Health Policy and Planning, 32, 2017, i75–i83
doi: 10.1093/heapol/czv133
Original Article

Bolivia programme evaluation of a package to reach an underserved population: Community-based maternal and newborn care economic analysis

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Accepted on 4 December 2015

Abstract

To address inequitable access to health services of indigenous communities in the Bolivian highlands, the Bolivian Ministry of Health, with the support of Save the Children—Saving Newborn Lives, conducted operational research to identify, implement and test a package of maternal and newborn interventions using locally recruited, volunteer Community Health Workers (vCHW) between 2008 and 2010. The additional annual economic and financial costs of the intervention were estimated from the perspective of the Bolivian Ministry of Health in two municipalities. The cost of intervention-stimulated increases in facility attendance was estimated with national surveillance data using a pre–post comparison, adjusted for secular trends in facility attendance. Three scale-up scenarios were modelled by varying the levels of coverage and the number (per mother and child pair) and frequency of home visits. Average cost per mother and average cost per home visit are presented in constant 2015 US$. Eighteen per cent of expectant mothers in the catchment area were visited at least once. The annualized additional financial cost of the community-based intervention across both municipalities was $43 449 of which 3% ($1324) was intervention design, 20% ($8474) set-up and 77% ($33 651) implementation. Drivers of additional costs were additional paid staff (68%), 81% of which was for management and support by local implementing partner and 19% of which was for vCHW supervision. The annual financial cost per vCHW was $595. Modelled scale-up scenarios highlight potential efficiency gains. Recognizing local imperatives to reduce inequalities by targeting underserved populations, the observed low coverage by vCHWs resulted in a high cost per mother and child pair ($296). This evaluation raises important questions about this model's ability to achieve its ultimate goals of reducing neonatal mortality and inequalities through behaviour change and increased care seeking and has served to inform innovative alternative models, better equipped to tackle stagnant inequitable access to care.

Keywords: Community Health Workers, geographic barriers to access, home visits, maternal health, newborn, volunteer Community Health Workers

Key Messages

- Volunteer Community Health Workers (vCHW) in the rural, sparsely populated, Bolivian highland conducted many home visits per mother (an average of seven visits per mother/child pair) but had contact with few mothers during the study period, leading to low overall coverage (only 18% of women received at least one visit from a vCHW).
- Management costs represented by far the greatest share of total costs, raising important questions about the efficiency of the programme's management structure.
- The cost per mother/child pair for this package in a 100 000 population at 95% coverage was $35.
- The observed low level of vCHW activity demands that the documented advantages of low-intensity, volunteer-based models must be weighted carefully against the efficiency gains of higher intensity models of community-based care, while recognizing the local imperatives to target underserved communities where a large share of newborn morbidity and mortality is now concentrated.

Introduction

Although Latin American and Caribbean countries have greatly reduced child and infant deaths, the reduction of mortality during the first 28 days of life (the neonatal period) has proven more difficult (Haws *et al.* 2004; Lawn *et al.* 2014). Newborn deaths now represent over half (53%) of all under-five deaths in the region (Benguigui *et al.* 2007) and 55% of those in Bolivia (20 per 1000 live births) (Box 1) (UN Inter-agency Group for Child Mortality Estimation 2015). Inequitable access to reproductive health care of historically marginalized groups has been a barrier to improving maternal and newborn health in Bolivia. Sixty-eight per cent of women in the bottom wealth quintile gave birth at home compared with one per cent in the highest quintile (Coa *et al.* 2009). Exogenous factors including female literacy, geographic barriers, and for indigenous people, inequality and discrimination, are responsible for 60% of this exclusion from the health care system; endogenous factors such as low coverage, poor quality of care and the non-responsiveness and/or incapacity of health care providers, especially vis-à-vis indigenous populations, account for the other 40% (UDAPE 2004; PAHO 2009).

