Costs and coverage of community health worker-led hypertension and diabetes screening in rural Lesotho (ComBaCaL): cost–consequence analysis of a cohort study

Nicoló Spaolonzi, Ravi Gupta, Giuliana Sanchez-Samaniego, Frédérique Chammartin, Alexander W Carter, Thesar Tahirsylaj, Fabian Raeber, Malebona Mathulise, Thuso Kabi, Mosoetsi Mokaeane, Malehloa Maphenchane, Manthabiseng Molulela, Makhebe Khomolishoele, Mota Mota, Sesale Masike, Matumaole Bane, Mamoronts'ane Pauline Sematle, Retselisitsoe Makabateng, Lebohang Sao, Mosa Tlahali, Malitaba Litaba, Pauline Grimm, Pedram Sendi, Alain Amstutz, Felix Gerber, Niklaus Daniel Labhardt**

Summary

Background **Community health workers (CHWs) could increase access to hypertension and diabetes screening and diagnosis in low-income and middle-income countries, particularly in rural areas. However, evidence from larger-scale real-world projects on the costs and reach of CHW-led combined hypertension and diabetes screening is scarce. We aimed to assess the coverage and costs of a combined hypertension and diabetes screening intervention run by CHWs in Lesotho by use of a clinical decision support application run on an electronic tablet.**

Methods **This is a prespecified cost–consequence analysis of the prospective Community-Based Chronic Care Lesotho (ComBaCaL) cohort study. CHWs in 103 villages in rural Lesotho were trained and equipped to offer hypertension and diabetes screening, by use of a specifically developed clinical decision support application (ComBaCaL app) based on the open-source Community Health Toolkit run on an electronic tablet. Each village had a median of 49 households (IQR 41–61) and was managed by one CHW. For this cost–consequence analysis, we assessed the screening coverage among eligible participants (aged ≥18 years for hypertension screening; aged ≥40 years or aged ≥18 years with BMI ≥25 kg/m^2 for diabetes screening) and costs per person screened and diagnosed. We used a combined bottom-up and top-down approach for the cost analysis, using financial records of local implementing organisations. We subsequently developed two costing models: the project model included all research expenses and the routine model reflected real-world implementation costs. The main endpoints of this analysis were coverage of hypertension and diabetes screening and diagnosis by CHWs 6 months after training, cost per person screened, and cost per person diagnosed, considering all eligible participants. The ComBaCaL study was registered with ClinicalTrials.gov (NCT05596773) and is ongoing.**

Findings **Between Feb 1, 2023, and June 30, 2024, 9221 adults (aged ≥18 years) were enrolled in the cohort, of whom, 9053 (98·2%) were eligible for hypertension screening and were included in the analysis; 5175 (57·2%) were female and 3878 (42·8%) were male. A total of 7706 (85·1%) of 9053 eligible participants were screened for hypertension, corresponding to an adjusted coverage of 88% (95% CI 87–89). Among the 9221 enrolled participants, 6345 (68·8%) were either aged at least 40 years or aged at least 18 years with BMI at least 25 kg/m^2, of whom, 6045 (95·2%) were eligible for diabetes screening and were included in the analysis; 3873 (64·1%) were female and 2172 (35·9%) were male. In total, 5507 (91·1%) of 6045 eligible participants were screened for diabetes, corresponding to an adjusted coverage of 95% (95% CI 94–96). In the project model, the costs were US$332 per diagnosis and $41 per person screened. In the routine model, the costs were $137 per diagnosis and $17 per person screened.**

Interpretation **CHWs, by use of a clinical decision support application run on an electronic tablet, provided high hypertension and diabetes screening coverage at moderate costs. Our findings support the integration of CHW-led hypertension and diabetes screening and diagnosis into routine programmes in similar settings.**

Funding **Swiss Agency for Development and Cooperation and World Diabetes Foundation.**

