1239    |
|                          | 1321 (83.4)      | 1121 (92.6)   | 1321    |
|                          | 1121 (92.6)      | 0.000         | 1121    |
|                          | 438 (69.4)       | 0.000         | 438     |
| Single/divorced/widow-ed | 22 (1.7)         | 32 (1.8)      | 22      |
|                          | 263 (16.6)       | 90 (7.4)      | 263     |
|                          | 90 (7.4)         | 0.000         | 90      |
|                          | 193 (30.6)       | 0.000         | 193     |
| Highest education        |                  |               |         |
| No education             | 191 (15.4)       | 453 (25.8)    | 191     |
|                          | 19 (1.3)         | 52 (4.8)      | 19      |
|                          | 52 (4.8)         | 0.000         | 52      |
|                          | 44 (8.3)         | 0.000         | 44      |
| Primary                  | 675 (54.3)       | 764 (43.5)    | 675     |
|                          | 1004 (69.2)      | 791 (72.7)    | 1004    |
|                          | 791 (72.7)       | 0.050         | 791     |
|                          | 268 (49.8)       | 0.000         | 268     |
|                              | 377 (30.3) | 539 (30.7) | 0.831 | 429 (29.5) | 244 (22.5) | 0.000 | 225 (41.9) |
|------------------------------|------------|------------|-------|------------|------------|-------|------------|
| **Secondary or more**        |            |            |       |            |            |       |            |
| **Parity**                   |            |            |       |            |            |       |            |
| Primiparous                  | 504 (40.0) | 674 (38.0) | 0.262 | 422 (26.6) | 337 (27.7) | 0.205 | 161 (25.4) |
| Multiparous                  | 756 (60.0) | 1098 (62.0) | 0.275 | 1160 (73.4) | 871 (72.3) | 0.210 | 465 (74.6) |
| Had prior miscarriage or stillbirth | 264 (20.9) | 454 (25.6) | 0.003 | 63 (4.0) | 65 (5.4) | 0.165 | 40 (6.3) |
| **Wealth quintile**          |            |            |       |            |            |       |            |
| Poorest (<20<sup>th</sup> percentile) | 201 (15.9) | 636 (35.8) | 0.000 | 238 (15) | 282 (23.3) | 0.000 | 167 (26.1) |
| Poor (20<sup>th</sup>-39<sup>th</sup> percentile) | 156 (12.4) | 357 (20.1) | 0.000 | 314 (19.7) | 284 (23.4) | 0.021 | 104 (16.4) |
| Middle (40<sup>th</sup>-59<sup>th</sup> percentile) | 277 (22) | 353 (19.9) | 0.164 | 284 (17.9) | 229 (18.8) | 0.505 | 120 (18.9) |
| Rich (60<sup>th</sup>-79<sup>th</sup> percentile) | 331 (26.2) | 255 (14.4) | 0.000 | 316 (19.9) | 234 (19.2) | 0.684 | 160 (25.2) |
| Richest (80<sup>th</sup>-99<sup>th</sup> percentile) | 296 (23.5) | 175 (9.8) | 0.000 | 438 (27.5) | 186 (15.3) | 0.000 | 83 (13.1) |
| Has health insurance         | 333 (26.4) | 536 (30.2) | 0.022 | -- | -- | -- | -- |

I: Intervention; C: Comparison

Table 3: Characteristics of Antenatal Care and Skilled Birth Attendance of Study Population by Country
### Maternal careseeking characteristics

