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Original Article

# Multi-country analysis of the cost of community health workers kits and commodities for community-based maternal and newborn care

**Diana Barger,[1,*] Helen Owen,[2] Catherine Pitt,[3] Kate Kerber,[1] Deborah Sitrin,[1] Chrispus Mayora,[4] Tanya Guenther,[1] Emmanuelle Daviaud[5] and Joy E Lawn,[2] on behalf of the Coin Care Tool Group**

[1]Save the Children, Washington, DC, USA, [2]London School of Hygiene and Tropical Medicine, MARCH Centre, London, UK, [3]Department of Health Policy Planning and Management, London School of Hygiene and Tropical Medicine, London, UK, [4]Makerere University School of Public Health, Kampala, Uganda and [5]Medical Research Council, Cape Town, South Africa

*Corresponding author. Save the Children International, Washington DC, USA 899 N. Capitol Suite 900 Washington, DC 20002, USA. E-mail: diana.barger@gmail.com

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## Abstract

Community-based maternal and newborn care with home visits by community health workers (CHWs) are recommended by WHO to complement facility-based care. As part of multi-country economic and systems analyses, we aimed to compare the content and financial costs associated with equipping CHWs or 'home visit kits' from seven studies in Bolivia, Ethiopia, Ghana, Malawi, South Africa, Tanzania and Uganda. We estimated the equivalent annual costs (EACs) of home visit kits per CHW in constant 2015 USD. We estimated EAC at scale in a population of 100 000 assuming four home visits per mother during the pregnancy and postnatal period. All seven packages were designed for health promotion; six included clinical assessments and one included curative care. The items used by CHWs differed between countries, even for the same task. The EAC per home visit kit ranged from $15 in Tanzania to $116 in South Africa. For health promotion and preventive care, between 82 and 100% of the cost of CHW commodities did not vary with the number of home visits conducted; however, in Ethiopia, the majority of EAC associated with curative care varied with the number of visits conducted. The EAC of equipping CHWs to meet the needs of 95% of expectant mothers in a catchment area of 100 000 people was highest in Bolivia, $40 260 for 633 CHWs, due to mothers being in hard-to-reach areas with CHW conducting few visits per year per, and lowest in Tanzania ($2693 for 172 CHWs), due to the greater number of CHW visits per week and lower EAC of items. To inform and ensure sustainable implementation at scale, national discussions regarding the cadre of CHWs and their workload should also consider carefully the composition and cost of equipping CHWs to carry out their work effectively and efficiently.

**Keywords**: Community health workers, commodities, home visit kits, economic evaluation, costing, scale-up, home-visits, maternal and newborn

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**Key Messages**

- Home visit kits used by CHWs for Community-based Maternal and Newborn Care differed between countries, even for those carrying out similar duties.
- Annual equivalent financial costs ranged from $15 in Tanzania to $116 in South Africa.
- 82 and 100% of the cost of CHW home visit kits did not vary with the number of home visits conducted in the case of health promotion and preventative packages.
- The composition and cost of CHW home visit kits should be considered in national discussions on CHW cadres and their workload.

## Introduction

There has been wide recognition of the role that trained and supported community health workers (CHWs) can play in overcoming health workforce shortfalls and improving access to and coverage of basic health services (WHO 2006; Haines *et al.* 2007). High intensity CHW home visit programmes have been shown to prevent up to 60% of newborn deaths in high mortality settings (Gogia and Sachdev 2010) and have since 2009 been recommended by the World Health Organization (WHO) and UNICEF as a complementary strategy to facility-based antenatal and postnatal care (WHO *et al.* 2009).

Early trials evaluating the impact of community-based maternal and newborn care (CBMNC), which underpinned the WHO recommendations, were conducted in South Asia and have varied both in terms of the cadres deployed and content of the home visit (Gogia and Sachdev 2010). They have mainly reflected controlled, rather than 'real world' implementation settings (Ref. 1st paper, Supplement). More recently, the Cochrane Review by Lassi and Bhutta (2015) maintained that there was sufficient evidence to scale up these packages while noting both the diversity across settings and a range of impacts contingent on both context and scope. The recently concluded effectiveness trials included in this supplement have mainly assessed preventive packages in African settings and have shown significant increases in the coverage of healthy practices and service utilization during pregnancy, childbirth, and in the postnatal period. Most, however, did not report a statistically significant impact on neonatal mortality rates (NMRs) (Kirkwood *et al.* 2013; Hanson *et al.* 2015) or were not powered to do so (Tomlinson *et al.* 2014; Waiswa *et al.* 2015). The Community-Based Interventions for Newborns in Ethiopia (COMBINE) trial in Ethiopia assessing sepsis management at health posts in addition to health promotion activities found a moderate yet significant reduction (17%) in neonatal mortality after the first day of life (Ref. Degefie *et al.*, 2017).