Lancet Prim Care 2025; 1: 100034

Published Online October 30, 2025
https://doi.org/10.1016/j.lanprc.2025.100034

See Comment https://doi.org/10.1016/j.lanprc.2025.100046

For the Sesotho translation of the abstract see Online for appendix 1

*Contributed equally and joint last authors

Division of Clinical Epidemiology, Department of Clinical Research, University Hospital Basel, Basel, Switzerland (N Spaolonzi MSc, G Sanchez-Samaniego PhD, F Chammartin PhD, T Tahirsylaj BSc, F Raeber MSc, P Sendi PhD, A Amstutz PhD, F Gerber MD, Prof N D Labhardt MD); **Department of Clinical Research, University of Basel, Basel, Switzerland** (N Spaolonzi, G Sanchez-Samaniego, F Chammartin, T Tahirsylaj, F Raeber, P Sendi, A Amstutz, F Gerber, Prof N D Labhardt); **Department of Health Policy, London School of Economics and Political Science, London, UK** (N Spaolonzi, A W Carter PhD); **SolidarMed Lesotho, Maseru, Lesotho** (R Gupta MPH, M Mathulise Diploma, T Kabi CNA, M Mokaeane CNA, M Maphenchane CNA, M Molulela BSc, M Khomolishoele BSc, M Mota Diploma, S Masike BSc, M Bane Diploma, M P Sematle BSc, R Makabateng Diploma); **Ministry of Health Lesotho, Maseru, Lesotho** (L Sao MSc, M Tlahali MD, M Litaba MPH); **SolidarMed Switzerland, Lucerne, Switzerland** (P Grimm PhD); **Population Health Sciences, Bristol Medical**

Introduction

Worldwide, non-communicable diseases (NCDs) are responsible for 71% of all deaths, corresponding to 41 million deaths annually.[1] In 2021, arterial hypertension and diabetes accounted for 10·8 million and 1·6 million deaths, respectively.[2,3] In southern Africa, NCDs are predicted to overtake communicable, neonatal, and maternal diseases as the leading cause of death by 2030.[1] Shortages of healthcare personnel, funding, and infrastructure limit the capacity of health systems to tackle the increasing NCD-related chronic care burden.[4]

The involvement of community health workers (CHWs) could be a promising approach to increase access to essential health services, especially in low-income and

School, University of Bristol, Bristol, UK (A Amstutz); Oslo Centre for Biostatistics and Epidemiology, Oslo University Hospital, University of Oslo, Oslo, Norway (A Amstutz)

Correspondence to: Prof Niklaus Labhardt, Division of Clinical Epidemiology, Department of Clinical Research, University Hospital Basel, 4051 Basel, Switzerland niklaus.labhardt@usb.ch

Research in context

Evidence before this study

We did a literature search for studies assessing costs and reach of hypertension and diabetes screening interventions by community health workers (CHWs) in low-income and middle-income countries (LMICs). We searched Google Scholar and PubMed for articles published between Jan 1, 2007, and Oct 31, 2024, using the search terms "community health workers", "screening", "diabetes", "hypertension", "cost", "low- and middle-income countries", and "Africa", with no restrictions on study type or language. We found three studies addressing the effectiveness and cost-effectiveness of CHW programmes for hypertension, diabetes, or both. In Kenya, a prospective quasi-experimental trial described the costs and outcomes of community-based hypertension screening and care, which reached 60% of the target population at a cost of US$17 per person screened. A retrospective cohort study from India reported that combined hypertension and diabetes screening and management was feasible. However, no cost data were provided. An observational study in Bangladesh, Guatemala, Mexico, and South Africa concluded that hypertension screening by CHWs was feasible and cost-effective, but the study did not specify the screening coverage attained. A literature review focusing on hypertension management in LMICs highlighted the cost-effectiveness of broader hypertension-control interventions, but indicated the lack of costing evidence for CHW-led hypertension programmes in LMICs. Moreover, a systematic review called for more economic evaluations of preventive non-communicable disease programmes to better guide policy makers.

Added value of this study

This cost–consequence analysis, nested within a prospective cohort study, provides the first large-scale, real-world evidence on both costs and population-level coverage of a digitally supported, CHW-led screening intervention for hypertension and diabetes in a rural African setting. In 103 remote villages in Lesotho, CHWs, by use of a clinical decision support application run on an electronic tablet, were estimated to have screened 88% of eligible adults for hypertension and 95% for diabetes within 6 months, after adjustment for coverage. In a routine implementation scenario, the estimated annual costs per CHW were $3059, corresponding to $17 per person screened and $137 per person diagnosed. These findings show that CHWs can enable high screening coverage for hypertension and diabetes in remote rural settings at moderate cost.