Beginning in 1996 with the National Childhood and Maternity Insurance (National Decree No. 24303), the Bolivian Ministry of Health (MOH) has progressively extended the coverage of health services for pregnant women and children under five. The complementary 'Community, Intercultural and Family Health Policy' (SAFCI) aims to address entrenched cultural barriers to access by acknowledging the communities' understanding of health and by incorporating traditional remedies into the health services. In addition to these specific policies, there have been significant government investments in reproductive, maternal, newborn and child health. In 2012, 206 million US dollars were spent, representing nearly a quarter (24.4%) of total spending on health and 3.4% of government spending overall (Dupuy 2014). Furthermore, relative to other indicators, the government is estimated to cover 76.8% of

Box 1 Bolivia at a glance

	Bolivia
Total population 2014	10 561 887
Millennium development goal progress	
Improve Child Survival (MDG4)	Met
Improve Maternal Health (MDG5)	Not met
Child and newborn mortality data	
Number live births (2015)	253 000
Neonatal mortality rate per 1000 live births (2015)	20
Annual number of newborn deaths	5000
Mortality rate per 1000 live births for children under-5 (2015)	38
Annual number of child deaths under-5	9000
Health system (2007–14)	
Number of nurses and midwives (2011)	10 139
Nurses & midwives per 10 000 (2007–13)	10.1
Skilled[a] attendant at birth	84%
Antenatal care coverage[b], >1	86%
Antenatal care coverage[b], at least ×4	59%
PNC for mothers, within 2 days (2008)	77%
Under-fives with suspected pneumonia receiving antibiotics	64%
Overseas Development Assistance (ODA) 2010	
ODA (US$) to 0–5 year olds from all donors	1 234 922

Context Community Care: Volunteer Community Health Workers, Community Health Workers, supported by a local NGO (APROSAR), have been engaged in IMCI. Postnatal home visits were integrated into this package

Data sources: Population data (The World Bank); Skilled attendant at birth, <5s receiving antibiotics; ANC coverage and number of nurses and midwives per 10 000 (World Health Statistics 2015, WHO); neonatal and under-five mortality (UN Interagency Group for Child Mortality Estimation 2015); number of nurses and midwives (WHO-Data by country); annual live births and PNC coverage (Countdown: 2010–2015 Profile); ODA (Pitt 2012; Hsu 2012 using OECD data).

Note: Number of nurses and midwives and PNC are for the most recent year.

[a]Doctor, nurse or midwife.

[b]Percentage of women (aged 15–49) attended by any provider.

expenditure on reproductive, maternal, newborn and children health vs 13.3% of out-of-pocket expenditure (Dupuy 2014). Despite these efforts, 43% of the population still cannot exercise their right to access health care (Dupuy 2011).

Community-based interventions have been shown to be an effective means of extending health services to the most isolated and often poorest communities and improving health outcomes (Rich *et al.* 2012; Kim *et al.* 2013). Evidence suggests that such programmes targeting newborns, infants and children can, if well implemented, successfully reduce mortality and improve healthy behaviours (Baqui *et al.* 2009; Lassi *et al.* 2010; Bhutta *et al.* 2014). The WHO and UNICEF recommended postnatal home visits as a complementary strategy to facility-based assisted deliveries in 2009 (WHO *et al.* 2009). Strategies involving pregnancy and newborn home visits have since been widely adopted and integrated into existing maternal and child health programmes throughout Asia, Africa and Latin America (Liu *et al.* 2011). With questions about the feasibility of these interventions in a Latin American setting and their cost-effectiveness still unresolved, Save the Children—Saving Newborn Lives (SNL) Bolivia partnered with the MOH and la Asociación de Promotores de Salud de Area Rural (APROSAR), a local non-governmental organization (NGO), to conduct operational research to identify, implement and test the effectiveness of a package of pregnancy and newborn care delivered through home visits.

The aim of the main intervention was to identify and validate a minimum package of services to improve maternal and neonatal care at both the community and health facility level. The intervention comprised three priority strategies for delivering postnatal care (Koblinsky 2005): a community delivery-based strategy using vCHW, an outreach by skilled personnel-based strategy and finally, a health services-based strategy. Since 1999, NGOs have worked with locally recruited, vCHW who perform pregnancy visits, deliver Integrated Management of Childhood Illnesses (IMCI), and occasionally attend home deliveries with or without the support of a trained health worker. This study integrated postnatal home visits into this package of interventions. vCHWs were trained and equipped to: monitor respiration, take temperature, manage breastfeeding problems and identify danger signs for mothers and newborns and, if needed, refer mothers and newborns to health facilities. One part-time supervisor from APROSAR was assigned to support approximately 35 vCHWs in each municipality by reinforcing maternal and newborn care messages.

The primary aim of this article is to isolate the additional costs of integrating maternal and neonatal home visits into the IMCI programme from the perspective of the provider, the MOH. We estimate the additional economic and financial costs of the community-based programme and the resulting costs of increased facility-utilization. The secondary aim, to evaluate the programme's sustainability and feasibility at scale, was addressed by modelling different efficiency and coverage scenarios of vCHW-provided antenatal and postnatal services in the home to determine the financial and human resource implications.