|                          | Cambodia | N=3,037 | Kenyan | N=2,805 | Zambian | N=1261 |
|--------------------------|----------|---------|--------|---------|---------|--------|
|                          | I: n (%) | C: n (%) | p value | I: n (%) | C: n (%) | p value |
| **Antenatal care (ANC)** |          |         |        |         |         |        |
| Received ≥4 facility ANC visits | 997 (81.2) | 949 (58) | 0.000 | 1048 (70.5) | 645 (62.7) | 0.000 |
| Month of 1st ANC visit | 2.4 | 2.7 | 0.000 | 4.4 | 4.3 | 0.014 |
| 1st trimester | 994 (81.4) | 1187 (73.3) | 0.000 | 419 (28.8) | 302 (29.9) | 0.595 |
| 2nd trimester | 212 (17.4) | 391 (24.2) | 0.000 | 942 (64.7) | 654 (64.8) | 0.908 |
| 3rd trimester | 15 (1.2) | 40 (2.5) | 0.013 | 95 (6.5) | 54 (5.3) | 0.210 |
| ANC services received |          |         |        |         |         |        |
| ANC Services Index Score | 9.2 | 7.8 | 0.000 | 10.0 | 9.8 | 0.000 |
| 2 tetanus toxoid vaccination | 533 (42.5) | 715 (42.1) | 0.826 | 420 (27.2) | 249 (23.6) | 0.043 |
| Iron and folic acid | 1242 (99.1) | 1638 (96.4) | 0.000 | 1436 (94.1) | 776 (71.1) | 0.000 |
| Antimalarials | 19 (1.5) | 17 (1.0) | 0.222 | 1094 (71) | 783 (74.4) | 0.053 |
| Weight measurement | 1772 (93.7) | 1468 (90.1) | 0.000 | 1506 (99.3) | 938 (90.2) | 0.000 |
| Blood pressure measured | 1222 (97.5) | 1481 (87.2) | 0.000 | 1468 (96.8) | 825 (79.3) | 0.000 |
| Urine test | 671 (53.6) | 396 (23.3) | 0.000 | 1355 (89.4) | 712 (68.4) | 0.000 |
| Blood test | 1072 (85.6) | 995 (58.6) | 0.000 | 1327 (87.5) | 664 (63.8) | 0.000 |
| Nutrition advice | 1184 (94.7) | 1466 (90) | 0.000 | 1240 (81.6) | 809 (78.6) | 0.063 |
| Counseling on pregnancy complications and danger signs | 1144 (91.3) | 1359 (80.4) | 0.000 | 1331 (86.6) | 813 (77.1) | 0.000 |
| Informed about where to go if pregnancy-related complications develop | 1133 (99.1) | 1341 (98.1) | 0.019 | 1328 (99.5) | 796 (98.2) | 0.006 |
| Informed about PMTCT | 1048 (84) | 1260 (74.7) | 0.000 | 1511 (98.1) | 1004 (95.8) | 0.002 |
| Offered HIV test | 1061 (84.7) | 1139 (67.0) | 0.000 | 1522 (98.7) | 1033 (98.1) | 0.318 |
| Delivery care |          |         |        |         |         |        |
| Skilled birth attendance | 1249 (99.1) | 1505 (84.8) | 0.000 | 1460 (92.8) | 1082 (91.7) | 0.348 |
| Doctor | 157 (12.5) | 143 (8.1) | 0.000 | 241 (15.3) | 215 (18.2) | 0.043 |
| Clinical officer | - | 1 (0.06) | - | 245 (15.6) | 103 (8.7) | 0.000 |
| Nurse | 3 (0.24) | 6 (0.33) | 0.608 | 900 (57.2) | 724 (60.7) | 0.073 |
| Trained midwife | 1089 (86.4) | 1355 (76.3) | 0.000 | 74 (4.7) | 50 (4.2) | 0.563 |
| Unskilled birth attendance | 12 (0.9) | 271 (15.2) | 0.000 | 122 (7.2) | 107 (8.3) | 0.348 |
| Community health worker | - | 20 (1.1) | - | 24 (1.5) | 10 (0.8) | 0.098 |
| Relative/friend/neighbor | 1 (0.08) | 5 (0.28) | 0.174 | 34 (2.2) | 40 (3.5) | 0.055 |
| Traditional birth assistant (TBA) | 9 (0.7) | 235 (13.3) | 0.000 | 5 (0.3) | 9 (0.8) | 0.125 |
| No one | 1 (0.08) | 11 (0.62) | 0.008 | 50 (3.2) | 37 (3.1) | 0.955 |

I: Intervention; C: Comparison

1. Facility-based ANC includes: Private or Government facility, clinic, or hospital

2. ANC Services Index calculated by summing the total number of services (out of

34
12) each woman received during her last pregnancy, giving equal weight to each of the 12 services. Minimum score=0; Maximum score=12.