As the body of literature on the effectiveness of CBMNC programmes grows, there is still a relative lack of evidence on both programme costs and cost-effectiveness (Global Health Workforce Alliance 2010). A recent systematic review on the cost-effectiveness of strategies to improve the provision and utilization of maternal and newborn care identified only two studies on CHW-delivered community-based newborn interventions (Mangham-Jefferies *et al.* 2014). Since then, a cost-effectiveness analysis of the Newhints home visit intervention in Ghana, which we include in this cross-country comparison, has also been published (Pitt *et al.* 2016). Pitt and colleagues concluded that the home visit strategy had a high probability of being cost-effective in a range of low-income settings with NMR of 20 to 60 per 1000 live births in spite of modest mortality reductions achieved. The findings from the costing studies from settings in Bolivia, Ethiopia, Malawi, Tanzania and Uganda (Barger *et al.* 2017; Greco *et al.* 2017; Manzi *et al.* 2017; Daviaud *et al.* 2017b; Ekirapa-Kiracho *et al.* 2017; Mathewos *et al.* 2017), provide a more comprehensive picture of training, supervision and remuneration across these countries programmes and guidance for local decision makers interested in understanding the budgetary requirements associated with CBMNC programmes (Daviaud *et al.*, 2017a).

Reaching women and newborns effectively through home visits during pregnancy and soon after delivery requires that CHWs be provided with appropriate equipment, supplies and transport. The sustained availability of these items has been identified as a 'weak link' in CHW programme effectiveness (Lehmann and Sanders 2007) and there has been greater recognition globally of the importance of commodity supply chains, reflected in the establishment of the United Nations Commission on Life-Saving Commodities for Women and Children (UNCoLSC) (UNICEF 2012) and the work of the Clinton Health Access Initiative, the Millennium Development Goal Alliance, and the 1 Million CHW Campaign (Singh and Sachs 2013). A recent review of country progress between 2012 and 2015 against the UNCoLSC's plan to expand access revealed that considerable work is needed to achieve the stated goals and recommendations, especially regarding commodities for newborn health (Pronyk *et al.* 2016). In addition to the provision of equipment and supplies, the 1 Million CHW campaign argues that a 'new generation of CHWs must be equipped with new technologies', including mobile phones (Earth Institute at Columbia University 2013). Mobile health (mHealth) innovations can improve communication between health workers at different levels and between CHWs and households, providing faster and more accurate diagnostic capability, improving supervision and accountability of CHWs, and facilitating data collection and analysis. Results from a systematic literature review have concluded that mHealth offers an innovative means of delivering health services, including those for mothers and their children. But funding dependency, unclear health systems responsibilities, unreliable infrastructure and a lack of evidence of their cost-effectiveness have been identified as weaknesses (Braun *et al.* 2013; Aranda-Jan *et al.* 2014).

Now, almost all of the 75 Countdown priority countries have a policy for CBMNC visits and many are investing in a range of cadres and different implementation strategies (WHO 2012). There is therefore a pressing need to investigate what is required to equip CHWs to perform home visits and the costs of these inputs. Our analysis focuses on uniforms, equipment, supplies, medicines and transport provided to CHWs recruited to CBMNC programmes and used to conduct pregnancy and newborn home visits. We refer to these items throughout this article for the sake of brevity as 'home visit kits'.

### Aims

(1) To estimate the equivalent annual financial cost (EAC) of CHW home visit kits in seven countries and to evaluate and compare the drivers of these costs. In the case of multi-purpose CHWs (e.g. Malawi and Ethiopia), we focus on items added to the home visit kit for the purpose of the pregnancy and newborn home visit only.

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**Figure 1.** A comparative summary of the nature of the interventions, context and the cadre of CHW by country

(2) To compare the EAC of equipping CHWs performing home visits in a population of 100 000 people based on programme- and country-specific data, activity rates, and demographics for the seven programmes (Figure 1).