Methods

Study context and timeline

Local health authorities selected five municipalities for the implementation of the community programme in the Oruro Department in the Bolivian highlands (Altiplano). Oruro has one of the highest neonatal mortality rates (23 deaths per 1000 live births) in Bolivia (Coa *et al.* 2009). Corque and Caracollo, two of the municipalities, were chosen for the costing exercise, which was conducted in 2010. Corque is rural whereas Caracollo is peri-urban. The main economic activity in both municipalities other than subsistence farming was informal trade. The communities are therefore relatively mobile, often migrating for economic opportunities elsewhere. Corque has a population of 11 200 and Caracollo 24 500. Each municipality has a district hospital and refers serious cases to the Oruro central hospital. Figure 1 provides a timeline of the design, set-up and programme implementation covered by the costing exercise.

Data collection

The human resources and finance departments at the Saving Newborn Lives II and APROSAR provided data on costs for salaries, equipment and maintenance. The MOH supplied unit costs of drugs and laboratory tests used at facilities. To assess the economic

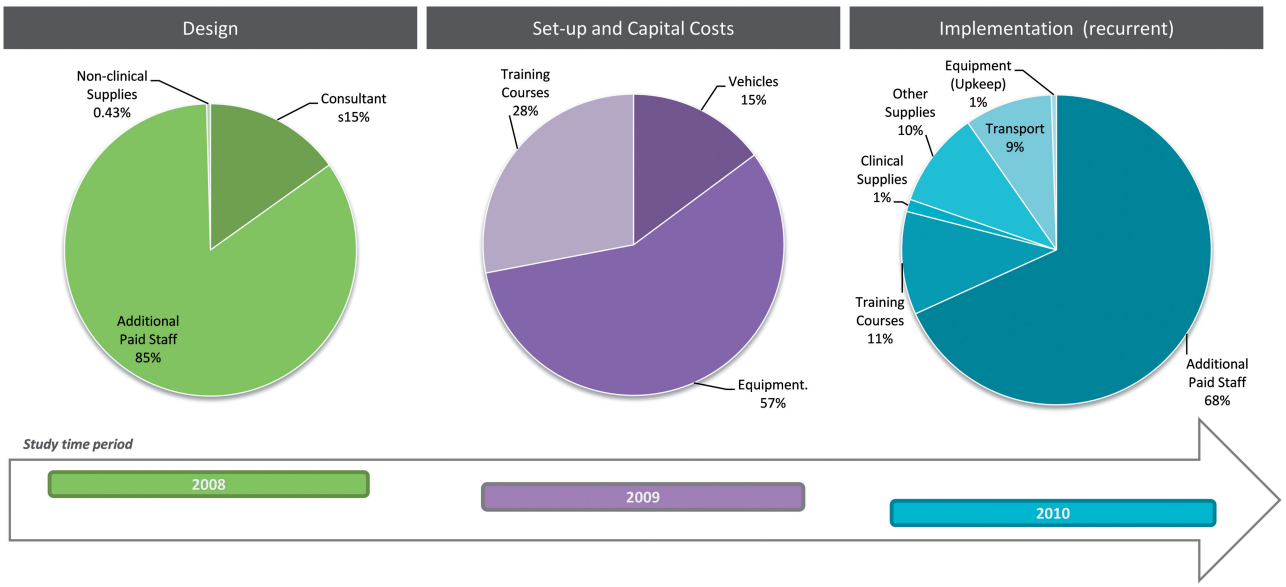

Figure 1. Distribution of the input costs by phase—design, set-up and implementation and study time period

costs of acting as a vCHW, the national minimum wage in 2010 as reported by the National Institute of Statistics [679.50 Bolivian Bolivianos (BOB)/month] was applied as a shadow price (INE 2015). For capital items, the replacement cost in the base year was applied.

Activity data, specifically the number and type of home visits conducted by vCHWs, were retrieved from the programme's monitoring and evaluation system. We extrapolated the number of additional facility visits resulting from the programme from MOH estimates of facility utilization. From facility records, we collected the quantity and type of medicines and tests provided at facility-based antenatal and postnatal visits.

Data collection and entry were performed by local project staff and supervised by a senior health economist. Queries regarding specific data items were addressed as required by local project staff and corrections made accordingly.