3. PMTCT: prevention of mother to child transmission of HIV

Table 4: Components of community health worker (CHW) visits and services by country
| Reported CHW Services                                      | I: N=1261 | C: N=1776 | p value | I: N=1590 | C: N=1215 | p value | I: N=634 |
|-----------------------------------------------------------|-----------|-----------|---------|-----------|-----------|---------|---------|
| n(%)                                                     | n(%)      | p value   | n(%)    | n(%)      | p value   | n(%)    |
| CHW visited during last pregnancy                        | 896 (71.8)| 613 (35)  | 0.000   | 864 (55.1)| 367 (31)  | 0.000   | 157 (24.8) |
| Mean Number of CHW visits                                | 2.4       | 2.5       | 0.081   | 3.5       | 2.9       | 0.000   | 2.5     |
| None                                                      | 364 (29.2)| 1146 (65.5)| 0.000  | 769 (49.1)| 835 (70.5)| 0.000  | 477 (76) |
| 1-2 visits                                                | 526 (42.1)| 352 (20.1)| 0.000   | 259 (16.6)| 164 (13.9)| 0.000   | 76 (12)  |
| 3-4 visits                                                | 321 (25.0)| 202 (11.5)| 0.000   | 373 (23.8)| 144 (12.2)| 0.000   | 69 (11)  |
| >4 visits                                                 | 46 (3.7)  | 50 (2.9)  | 0.000   | 164 (10.5)| 40 (3.4)  | 0.000   | 6 (1.0)  |
| Mean month of 1st CHW visit                              | 4.6       | 4.1       | 0.000   | 4.4       | 5.0       | 0.000   | 4.9     |
| 1st trimester                                            | 295 (33.9)| 277 (46.6)| 0.000   | 305 (35.4)| 81 (22.1)| 0.000   | 31 (20.1)|
| 2nd trimester                                            | 422 (48.6)| 233 (39.2)| 0.000   | 446 (51.6)| 214 (58.3)| 0.032   | 97 (63)  |
| 3rd trimester                                            | 152 (17.5)| 85 (14.2) | 0.097   | 112 (13.0)| 72 (19.6) | 0.127   | 26 (16.9)|
| CHW was courteous and respectful                         | 888 (99.1)| 602 (98.7)| 0.453   | 847 (98.4)| 358 (98.4)| 0.978   | 143 (96.6)|
| Satisfied with CHW services                              | 884 (99)  | 601 (98.4)| 0.305   | 844 (97.9)| 339 (93.6)| 0.002   | 141 (95.9)|
| CHW provided counseling during home visits               | 843 (94.9)| 418 (69.8)| 0.000   | 813 (97.7)| 339 (97.4)| 0.762   | 144 (99.3)|
| CHW used counseling aids/ storybooks                     | 703 (79)  | 153 (25.2)| 0.000   | 766 (89.1)| 259 (71.2)| 0.000   | 136 (90.1)|
| CHW discussed pregnancy complications                    | 692 (77.8)| 339 (55.6)| 0.000   | 813 (94.4)| 322 (88.7)| 0.002   | 137 (91.3)|
| CHW provided solutions and recommendations for woman's concerns | 625 (70.2)| 336 (55.1)| 0.000   | 801 (93.3)| 317 (87.8)| 0.007   | 136 (90.1)|
| CHW included influential family members in pregnancy-related discussions | 614 (69.6)| 342 (56.6)| 0.000   | 734 (85.7)| 244 (67.4)| 0.000   | 138 (91.4)|
| CHW facilitated woman's access to ANC                    | 551 (92.8)| 218 (89)  | 0.097   | 711 (95.7)| 270 (92.8)| 0.086   | 82 (54.3) |
| CHW conducted a follow-up visit after referral or visit to a health center | 600 (77.2)| 194 (59.1)| 0.000   | 429 (90.7)| 260 (89.7)| 0.641   | 68 (72.3) |

I: Intervention; C: Comparison
Table 5: Multivariate Logistic Regression of Factors Associated with Skilled Birth Characteristics by Country