Other variations in training, supervision, remuneration and incentive systems, which have a substantial impact on overall costs of CHW programmes, are discussed by Daviaud *et al.* in the introductory article of this Supplementary Material Daviaud *et al.* 2017a and in country-specific economic analyses (Barger *et al.* 2017; Daviaud *et al.* 2017; Ekirapa-Kiracho *et al.* 2017; Greco *et al.* 2017; Manzi *et al.* 2017; Pitt *et al.* 2016; Mathewos *et al.* 2017).

## Methods

We conducted our analysis from the perspective of the provider reflecting the costs borne by the health system partners and focussed on the additional cost of adding CBMNC to existing programmes. The focus of this analysis is on financial rather than economic costs.

### Study settings

This analysis includes data from regions in Africa (Ethiopia, Ghana, Malawi, South Africa, Tanzania and Uganda) and Latin America (Bolivia), where efforts to integrate CBMNC into existing programmes were being piloted or implemented between 2009 and 2012 (Daviaud *et al.* 2017a). The context, health systems and CHW cadres vary greatly between countries (Figure 1). NMR, corresponding to the first year the programme was implemented, ranged from 12 per 1000 live births in South Africa to 33 per 1000 live births in Ghana. NMR has declined in most countries since and ranged from 11 per 1000 live births in South Africa to 28 per 1000 live births in Ethiopia and Ghana in 2015 (Figure 1). Some study settings had a higher NMR than the national average. The observed CHW density, defined as the number of CHWs working in a given catchment area at the time of the costing exercise, also differed, ranging from 1 CHW per 2900 people in urban South Africa to 1 CHW for every 500 people in rural Bolivia.

### Cadres of CHW and scope of CBMNC interventions

CHWs in the respective programmes and research studies were characterized according to their integration within the wider health system (government workers, study worker, volunteer or a combination of two categories), diversity of duties (multi-purpose vs single purpose), and time spent on the activity (full or part-time) (Figure 1). The remuneration models for CHWs also varied. In Ethiopia and Malawi, CHWs are paid, multi-purpose, government workers linked to a health post or clinic. In Ethiopia, the 'Health Extension Workers' (HEWs) work with a team of (CHW) volunteers who conduct pregnancy surveillance and home visits. In Bolivia, CHWs were multi-purpose volunteers recruited from the communities they served via a local non-governmental organization. In Uganda, Tanzania, and South Africa, CHWs were recruited as part of cluster-randomized trials, although in Uganda and South Africa, the national governments have subsequently advanced their national CHW platform and have both endorsed multi-purpose CHWs (Daviaud *et al.* 2017a). In Ghana, existing 'Community-Based Surveillance Volunteers' were recruited to participate in the

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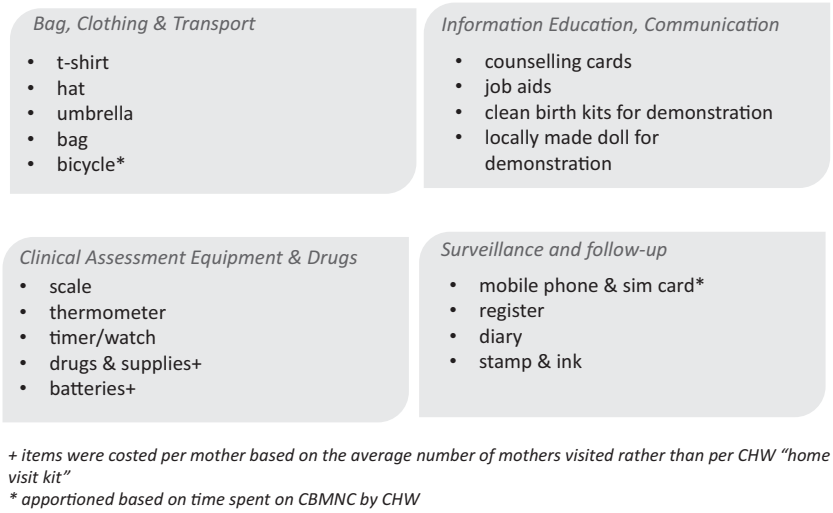


**Figure 2.** Composition of cost categories for items in the CHWs' 'home visit kit'. + Items were costed per mother based on the average number of mothers visited rather than per CHW 'home visit kit'. * Apportioned based on time spent on CBMNC by CHW

Newhints trial and the newborn home visit strategy was added to their existing activities (Kirkwood *et al.* 2013).