Analysis of costs

We used the Cost of Integrated Neonatal (COIN) Care Tool, a Microsoft Excel-based tool, designed by the South African Medical Research Council, to harmonize the collection of economic data and track the additional costs of providing newborn health packages at the community level together with their impact on increased facility activity (Daviaud *et al.* 2010). The methodology of the COIN tool is described in detail elsewhere (see Supplementary Data Web Annex, Section B). The COIN care tool aims to facilitate the collection and standardization of economic data by providing a user-friendly Excel-based format, complete with pre-defined yet modifiable categories, validated cells, linked sheets and automatic calculations (e.g. adjustment for inflation). Economic data can therefore be easily summarized from different perspectives (e.g. funders or MOH) by those with intermediate knowledge of Excel.

All costs were recorded in the local currency: BOB, adjusted for inflation to the base year (2015), and converted into 2015 US dollars ($US 1 = 6.74 BOB) (Kumaranayake 2000; OANDA 2015). The average annual rate of inflation between 2008 and 2015 was 4.8% (Trading Economics 2015).

We performed the analysis from the perspective of the provider, excluding costs related to research or incurred by households. Given the similar levels of input in terms of number of vCHWs, supervisors (one part-time) and similar numbers of mothers visited in the two municipalities, we have presented the combined total input costs. Both economic and financial costs were broken down between design costs (one-off costs which will not be incurred if the programme is rolled out to another district, i.e. design of programme, design of training and materials), set-up costs (costs which will occur if the programme is rolled out in a new district, typically printing of material, recruitment, initial training and kits) and those costs associated with 1 year of implementation.

Capital investments (furniture, computers and vehicles) were annualized using straight-line depreciation, dividing total costs by the number of useful life years (Walker and Kumaranayake 2002). For the vCHWs' bicycles, 50% of the bicycles' costs were allocated to the programme as the bicycles were also used for IMCI activities. For vCHW supervisors' motorbikes, including the cost of maintenance, 17% of the total costs were allocated to the programme as supervisors spent an average of 1 day a week on programme-related supervision. Non-capital costs associated with setting-up the intervention were annualized over the duration of the programme: 3 years. Retraining was estimated to occur every 1.5 years on average based on expert consensus. To calculate economic costs, a 3% discount rate was applied. To simulate routine health services delivery, we substituted SNL project staff's salaries with their Bolivian equivalents, derived by taking an average of the actual costs to the employer (APROSAR) of those cadres in 2010. As salaried health officials did not work overtime to accommodate the programme, we did not include any portion of their salaries in our calculation of additional costs. Saving Newborn Lives' overhead and management costs were directly allocated on a one to five basis as the programme covered five municipalities. APROSAR's overhead and management costs were allocated based on the municipality's share of the programme's vCHWs and supervisors.

To allow for budgetary projections for implementation in a new municipality, we excluded the one-off design costs and assessed the cost per mother and child pair and the cost per home visit for the intervention. We calculated the average additional financial cost per activity by adding the annualized set-up costs (capital and non-capital costs), and 1-year recurrent implementation cost and dividing by number of activities conducted. To assess the programme's sustainability, we calculated the annualized costs per capita based on the total population of the intervention's catchment area and presented it as a percentage of public health expenditure per capita, estimated most recently in 2013 as $174 and inflated to $188 in 2015 (World Bank 2014). To inform scale up, specifically the impact of higher coverage and greater frequency of home visits on average cost per home visit, input costs were broken down in terms of fixed costs (vCHW training, kit, bicycle and supervision) and variable costs which vary with the level of activity (supplies).

Impact of the community programme on health facility utilization

To evaluate the impact of the community programme on health facility utilization, we obtained baseline estimates for the number of antenatal, delivery and postnatal attendance in health centres and district hospitals in the two municipalities under study and the two control municipalities (Challapata and Salinas de Garcí Mendoza, also in Oruro) in 2008–09. We estimated the increase in facility attendance stemming from the programme by comparing the increase in facility attendance in the intervention municipalities during the following year, 2009–10, minus the secular trend observed in the control districts over the same period. Drugs and laboratory costs per type of visits were calculated through record reviews at Corque and Caracollo health centres. The average drugs and labs cost per type of visit were applied to the additional number of facility visits due to the programme.