| Characteristics | Cambodia | | | | Kenya | | | | |
|-----------------|---------|---------------------------------|-----------------|-------|---------|-----------------|-----------------|-----------------|-------|---------|
|                 | OR      | 95%CI   | aOR    | 95%CI  | OR      | 95%CI   | aOR    | 95%CI  | OR    | 95%CI   |
| Age             |         |         |        |        |         |         |        |        |       |        |
| < 24 yrs (ref)  | 1.10    | 0.84,1.45 | 1.65** | 1.14,2.39 | 0.80    | 0.60,1.08 | 0.94    | 0.65,1.36 | 0.48** | 0       |
| >= 24 yrs       |         |         |        |        |         |         |        |        |       |        |
| Education       |         |         |        |        |         |         |        |        |       |        |
| None (ref)      |         |         |        |        |         |         |        |        |       |        |
| Primary         | 2.88**  | 2.19,3.79 | 1.96* | 1.44,2.69 | 1.64    | 0.85,3.19 | 1.37    | 0.63,2.97 | 1.78   | 0       |
| Secondary +     | 5.02**  | 3.48,7.24 | 2.96* | 1.95,4.47 | 5.38*   | 2.49,11.63 | 3.61    | 1.48,8.79 | 1.8    | 0       |
| Parity          |         |         |        |        |         |         |        |        |       |        |
| Primi (ref)     |         |         |        |        |         |         |        |        |       |        |
| Wealth          |         |         |        |        |         |         |        |        |       |        |
| <40th percentile (ref) |         |         |        |        |         |         |        |        |       |        |
| >= 40th percentile | 4.70*** | 3.52,6.26 | 2.12*** | 1.53,2.94 | 1.38*   | 1.05,1.81 | 1.16    | 0.84,1.59 | 1.06   | 0       |
| Study Arm       |         |         |        |        |         |         |        |        |       |        |
| Comparison (ref) |         |         |        |        |         |         |        |        |       |        |
| Intervention    | 18.74** | 10.5,33.6 | 7.48*** | 3.87,14.5 | 1.18    | 0.90,1.55 | 0.60*   | 0.41,0.85 | 0.76   | 0       |
| Facility-based ANC |         |         |        |        |         |         |        |        |       |        |
| < 4 visits (ref) |         |         |        |        |         |         |        |        |       |        |
| >= 4 visits     | 4.48*** | 3.52,5.96 | 1.66* | 1.20,2.29 | 2.88    | 2.18,3.80 | 1.91*** | 1.36,2.67 | 2.40** | 1       |
| ANC Index (1-12) | 1.30**  | 1.25,1.35 | 1.13* | 1.08,1.19 | 1.21    | 1.17,1.26 | 1.19*** | 1.13,1.24 | 1.16*  | 1       |
| CHW Visits and Services |         |         |        |        |         |         |        |        |       |        |
| Number of CHW visits | 1.39**  | 1.25,1.55 | 0.96   | 0.82,1.12 | 1.08*   | 1.01,1.17 | 1.06    | 0.92,1.21 | 0.93   | 0       |
| CHW was courteous | 2.70**  | 2.06,3.54 | 2.91   | 0.32,6.7  | 1.22*   | 1.01,1.76 | 3.00    | 0.75,12.1  | 0.74  | 0       |
| Satisfied with CHW | 2.65**  | 2.02,3.37 | 0.31   | 0.03,2.96 | 1.28    | 0.97,1.69 | 0.99    | 0.19,5.13  | 0.73  | 0       |
| CHW provided counseling during home visits | 3.23*** | 2.38,4.38 | 1.06   | 0.61,1.86 | 1.25    | 0.94,1.67 | 0.95    | 0.29,3.31  | 0.80  | 0       |
| CHW used counseling aids/story books | 5.77*** | 3.63,9.15 | 1.58   | 0.79,3.17 | 1.24    | 0.93,1.66 | 0.95    | 0.41,2.19  | 0.78  | 0       |
| CHW discussed pregnancy complications | 3.57*** | 2.52,5.05 | 1.10   | 0.51,2.35 | 1.23    | 0.93,1.63 | 0.66    | 0.16,2.71  | 0.84  | 0       |
| CHW provided solutions to concerns | 2.98*** | 2.12,4.18 | 0.65   | 0.30,1.41 | 1.23    | 0.93,1.63 | 0.28    | 0.06,1.32  | 0.98  | 0       |
| CHW included influential family in discussions | 3.25**  | 2.29,4.62 | 1.69   | 0.92,3.13 | 1.52**  | 1.12,2.06 | 2.12*   | 1.06,4.26  | 0.96  | 0       |
| CHW facilitated access to ANC | 3.23**  | 2.18,4.78 | 0.66   | 0.37,1.81 | 1.29    | 0.96,1.74 | 0.70    | 0.33,1.49  | 1.01  | 0       |
| CHW follow up after referral/facility visit | 6.58*** | 3.94,9.07 | 2.44*** | 1.60,4.06 | 1.85    | 1.27,2.67 | 2.17*   | 1.25,3.75  | 0.56  | 0       |

SLR = simple logistic regression; MLR = multivariate logistic regression; OR = odds
ratio; aOR=adjusted odds ratio.

ANC Index calculated by summing the total number of services (out of 12) each woman received during her last pregnancy, giving equal weight to each of the 12 services. Minimum score=0; Maximum score=12.

*p<0.05; **p<0.01; ***p<0.001