Implications of all the available evidence

As the burden of non-communicable diseases grows in LMICs, CHW-led strategies that involve digital clinical decision support offer a viable and equitable approach to improve early detection. This study supports the integration of hypertension and diabetes screening into routine CHW services and provides a country-specific cost estimate to guide policy, budgeting, and scale-up. Investing in well-supported CHW programmes can strengthen primary health care systems and extend preventive care to underserved populations.

middle-income countries (LMICs).[5] CHWs can be trained and deployed more rapidly and at a lower cost than nurses and doctors.[6] Additionally, digital aids such as clinical decision support tools might enable CHWs to deliver more complex services at better quality and efficiency compared with traditional paper-based systems.[7,8] In various settings, CHW programmes have been shown to be effective and cost-effective for the management of infectious diseases; reproductive, maternal, neonatal, and child health; and NCDs such as diabetes and hypertension.[8–12] Beyond cost-effectiveness, CHW interventions can address critical access gaps in rural and underserved areas. Evidence on the real-world costs and reach of combined hypertension and diabetes screening interventions by CHWs supported by digital tools remains, however, scarce. To inform budget allocation and priority setting in LMICs, understanding of implementation costs and effectiveness of such programmes is essential.[13–15]

For **ComBaCaL** see https://www.combacal.org/

We aimed to assess the coverage rates and costs of a combined hypertension and diabetes screening intervention by CHWs in Lesotho by use of a specifically developed clinical decision support application (ComBaCaL app), based on the open-source Community Health Toolkit run on an electronic tablet. We aim to provide policy makers and Ministry of Health officials in LMICs with an economic and implementation framework for such an intervention.

For **Community Health Toolkit** see https://communityhealthtoolkit.org

Methods

Study design and participants

This is a prespecified cost–consequence analysis embedded within the prospective Community-Based Chronic Care Lesotho (ComBaCaL) cohort study,[16] evaluating the coverage and costs of combined CHW-led hypertension and diabetes screening and diagnosis in rural Lesotho. The ComBaCaL cohort study protocol was approved by the National Health Research and Ethics Committee of Lesotho (ID 210-2022). Additionally, the Ethikkomission Nordwest-und Zentralschweiz in Switzerland provided a statement confirming that the study meets all ethical requirements for a Swiss research project (ID AO_2022_00058). The study is registered with ClinicalTrials.gov (NCT05596773), where a full protocol is available, and is ongoing.

The ComBaCaL cohort is an open, continuously recruiting, prospective, population-based, observational cohort study in rural Butha-Buthe and Mokhotlong, Lesotho, with regular CHW-led monitoring to quantify prevalence and longitudinal trajectories of cardiovascular risk factors and other chronic conditions. Additionally, the ComBaCaL cohort aims to assess implementation outcomes (ie, feasibility, acceptability, appropriateness, service coverage, and costs) of CHW-delivered chronic disease services. The cohort study was designed as a platform for pragmatic trials using a trials-within-cohorts design.[16] The first nested trials evaluated the implementation, safety, and effectiveness of CHW-led hypertension and diabetes care, including first-line treatment delivery by CHWs. The ComBaCaL cohort study is implemented locally by the not-for-profit organisation SolidarMed and the Ministry of Health of Lesotho, in collaboration with the University of Basel, Switzerland. It includes inhabitants of 103 randomly selected rural villages in the study area. The two districts of Burtha-Burthe and Mokhotlong were selected due to the long-standing local collaboration of the implementing organisations. Both districts feature one central town and surrounding rural areas with remote villages and poor transport infrastructure.[16] Of the 675 rural villages existing in the two districts, 70 were excluded due to participation in other chronic disease studies. Of the remaining 605 villages, 140 (70 per district) were randomly selected and stratified by district and health-facility access. Villages were eligible for inclusion if they had an estimated 40–100 households, geographically clustered homes suitable for service delivery by one CHW, oral consent provided by the village chief, and a potential CHW candidate from the local population (figure 1). As of 2022, the CHW-to-population ratios in the two districts where our intervention was implemented were greater than the WHO health workforce density threshold[17] of 25 CHWs per 10 000 population. Specifically, the ratio was 49 CHWs per 10 000 in Butha-Buthe and 46 per 10 000 in Mokhotlong.[18] However, due to the geographical reality of a country with small remote villages, the Lesotho Ministry of Health aims to have one CHW per village (one CHW per 250 people).[18]