Modelling of scale-up

We modelled the resource implications, the cost per mother/child pair and the cost per home visit of different scenarios by increasing the levels of coverage, varying the number of home visits per mother/child pair and increasing the level of activity of the vCHWs

- **Scenario 1: Target coverage and target number of home visits per mother:** We assumed that 95% of pregnant women in the community were visited by a vCHW and that each vCHW conducted seven home visits per mother/child pair.
- **Scenario 2: Increased coverage, workload and therefore efficiency in the study area:** We assumed that vCHWs increased their level of activity from a rate of 0.3 visits per week to one visit/week (representing 3 h per week spent on the combined activities of the intervention, allowing for time to be spent on IMCI activities). Each vCHW would perform 48 visits/year compared with the observed 14 visits per year. We applied this

scenario at high coverage (95%), assuming mother and child pairs were visited either seven times (2a), as observed, or four times (two antenatal and three postnatal) (2b).

- **Scenario 3: Standard population of 100 000 with Bolivia's 2013 crude birth rate (25.95 per 1000):** We assumed higher levels of CHW activity (one visit per week) and fewer visits per mother/child pair (four vs seven home visits) (Scenario 2b). We modelled the assumptions of Scenario 2b in a population of 100 000 at three levels of coverage: 50%, 70%, and 95%.

For all three scenarios, we held the ratio of vCHW to part-time supervisors constant [35 vCHW per 17% Full-Time Equivalent (FTE) supervisor] and assumed that each vCHW could perform a maximum of 48 visits per year or 114 h per year on home visits. The management overheads costs were held constant as these were likely to be an over estimation due to the fact that the organization managed only five municipalities.

For Scenario 3, we assumed that the increase in facility utilization and its associated cost increased proportionally with the increase in the number of women visited.

Results

Coverage of the community-based programme

A total of 781 deliveries occurred (200 in Corque; 581 in Caracollo) during the year of implementation under study. The facility-based delivery rate was 15% in Corque and 41% in Caracollo. Corque and Caracollo had a similar number of vCHWs: 35 for the former and 36 for the latter. vCHWs were similar in terms of their background; they were mainly women and members of the communities they served. vCHWs also visited a similar number of mother and baby pairs: respectively, 71 and 72. Coverage, defined as the percentage of pregnant women in the community receiving least one visit, was 36% in Corque and 12% in Caracollo or on average 18% coverage for both municipalities.

A total of 575 home visits were conducted in Corque, equally distributed between antenatal and postnatal visits. In Caracollo, 420 home visits were conducted, 76% of which were postnatal home visits. vCHWs visited two mothers on average during the year, performing on average seven home visits per mother. In both municipalities, vCHWs conducted less than one home visit per week, averaging between one and two per month in Corque and less than one per month in Caracollo. The average level of activity for both municipalities was estimated to be less than one visit every three weeks (0.3 visits per week).

Costs of the community-based programme: 2009–10

As illustrated in Table 1, annualized additional economic costs of the community-based intervention were $44 648. Financial costs were $43 449 of which 3% ($1324) was allocated to the intervention's design costs, 20% ($8474) to set-up and 77% ($33 651) to recurrent implementation costs. After excluding design costs, annualized additional financial costs amounted to $42 125, of which management and overheads were the main cost driver (56%), vCHWs equipment and training 25%, supervision (salary, training and transport) 16% and 3% consumables for mothers and babies.

The distribution of non-annualized financial costs by phase is presented in Figure 1 for the three phases of the community-based intervention. In the design phase, they were $3972 (Table 1). The main drivers were the human resources required to design both the manuals and the training material (85%).

Non-annualized financial set-up costs including capital costs, which would be incurred up front if the programme were rolled out to another municipality, were $26 561. Equipment represented the greatest share, 57%, the share of the managing NGO's, APROSAR, furniture and computer equipment was $15 279 and the vCHWs kits $3009. Vehicles represented 15% of set-up costs and included one bicycle per vCHW and a motorcycle per supervisor (17% of a unit cost of $1385). Initial training of vCHWs, represented 27% of costs during the set-up phase, costing $7309, $102 per trainee.

The total recurrent costs associated with the community-based programme for 1 year of implementation were $33 651. The main drivers were staff cost (68%), totalling $23 096, of which $18 614 represented management and support by APROSAR and the remaining $4482 was attributed to the 17% of an FTE spent by supervisors on the community programme. Although vCHWs did not receive a stipend, refresher trainings were carried out at regular intervals (every 18 months), costing $3645 in the period under study.