CHWs in each setting delivered a package of interventions that ranged in complexity. Health promotion packages implemented in South Africa focused on the promotion of mother-led healthy practices in the context of high HIV prevalence (including exclusive breastfeeding, clean cord care, household hygiene, as well as access to social services like a child health grant). Packages in Bolivia, Ghana, Malawi, Tanzania and Uganda covered both health promotion and newborn clinical assessments (including weighing, measuring, taking temperature, checking breathing and supporting breastfeeding) and referral to a health facility if necessary. As part of the COMBINE study (Ref. Mathewos *et al.* 2017), sepsis management, delivered at the health post, was added to the package of interventions delivered by Ethiopia's HEWs as part of an existing government policy. Although antibiotics in Ethiopia were not used during home visits, we have included them in this analysis. This is unlike all the other supplies in the analysis, which physically travelled with the CHWs as they attended to women in the home.

The time CHWs spent on the CBMNC programme was estimated through CHW-completed forms differentiating between types of activities: home visits (travel time and time spent in the home), supervision meetings, other meetings and administrative tasks. In the Newhints study in Ghana, CHW time in homes was assessed through supervisors' observation (Kirkwood *et al.* 2010). The time spent on CBMNC varied between countries, as did the number of home visits CHWs conducted per week. These differences were due to a number of factors that are described in more detail elsewhere including local policy, remuneration, supportive supervision, and population density and distribution of CHWs (Daviaud *et al.* 2017a). On average CHWs performed 5.4 home visits per week in South Africa as they were paid to work exclusively on the programme and 0.3 visits per week in Bolivia (1 visit every 3 weeks) as they were volunteers. In the other countries, CHWs performed one to two visits per week.

## Data sources and collection

Data for this analysis were collected as part of Save the Children's Saving Newborn Lives programme, which works in partnership with countries to reduce newborn mortality and improve newborn health. The adaptable Microsoft Excel-based Cost of Integrated Newborn Care (COIN Care) Tool (Daviaud *et al.* 2017) was designed to track the additional costs of implementing the CBMNC interventions across the continuum of care. The tool was designed to capture activities from the community to facility or district level, including any additional costs of increased utilization of health facilities prompted by home visits and community mobilization (Daviaud *et al.* 2010). It supported the collection of cost data from five effectiveness trials and two programme evaluations. Separate cost analyses for five of the seven studies have been published separately (Barger *et al.* 2016; Daviaud *et al.* 2016; Ekirapa-Kiracho *et al.* 2016; Greco *et al.* 2016; Manzi *et al.* 2016), as have cost-effectiveness analyses for two of the studies (Pitt *et al.* 2016; Mathewos *et al.* 2017), and effectiveness findings from the five trials (Kirkwood *et al.* 2013; Tomlinson *et al.* 2014; Hanson *et al.* 2015; Waiswa *et al.* 2015). The design of the trials is described in detail elsewhere (Schellenberg 2009; Kirkwood *et al.* 2010; Tomlinson *et al.* 2011; Waiswa et al. 2012). The data from Bolivia, Ethiopia, Malawi and Tanzania were obtained from project and surveillance databases. Country teams familiar with the respective home visit kits' content supplemented and verified all data, adding additional categories as needed, and extracted initial purchase cost of items and useful life years as required.

Data were collected in local currency values, inflated to constant 2015 values using the World Bank Consumer Price Index for each country, and converted to constant 2015 USD using the average exchange rates for the year 2015 (Walker and Kumaranayake 2002; OANDA 2015; World Bank 2015).

Where applicable, itemized costs were grouped according to the following subcategories to simplify interpretation: 'Bag, Clothing and Transport', 'Clinical Assessment Equipment and Drugs', 'Information, Education and Communication' (IEC) and 'Monitoring and Follow-up Tools'. The items within each of these subcategories are detailed in Figure 2.

## Descriptive comparative analysis of financial costs

We valued uniforms, equipment, medicines, supplies and transport by calculating their financial costs, representing their purchase costs, even if donated by another partner. To calculate EAC, adding capital and recurrent inputs together in a consistent fashion, we treated items that were used for more than 1 year as 'capital items' and

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**Figure 3.** Heat map: EACs of 1 CHW home visit kit per year by country in 2015 constant USD

those that were used for < 1 year as 'recurrent items'. We thus calculated the annual cost of capital inputs by applying a straight-line depreciation where the unit cost was divided by the estimated years of useful life, estimated by country teams familiar with the frequency of replacing these items (Walker and Kumaranayake 2002).