CHWs in Lesotho receive a monthly stipend of Lesotho Loti (LSL) 800 per month (US$43 per month). According to the Lesotho Village Health Program Policy, the CHW position is classified as part-time, with an average of 20 working hours per week, although this varies considerably.[19] For ComBaCaL, CHWs were selected according to the Lesotho Village Health Programme Policy,[19] with specific criteria described in detail elsewhere.[16] Once selected, CHWs underwent 10-day training on data collection and consent procedures, followed by two additional 3-day training courses on hypertension and diabetes screening and diagnosis.[7,16] Enrolment, data collection, and screening were done by CHWs during home visits, each lasting about 30 min. The first visit covered recruitment and baseline data collection, followed by one screening visit, and, depending on the screening results, a second confirmatory screening visit. CHWs were supported by a clinical decision support application based on the open-source Community Health Toolkit which ran on an electronic tablet (allocated to the CHWs by the study team), provided algorithmic guidance to ensure procedural

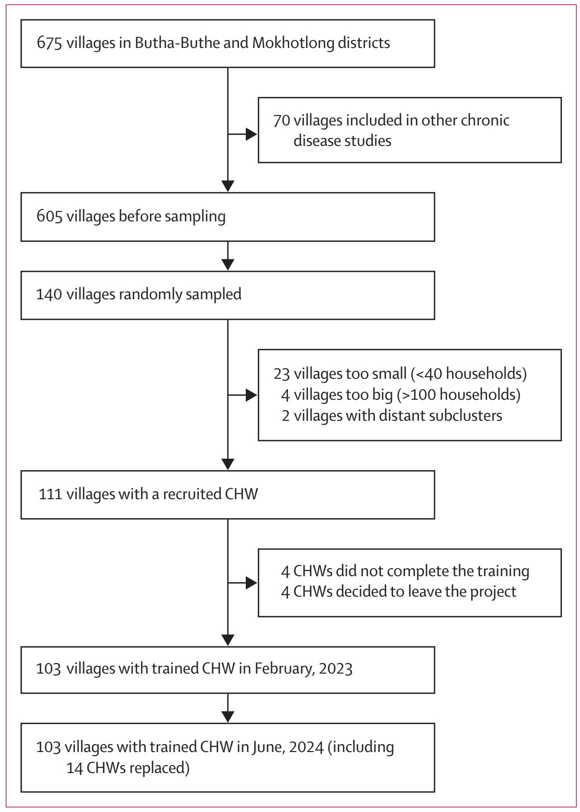

Figure 1: **ComBaCaL village trial profile**
The 140 villages were assessed for eligibility applying the following criteria: estimated village size of 40 to 100 households, geographical distribution of households that allows coverage by one CHW, village consent obtained from village chief, and possibility to identify or recruit a CHW from the village population. The upper limit of household numbers was chosen to ensure each study village could be served by one CHW, while the lower ensured a reasonable minimal workload per CHW. The village eligibility assessment for the wider ComBaCal study was done after the random sampling because of its operational complexities, requiring physical visits by the study team and consent of the village chiefs, which were not feasible to do for the entire sampling pool of 605 villages.[16] CHW=community health worker.

adherence, and fed data into a centralised dashboard accessible to the SolidarMed-employed study nurses who distantly monitored the CHW activities (MMa, TK, MMok, MMap, MMol, MK, MMot, MB, MPS, and RM). If required, in case of problems or upon request, study nurses did on-site supervisory visits, occurring between zero and six times annually—for example, if a CHW did not enter data regularly or if a CHW needed support for communication with particular participants after a new diagnosis etc, to ensure safety of participants and provide mentorship to CHWs. In addition, CHWs attended routine monthly meetings at the closest government health centre. During these meetings, government nurses provided mentorship and addressed clinical or procedural queries.[7,16,20]

Informed consent forms were available in Sesotho and English and written informed consent was collected using an electronic signature. Oral consent was provided by the village chief and household head; written individual consent by participants via electronic signature. The details on consent procedures and the application are available in the cited ComBaCaL cohort profile and eConsent publications. Participants with illiteracy could confirm informed consent by drawing a cross in the electronic signature field, countersigned by an impartial witness.