Costs associated with additional facility attendance in 2009–10

Data from the routine health information system did not show variations in the number of antenatal or postnatal facility visits which could be attributed to the programme, and only a very small increase (1%) in deliveries. Five additional facility deliveries were attributable to the programme. Although this variation is not statistically significant, drugs prescribed and laboratory tests were recorded as additional costs ($94). No additional staff were recruited or paid for overtime. This assumption was corroborated by a review of the staff utilization in health centre records that indicated underutilization of current staff as a result of persistently low levels of facility-based deliveries.

Cost of rolling out the programme: analysis of recurrent costs

Combining annualized set-up and implementation costs, Table 2 presents the financial costs broken down into fixed costs, which must be incurred regardless of activity levels, and variable costs, which fluctuate with activity levels, per vCHW, per mother/child pair and per home visit.

Table 1. Additional financial and economic costs according to phase of implementation, in US$ 2015

Costs US$ 2015	Pre-implementation costs				Recurrent (1 year)	Annualized set-up and recurrent implementation
	Total costs		Annualized costs			
	Design	Set-up	Design	Set-up		
Financial	3972	26 561	1324	8474	33 651	42 125
Economic	3972	29 029	1324	8828	35 820	44 648

Table 2. Annualized fixed and variable activity costs in $US 2015

	Cost (2015 US$ annualized)				
	Total (combined)	% of total annualized costs	Per CHW ($N = 71$)	Per mother/child pair ($N = 143$)	Per home visit ($N = 995$)
Variable costs					
Consumables (home visits)	1186	3	17	8	1
Consumables (facilities)	94	<1	1	0.65	.09
Variable costs total	1280	~3	18	9	~1
Fixed costs (home visits)					
Community Health Worker	10 688	25	151	75	11
Supervision	6553	16	92	46	7
Management and overhead	23 699	56	334	166	24
Fixed costs total	40 939	97	577	287	42
Grand total	42 219	100%	595	296	43

Table 3. Fixed and variable cost breakdown of Community Health Worker (CHW) kit content

Category	Description	Actual cost per item	Annualized or recurrent costs per year
Fixed costs			
Equipment	Bag	8.2	2.7
Clinical Assessment Equipment	Thermometer	4.5	1.5
	Timer for breath counting	6.2	2.1
Information, Education, and Communication (IEC) Materials	Counselling cards/Job aids (held by CHW)	17.7	5.9
Other	Soap box, ink pad	3.1	1.0
Total fixed costs		39.70	13.20
Variable recurrent costs			
Medical supplies	Cotton wool	1.23	3.01
	Soap, alcohol gel	1.35	1.39
Stationary	Referral slip	0.74	0.74
Consumables	e.g. Batteries (avg. cost per year)	0.37	0.74
Total variable costs		3.70	2.6
Grand total		43.40	19.12

Fixed costs per vCHW include vCHW costs (e.g. training, bicycle and kit), supervision (e.g. transport and salary) and finally management and overhead. Together these represented 97% of the annualized set-up and implementation costs. The largest share was management and overheads, which represented 56% of programme costs at $23 699. Costs associated with vCHWs were 25% of total costs whereas those associated with supervision were 16% of total annual costs. Variable costs, accounting for the remaining 3% of annual costs, represent the additional drugs consumed at facilities and the replacement of vCHW kit supplies. With variable costs being so low, the analysis of costs per vCHW, per mother visited or per home visit is calculated for the two municipalities combined, despite differing number of home visits. The annual cost per home visit was $43 whereas cost per mother–child pair during the year of implementation averaged $296 (Table 2).

Annualized costs per vCHW were $595, 97% of which were fixed and only 3% of which were variable costs. Volunteer CHWs, whose main duties were health promotion activities, were equipped with a blanket, a digital thermometer, a watch, alcohol gel, soap and cotton wool. The total annualized cost of the kit amounted to $19.12. The main drivers were job aids, including information, education and communication materials (IEC), carried by vCHWs cost $5.90. The vCHWs' bag to carry the kit supplies cost $2.70 (Table 3).

Supervision costs represented 16% of annualized recurrent costs. As supervisors were not trained for the programme nor provided with additional supplies, the only fixed cost associated with supervision of vCHWs was the motorbike, with only $256 allocated to the programme annually, and their salaries. Variables costs included remuneration and the costs associated with transportation, e.g. petrol and maintenance of motorbikes (Table 2).