For countries where CHWs were provided transport or mobile phones, we allocated a portion of the cost based on the amount of time dedicated to CBMNC activities as CHWs were multi-purpose workers. In Bolivia and Ghana, their time was split between CBMNC and other activities and therefore 50% of bicycle costs were apportioned whereas in South Africa 100% of mobile phone, sim card and airtime costs were apportioned as CHWs worked exclusively for the CBMNC programme.

Recurrent costs were incurred for items which were provided to the mother and child pair, such as antibiotics, or supplies or for health promotional information distributed by CHWs to mothers. We therefore calculated the annual cost of medicine, supplies and gifts provided to mothers and newborns by multiplying the average cost per mother by the average number of mothers and newborns seen per CHW per year.

We present the EAC per CHW representing the annual cost of capital items plus the recurrent cost of supplies per CHW. This metric provides an indication of the budgetary provisions which must be made on an annual basis based on the observed level of utilization of the programme.

### Modelling scale-up analysis

We used a consistent approach to model the annualized financial cost of equipping CHWs to provide 95% of pregnant women in a catchment area of 100 000 people with four home visits for each of the seven programmes. The choice of four home visits is in line with the WHO and UNICEF Joint Statement on Home Visits for the Newborn Child which proposes at least three home visits (WHO *et al.* 2009). We estimated the expected number of pregnancies in each country based on the national crude birth rate in 2014 (World Bank 2015) and scaled to a population of 100 000. The average number of visits per CHW per week observed in each setting was used to estimate the number of CHWs required to visit 95% of expected pregnancies. We assumed that CHWs worked 48 weeks per year. We then estimated the number of CHWs required in each country to reach 95% of pregnant women with four visits by dividing the required number of visits by the average observed number of visits per CHW per year in each country. We thus assumed that average CHW activity rates would not change, but that the number of CHWs employed or engaged could be varied.

To estimate for each country the EAC of equipping CHWs for 100 000 population, we multiplied the required number of CHWs by the country's annual capital cost per kit and added the variable costs (required number of home visits multiplied by that country's average variable cost).

## Results

### 'Home visit kit' contents

The content of the CHW kits by category and their itemized EAC is presented in Figure 3. The EAC per CHW were highest in South Africa at $116 and lowest in Tanzania at $15 (Figure 3). The heat

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**Table 1.** Financial cost of equipping CHWs to cover a population of 100 000, assuming four target home visits per woman, in USD 2015

| Country | Total number or pregnancies expected in a population of 100 000 | Number of home visits required to achieve 95% coverage assuming four visits per mother | N visits actually performed per CHW per week | Total annual cost per CHW | Total cost of equipping CHWs in a population of 100 000 |
|---|---|---|---|---|---|
| Bolivia | 2840 | 9120 | 0.3 | $36 | $40 260 |
| Ethiopia | 3200 | 12 160 | 1.4 | $41 | $7464 |
| Ghana | 3300 | 12 540 | 1 | $39 | $7649 |
| Malawi | 3900 | 14 820 | 2.4 | $16 | $3051 |
| Tanzania | 3900 | 14 820 | 1.8 | $19 | $2693 |
| South Africa | 2100 | 7980 | 5.4 | $543 | $17 124 |
| Uganda | 4300 | 16 340 | 1.5 | $26 | $4472 |

map highlights which items drove the overall cost of equipping CHWs in terms of the EAC per CHW in each country.

## Bag, clothing and transport

All CHWs were equipped with a bag to carry supplies and support materials. The nature of this bag varied widely, e.g. in Malawi, Health Surveillance Assistants were equipped with a briefcase whereas in Tanzania CHWs were equipped with a locally made cloth sac. The EAC cost of the bag was highest in Bolivia and Ethiopia, estimated at $6.30 and $3.20 respectively and lowest in Tanzania ($0.60). Clothing or uniforms were provided in four of the countries (Ghana, South Africa, Tanzania and Uganda). In both Malawi and Ethiopia, CHWs were already employed and therefore the cost of their uniform fell outside of the scope of this analysis and is therefore not presented. In three of the seven countries, CHWs were provided with a bicycle. In Bolivia, as the intervention area was sparsely populated, CHWs were given a bicycle at an EAC of $16.40. In Ghana and Malawi, only CHWs charged with reaching remote areas were provided with a bicycle (e.g. only 28 of the 444 CHWs in Ghana). In Ghana, the average EAC of the bicycle was $12.80, whereas in Malawi, as these were already existing equipment, they were outside the scope of this costing exercise.