Subsequent trials

The hypertension and diabetes screening described in this Article were followed by three cluster-randomised trials nested within the ComBaCaL cohort study to evaluate the effectiveness of CHW-led care for hypertension and diabetes, which will be reported separately.[16,21,22] As part of the nested trials, CHWs provided community-based hypertension and diabetes care with follow-up visits for participants diagnosed with either condition. Participants with both hypertension and diabetes were enrolled in trials for both conditions at the same time. Follow-up care visits after diagnosis were delivered as part of these trials and are not included in this cost–consequence analysis because they did not contribute to screening or diagnosis; health outcomes and trial endpoints will be published separately. We chose a staged reporting approach due to the broad scope of ComBaCaL. In this Article, we focus on early, actionable data on coverage and cost estimates for CHW-led screening that can inform specific health policy in LMICs worldwide.

Procedures

CHWs started enrolling participants into the ComBaCaL cohort study on Feb 1, 2023. All inhabitants of the 103 randomly selected study villages were eligible for participation in the ComBaCaL cohort study, independent of age. However, for hypertension and diabetes screening and this cost–consequence analysis, only ComBaCaL cohort participants ≥18 years of age were considered. All participants aged at least 18 years were eligible for hypertension screening and all adult participants aged at least 40 years or aged at least 18 years with BMI at least 25 kg/m^2 were eligible for diabetes screening. The screening and diagnostic algorithms followed the Lesotho Standard Treatment Guidelines with confirmation of elevated measurements on a different day to establish a new diagnosis (appendix 2 pp 6–7).[20]

See Online for appendix 2

To calculate screening coverage for hypertension and diabetes, we defined separate denominators for 1-month, 3-month, and 6-month cohort follow-up periods on the basis of participants who fulfilled the eligibility criteria at each timepoint. For the 1-month screening coverage, only cohort participants who were part of the cohort for the entire month after screening start were considered. For the 3-month and 6-month coverages, participants who were part of the cohort for at least 2 months during the screening period were considered. This approach accounted for the dynamic nature of our open cohort, in which active membership varied due to migration, death, or withdrawal of consent. Participants with pending or incomplete screening were classified as not screened and were retained in the denominator.

The start-up phase lasted from Oct 1, 2022, to Jan 30, 2023, followed by the running phase from Feb 1, 2023, to June 30, 2024 (table 1; figure 2 appendix 2 pp 1–3). Screening was asynchronous in the villages due to stepped training sessions, as well as maternity and sick leave for CHWs. Overall, there was a 3-month gap between the start of hypertension screening in the first and last village and a 7-month gap for diabetes screening. Due to the stepped introduction of hypertension and diabetes screening and the differences in actual screening start dates between villages, the total time required to complete the 6-month observation period for both diseases across all 103 villages spanned 17 months.

We did the cost analysis using a health system perspective and a combined top-down and bottom-up approach. Predominantly, we used the top-down method, adhering to the methodological costing checklist developed by Špacírová and colleagues.[23] The bottom-up approach was used when resource use could be allocated in detail, specifically for equipment and daily personnel costs during the start-up phase (table 1; appendix 2 pp 1–2). We consulted with programme coordinators in Lesotho and Switzerland and used the financial records of the local implementing organisations SolidarMed and the Ministry of Health of Lesotho. All expenses were reported in LSL, rounded to the nearest whole number and converted to US$ by use of the LSL to US$ average exchange rate for 2023 as reported by the World Bank (LSL1=US$0·05424).[24] We developed two costing models (figure 2). The project model included local research-related expenses specific to this project, whereas the routine model was designed to reflect the real-world implementation of the intervention in a non-research context from a health-system perspective. Both models included start-up and running costs. Considering that the project model's running phase lasted 17 months, we applied a 3% discount rate to the costs incurred during the second year, in line with conventions commonly used in global health settings.[5]