With the community-based intervention's observed cost structure and its current coverage levels (18% of expectant mothers in the catchment area), the annualized cost of the programme expressed in cost per capita (total population) amounted to $0.86, representing 0.63% of the annual public health expenditure per capita, estimated in 2013 at $174, and equalling $188 in 2015 US$ (World Bank 2014).

Modelling of scale-up costs

Scenario 1: target coverage (95%) and target number of home visits per mother (seven)

As only 18% of pregnant women in the community took part in the programme, the coverage of pregnant women was far from optimal. Scenario 1 examines the resource implications of achieving target coverage (95%) and target number of home visits (seven) per mother. At this higher level of coverage but keeping an average of

Table 4. Bolivian programme actual costs and standardized modelled costs for three scenarios

	Actual	Scenario 1: Gold standard	Scenario 2: Increased CHW workload and efficiency		Scenario 3: Standardization to		
					100 000 total population		
	Average number of achieved visits	Target visits	Target visits (7) [2a]	4 visits [2b]	Single purpose CHW – Average 4 visits per mother		
Coverage	Achieved	Target	Target	Target	Variable		
% of potential mothers visited	18	95	95	95	50	70	95
Activity							
Number mothers visited	143	742	742	742	1298	1817	2465
Number visits/mother	7	7	7	4	4		
Total home visits	995	5194	5194	2968	5190	7266	9861
Number CHWs	71	371	108	62	108	151	205
Number mothers per CHW/year	2	2	7	12	12	12	12
Visits per CHW/week	0.3	0.3	1	1	1	1	1
Time							
% CHW time on programme	na	na	na	na	na	na	na
Supervisors FTEs	0.34	1.77	0.52	0.30	0.52	0.72	0.98
Cost							
Cost per mother ($)	295	162	76	58	44	39	35
Cost per home visit	42	23	11	14	11	10	9
Programme cost	42 219	120 365	56 648	42 735	56 989	70 305	86 951
Programme cost as % public health expenditure in 2013 inflated to 2015 US$ ($188)	0.63	1.79	0.84	0.64	0.30	0.37	0.46

0.3 visits per vCHW per week, 371 vCHWs would be required and 1.77 FTE supervisors. Due to the increase in the coverage, cost per mother would decrease from $295 to $162, and the cost per home visit would fall by 45%, from $42 to $23 (Table 4).

Scenario 2: increasing coverage, workload and therefore efficiency of vCHWs in the study area

Scenarios 2a (seven visits per mother) and 2b (four visits per mother) focus on optimizing time spent by vCHWs on the intervention (Table 4). With vCHWs performing one visit per week vs the observed average of 0.3 visits/week, an increase of (271%), it was assumed that the number of mother and child pairs visited per vCHW would increase. At seven visits per mother and child pair, this increase in activity would translate to seven mother and child pairs per vCHW per year compared with the current two. At only four home visits per mother and child pair, vCHWs would be able to attend to 12 mother and child pairs per year. In Scenario 2a, the cost per mother would decrease by 53%, from $162 to $76. By reducing the number of visits per mother from seven to four, the cost per mother would further decrease to $58, although the cost per home visit would increase.

Scenario 3: standard population of 100 000 with Bolivia's crude birth rate (25.95 per 1000)

Table 4 presents the assumptions of Scenario 2b for a total population of 100 000 with Bolivia's 2013 crude birth rate. We estimated that 2595 pregnancies would be expected per year. At 95% coverage, the cost would be $35 per mother and $9 per home visit. The annualized cost of the intervention would be $86 951, representing 0.46% of public health spending per capita.

Discussion

Integrating pregnancy and newborn home visits into the wider IMCI programme using vCHWs from the communities they serve was found to be acceptable and feasible in the Bolivian highlands. Furthermore, even at current levels of activity, which were relatively low when compared with other vCHW programmes (Ref. Uganda paper of this supplementary data), the community-based programme as it was implemented in the two municipalities under study represents a very small proportion of public sector health expenditure per capita at 0.63%, speaking to its affordability. Although the observed coverage was low (18%), programme costs would not increase significantly with target coverage of 95% if the efficiency of vCHWs were improved.