## Clinical assessment equipment and supplies

Scales for weighing the newborns were provided to CHWs in Ethiopia, Ghana and Malawi, at an EAC of approximately $1.00. In Tanzania, where CHWs had a limited clinical assessment role, a special counselling card was developed which incorporated a newborn foot length measurement tool to assess newborns for low birth weight and prematurity (Marchant *et al.* 2014). The newborn foot length tool cost $0.30 per card. Thermometers, used to detect hypothermia or fever and prompt referral, were also provided in Bolivia, Ethiopia, Ghana and Malawi, at an EAC of $1.40 in Ethiopia, $1.50 in Bolivia, and $6.50 in Malawi. The EAC of thermometers in Ghana was considerably less, estimated at $0.07. Timers for breath counting or watches were included in the CHW kits in Bolivia, Ethiopia, Ghana and Malawi. The EAC of these items ranged from $0.50 in Ghana to $5.90 in Malawi. These observed differences in costs may reflect the procurement mechanisms used by implementers, e.g. through UNICEF vs a local supplier, MoH etc.

Recurrent costs which are contingent on the level of activity were only a substantial part of CHW home visit kit EAC in Ethiopia as a result of administering antibiotics at the health posts. The EAC per CHW was $84, representing the cost associated with visiting 69 women per year. In Bolivia, the cost of supplies included items like soap, alcohol gel for umbilical cord care, batteries and cotton wool, at an EAC $7.40 per CHW (two mothers per year). The EAC associated with supplies per CHW were otherwise negligible (Figure 3).

## Information, education and communication

All CHW packages involved health promotion activities, generally communicating with the mother and family about importance of antenatal care, clean delivery practices, clean cord care, exclusive breastfeeding, thermal care for low birth weight babies and teaching mothers about danger signs. All CHWs were given IEC materials for this purpose. The EAC of these counselling cards was highest in Ghana and Malawi, at an ACE of $7.10 and $4.80, respectively. In Uganda and Ethiopia, counselling cards were reported to be considerably less expensive than in Malawi and Ghana, at $3.60 in Uganda and $1.90 in Ethiopia, but were replaced annually. The EAC associated with counselling materials were considerably lower in Tanzania, at only $0.08.

In Uganda, CHWs carried the government-endorsed 'Mama Kit' which all women are advised to bring to the health facility when they deliver. The estimated EAC of the Mama Kit was $5.00. In Tanzania, CHWs were provided with a locally made doll to demonstrate breastfeeding positioning and cord care, at an EAC of $2.70.

## Monitoring and follow-up tools

In Ethiopia, Ghana, Malawi, Tanzania and Uganda CHWs were equipped with a register at an EAC of $10.60 in Ethiopia and $2.10 in Tanzania. CHWs in South Africa were also equipped with a diary to keep track of their visit schedules. Only the Goodstart trial in South Africa provided CHWs with a mobile phone and SIM card to aid supervision, improve data quality, and facilitate referrals (Daviaud *et al.* 2016). At an EAC of $67.80 for the cell phone and SIM card, equipping CHWs with mobile phone was the greatest share of 'home visit kit' costs in South Africa, making the kits more expensive than those in other settings, accounted for 89% of total costs of equipping the South African CHWs (not including the promotional materials left with mothers), even though the South African package was limited to health promotion activities. Cell phone credit or airtime was $35.80 per CHW per year in South Africa.

'Mother cards' for women to track the care provided during pregnancy and after delivery were provided in Bolivia, South Africa and Uganda, at a cost per woman of $0.32 in Bolivia, $6.20 in South Africa and $0.08 in Uganda. In Uganda, CHWs assisted women in filling out a birth plan, indicating what was required, where they planned to deliver etc. Women in Uganda were also given a family card, informing them about danger signs and the steps to take. In South Africa, as each CHW saw an average of 62

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mothers, the EAC of these materials per CHW was $385 (data not shown in Figure 3). In Bolivia, women were provided with a basin as a gift costing ~$4.00 per mother and thus costing $8.00 annually as CHWs only saw an average of 2 mothers per year.

### Equipping CHWs at scale

The total expected number of pregnancies ranged from 2100 in South Africa to 4300 in Uganda in population of 100 000 (Table 1). In South Africa, CHWs were assumed to be able to perform 259 visits per year on average (based on the observed 13 h per week spent on home visits), whereas in Bolivia, only 14 visits were estimated per CHW per year (based on the observed 0.3 visits per week). Driven by differences in workload, only 31 CHWs were required in the peri-urban South Africa study setting with paid CHWs working full-time whereas 633 would be required in mostly rural Bolivia where CHWs are volunteers and thus worked fewer hours to cover 1995 and 2280 pregnancies respectively. In countries where CHWs were multi-purpose workers (Ethiopia and Malawi), able to dedicate less time to the programme compared with single-purpose workers, 181 CHWs would be needed in Ethiopia and 129 in Malawi to cover 95% of expectant mothers. These underlying dynamics translated to vastly differing EAC in terms of equipping CHWs (Table 1).

In a population of 100 000 with 95% coverage of expected pregnancies, under observed study conditions, EAC of equipping CHW was highest in Bolivia, at $40 260, driven by the low CHW activity levels (0.3 visits per week), and lowest in Tanzania, $2693 for 172 CHWs, driven by higher CHW visits per Week (1.8 visits per week) and lower kit costs (Table 1).

## Discussion

The EAC per CHW home visit kit can represent a substantial proportion of CBMNC programmes and influences affordability and financial sustainability. It is also fundamental to determining whether scaling up the programmes is achievable. Estimating these costs is therefore a crucial part of programme design and is influenced by the content of the visits, the cadre of the CHW and other contextual issues.

The development of these home visit kits is a complex process which hinges on what is seen as the appropriate level of care, and then, determining what is needed and affordable. Both local and international actors have weighed in on the content of the CHW home visit kits, not always considering the broader health system sustainability, resulting in substantial variation between countries, even for those CHWs carrying out similar functions. This is the first multi-country analysis of commodities used for CBMNC and our findings highlight major variations across countries. This article thus contributes to broadening this evidence-base by providing estimates of EAC per country as well as comparisons of this metric across countries.

The main drivers of EAC of the home visit kit per CHW varied between countries; however, in countries where CHWs undertook health promotion or clinical assessments, between 80–100% of EAC per CHW home visit kit per year were for items relating to this intervention/activity. As CHWs were often providing information and counselling or performing clinical assessments, they provided the mother and newborns with a limited number of items, resulting in relatively low recurrent costs in most settings. However, there are two notable exceptions to this where the item represented a substantially higher cost per mother than in the other countries; these were the basin provided to mothers in the Bolivian highlands and the health promotional materials provided to mothers in South Africa. In the case of Bolivia, in spite of a relatively high proportion of facility-based deliveries nationally, the population targeted in this intervention faces entrenched cultural barriers to access thus potentially justifying the provision of items in the home (Barger *et al.* 2016). The package studied in the Goodstart Trial in South Africa aimed to reduce mother to child transmission of HIV and promote exclusive breastfeeding in a poor peri-urban community. Women were responsible for acquiring clean birth kit items themselves in Tanzania. The cost of these items was not reflected in this analysis as the perspective adopted was that of the provider (Manzi *et al.* 2016). In Uganda, a Mama kit (clean birth kit) was provided free of charge by the government in Uganda but was provided via a different mechanism.

The only country that did not follow this pattern was Ethiopia where CHWs were charged with providing clinical assessments, including the administration of injectable antibiotics to treat sepsis at health posts (Ref. Mathewos *et al.* 2017, Supplement). The efficacy of these interventions and other health systems consideration (e.g. supply chains) should be considered in the assessment of costs. It has been argued by Sanders and Carver (1985) that 'equipping village health workers with curative skills does not simply provide health care to more people, more quickly and more cheaply, but it also gives the village health worker greater credibility in the eyes of the community'. It is also possible that CHWs' higher standing in the community could in turn improve the intervention's overall effectiveness. Sanders' argument is supported by CHW programmes which failed as a result of the disappointment about the limited range of services provided by CHWs (Lehmann *et al.* 2004).