A number of bottlenecks have been hypothesized to have hindered the implementation of this programme, making the improvement of maternal and newborn health in this community unlikely. Firstly, both municipalities had low population density compared with CHW-lead interventions in other settings. This may have made it challenging to reach expectant mothers with appropriate care 'on time', especially in the case of postnatal visits in the first week of life. Lower population density also implies a higher ratio of vCHW to the population. Secondly, as this intervention was implemented in collaboration with a local NGO, the supervisors were project managers rather than health workers. The lack of a formal link with the existing health system may have limited vCHW ability to identify expectant mothers and provide prompt follow up in the community. Finally, as the vCHW were not paid and asked to intervene on a part time basis, they may have been required to choose between health promotion duties and income generating opportunities. As this programme was implemented during a period of economic transition in the communities under study, the intrinsic motivations of the vCHWs who were part of this intervention may have been affected. These communities, historically close-knit and relatively sedentary, began to enter the flows of rural to urban economic migration during the study period. These changing economic forces may have limited the ability of the programme's managers to maintain the motivation of recruited vCHWs.

In the two study municipalities, vCHWs saw on average two women per year, conducting on average seven home visits per mother/child pair. This implies that vCHWs conducted less than one home visit every 3 weeks. If vCHW performed four visits as opposed to seven, two antenatal and two postnatal, even fewer vCHWs would be required to achieve 95% coverage (39 vs the 71 involved in the programme). In the most ambitious scenario modelled (Scenario 3) at high coverage, the additional cost per mother/baby pair decreased from the observed $295 to $35.

This costing exercise revealed that the vast majority (97%) of additional costs was fixed. Fixed costs represented the training and capital costs, the bicycles provided to vCHW and motorbikes provided to supervisors, as well as supervisors' salaries. The relatively high costs of training and bicycles for vCHWs raise concerns about the limited coverage achieved due to low activity levels. However, the most significant portion of these fixed costs was attributed to management and overhead, representing over half of the programme costs. This high percentage is largely due to the fact that the current management organization only covered the five municipalities of the programme, and is thus likely to be an over estimation of the costs associated with rolling out this programme across more municipalities. The level of management and overhead was maintained in each of the scale-up scenarios rather than increased proportionally relative to the increase in the catchment area. The management requirements should likely be reassessed to determine the optimal number of municipalities that can be managed to ensure that ambitious scale-up proposals do not inadvertently weaken the programme by spreading time and resources too thin. If the existing management structure were extended to support other municipalities, the management cost per municipality would in turn decrease substantially.

Limitations

Although this study adds to the ongoing debate about the ideal components of community-based subsystems, these findings should be interpreted keeping the following limitations in mind. This study focussed primarily on the additional financial costs of integrating community-based antenatal and postnatal programme into the IMCI. This relatively narrow perspective has limited our ability to assess the overall efficiency of the encompassing health system.

Although we have successfully described the cost profile of the implemented programme and attempted to identify the costs drivers to inform further implementation or modifications to the implemented model, the results of the sensitivity analysis indicate that the total additional costs are sensitive to changes in remuneration, equipment level, and how vCHW are incentivized.

It is ideal to present new packages of interventions in terms of their cost-effectiveness. For example, the additional cost of integrating community-based antenatal and postnatal programme into the IMCI should ideally be assessed in terms of lives saved. Unfortunately, we lacked the outcome data on neonatal mortality to perform this level of analysis.

Furthermore, for the sake of consistency, we have relied on World Bank estimates for per capita health expenditure. These estimates may vary slightly from nationally produced estimates.

Conclusion

With growing global interest in innovative strategies for reaching the poorest families, especially in middle income countries, this study adds key evidence to the debate over the ideal 'community health worker subsystem' (Hongoro and McPake 2004). Although there is considerable literature on the role that CHWs play as trusted interlocutors who are able to access otherwise isolated communities, in this setting, the CHW workloads were very low and cost per woman much higher than other countries (Daviaud *et al*., 2017a). This raises important questions about this model's ability to achieve its ultimate goals of reducing neonatal mortality and inequalities through behaviour change and increased care seeking. The design of this intervention was clearly limited by the narrow assumption that CHW home visits were the primary model to achieve these goals. This programme evaluation has served to inform alternative models, potentially better equipped to tackle stagnant inequitable access to care by overcoming the cultural barriers to access faced by communities with a disproportionally high burden of newborn deaths.

Funding

This supplement publication cost was supported by the Health Systems Research Unit, South African Medical Research Council. The "Cost of Integrated Newborn (COIN) Care Tool" was developed by the South African Medical Research Council and funded by Save the Children's Saving Newborn Lives (SNL) programme.

Ethical Clearance

This study was performed using aggregated data and therefore did not require ethical clearance.

Conflict of interest statement. None declared.

Supplementary Data

Supplementary data are available at *HEAPOL* online.

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