Nevertheless, the decision to provide curative care must be rational, taking into consideration the incidence of infection or disease in the catchment areas covered by the CHW. For instance, for common childhood illnesses (diarrhoea, malaria or pneumonia), CHWs serving a reasonably small catchment area might see an average of approximately three cases per child per year for diarrhoea alone. The incidence of neonatal sepsis is considerably lower than these common illnesses (1 per 10 newborns), implying that a CHW might only be expected to encounter between one and two cases per year in a scenario like that of Ethiopia. The lower caseload makes ensuring that CHWs remain adequately trained and equipped with the appropriate supplies more challenging and raises the question as to whether the additional investment is ultimately cost-effective.

There are a number of other published studies of CBMNC with curative home care and more complex equipment, but none of these have provided detailed itemized EAC of the items comprising the CHW 'home visit kit'. In Nepal, CHWs were equipped with counselling cards, thermometers, scales and registers, with the addition of co-trimoxazole and a bag and mask and DeeLee suction. (Sitrin *et al.* 2013). However, as CHWs were not present at birth, the bag and mask were ultimately removed. In Pakistan, a cluster randomized control trial evaluated the impact of delivering a comprehensive neonatal kit, distributed through the Lady Health Worker programme, comprising a clean delivery kit, electronic scales, sunflower oil emollient, chlorhexidine, ThermoSpot, Mylar infant sleeve and a reusable instant heat pack—although this kit is described as 'low-cost' the amount is not specified (Turab *et al.* 2014).

The results of the modelling exercise underscore the importance that CHWs' workload has on the overall cost of equipping CHWs to meet the needs of most pregnant women in a given catchment area effectively. Differences in costs were therefore more of a function of the level of activity witnessed in each setting rather than the composition of the CHW home visit kit. This resulted in

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substantially higher costs when projected in a population of 100 000 people, even in countries where equipment had been intentionally very limited. As illustrated in the country-specific scenarios for scale-up, the time that CHWs are able to dedicate to the programme, increasing the number of mothers visited where possible, improves efficiency (Daviaud *et al*. 2017a).

## Limitations

This article contributes to the growing body of literature assessing CHW systems and more specifically those cadres engaged in conducting pregnancy and newborn home visits. We aimed to isolate the cost of equipment and supplies used by CHW for the purpose of the multi-country comparison to better inform decision-making, planning and budgeting. However, it is important to note the broader societal perspective, which includes indirect costs, thus covering all costs and all consequences (good or bad) no matter who incurs them and who faces them is valuable and should be the focus of future research. Furthermore, it is important to take into account the context, CHW cadre and the package content when considering these findings. For example, in the Bolivian highlands, this programme aimed to overcome entrenched cultural barriers to access and therefore the higher kit costs may still be considered acceptable to local policymakers given the higher health care expenditure per capita compared with the other countries.

The following limitations should also be considered. The depreciation of costs was based on self-reported estimates of the average rate of replacement, which are subject to reporting bias. This analysis does not take into account health systems level factors such as the cost of running the supply chain, which are fundamental to the study of commodities. These include the cost of procuring, storing, transporting drugs and other supplies. There are also some specific factors, for example, in both Ethiopia and Malawi, the workers are paid extension workers based in health posts. Some of their commodities were used for other interventions and not included under the applied definition of additional costs for CBMNC. This may underestimate the cost of commodities for these two programmes. Since the total commodities costs is not tracked routinely, we could not take into account what proportion the pregnancy and newborn home visits kit represented relative to the total equipment costs.

## Conclusion

This comparative analysis of CHW home visit kits raises important questions often overlooked in the discussion of CHW systems. These questions are relevant in light of current investments in community-based programmes (Singh and Sachs 2013). In the case of both health promotion and clinical assessment kits, the majority of costs associated with equipping CHWs were for capital items and did not depend on the number of home visits CHWs carry out. This was because newborns and mothers received only minor clinical interventions, often related to providing clean cord care. The cost of these capital items (some of which are shared to implement other interventions) should be considered in national discussions around the type of cadre and their workload. Where CHWs are multipurpose workers, careful consideration should be given to the current investment in CHWs and the relative cost of adding the promotion of essential newborn care or newborn clinical assessments to existing programmes. Adding curative care like antibiotics to CBMNC programmes, as in Ethiopia, shifted the breakdown of EAC from capital items to recurrent items. It also meant that other equipment, such as weighing scales, thermometers and breath counters, had to be added. Multi-country evaluations of cost-effectiveness are required to better inform the trade-offs that must be made by decision-makers considering investments in health promotion, clinical assessments and curative care provided by CHWs in the home.

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