The start-up phase included one-time activities such as CHW recruitment, training, management, and equipment costs. These were subtracted from total cumulative costs in some analyses to isolate and estimate the routine running costs of the intervention (table 1; appendix 2 pp 1–2). Costs of training new CHWs to replace those lost to attrition were included in both models. Supervisors received training from academic employees from the University of Basel; CHWs were subsequently trained by the supervisors. Lesotho Ministry of Health officials were part of the project steering committee and were involved in the study conceptualisation (LS, ML, MT). Additionally, Ministry of Health representatives facilitated collaboration between the study team and government staff at health facilities covering the villages where the CHW selection by the population took place. More details about Ministry of Health representative–nurse involvement are outlined in the cited

ComBaCaL cohort protocol. We calculated the opportunity cost for all individuals participating in the training process on the basis of their salaries. The annual salary cost of a local Ministry of Health doctor (LSL925 361 or $50 192) was used as a proxy for the University of Basel personnel's wages (appendix 2 p 2). Consistent with a local health-system perspective, costs incurred by the research team members of the University of Basel in Switzerland, not related to local implementation (eg, study design, app development, data analysis, and travel), were not included. Each CHW was equipped with essential equipment and supplies, including a blood pressure machine, glucometer, weight scale, first aid kit, measuring tape, consumables, a tablet computer, rucksack, raincoat, and freezer suit. Supervisors and coordinators were provided with laptops (appendix 2 p 1). In the running phase, CHWs carried out the screening. Their activities were supervised and coordinated on a part-time basis by the SolidarMed team, based in two offices, in Butha-Buthe and Mokhotlong town (table 1; appendix 2 p 3).

To establish overhead costs, we compared the ComBaCaL expenses with the overall budget of SolidarMed and used this as the cost-driver rate for the overheads within SolidarMed activities. However, given the differences in staff ratios within the two offices, we adjusted the allocation to 18% of the expenses for both offices.

During the preparation of this work the author(s) used ChatGPT (GPT-5), by OpenAI in order to improve the language. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Outcomes

For this cost–consequence analysis, the main endpoints were coverage rates of hypertension and diabetes screening and diagnosis by CHWs 6 months after training, cost per person screened, and cost per person diagnosed. We also assessed the annual intervention cost and the annual cost per CHW.

The main outcomes of the overall ComBaCaL cohort study that will be assessed and published separately are further indicators of the hypertension and diabetes care cascade, including disease awareness, linkage to care, engagement in care, level of adherence, and control of hypertension and diabetes, as well as occurrence of clinically relevant events. Further prespecified outcome measures will address implementation outcomes of CHW-led hypertension and diabetes screening, diagnosis, and care in the cohort (eg, feasibility, acceptability, satisfaction, and perceived appropriateness among cohort participants; CHW performance indicators such as number of households visited, number of individuals monitored, number of individuals newly diagnosed, number of village inhabitants refusing screening or care, completeness of collected data, and adherence to the clinical algorithms are provided in the app).

	Project model	Routine model
Start-up costs		
Recruitment and training		
CHW recruitment	$19 877	NA
Supervisor and CHW training (including CHW replacement)	$75 486	$29 234
Equipment		
Medical devices	$41 418	$41 418
IT hardware and accessories	$61 365	$56 538
Management		
Project manager salary	$11 804	$2145
Project accountant salary	$2002	NA
Data and IT officer salary	$2801	$2801
Overhead costs		
Offices (eg, rent, bills, clerk)	$3353	$3353
Total	$218 106	$135 489
Running costs		
Health-care personnel		
CHWs	$40 761	$53 633
Supervisors	$87 027	$43 514
Equipment		
Medical consumables	$13 276	$13 276
IT hardware maintenance	$3840	$3840
Data and airtime	$21 902	$21 902
Management		
Project manager	$35 411	NA
Local coordinator	NA	$6436
Project accountant	$6007	NA
Data and IT officer	$5394	$5394
Administrative services	NA	$11 570
Overhead costs		
Offices (eg, rent, bills, clerk)	$10 059	$10 059
Other costs		
On-site supervision of CHWs	$9913	$9913
Total	$233 590	$179 537

All values are given in US$. All variable expenses reported encompass 4 months as the start-up phase spanned from Oct 1, 2022, to Jan 30, 2023. Recruitment and personnel training include personnel, accommodation, and transport costs. From Feb 1, 2023, to June 30, 2024, a total of 14 CHWs were replaced. Medical equipment includes consumables (eg, examination gloves, sharp containers, and alcohol swabs) and durable items (eg, blood pressure measurement instruments, glucometer, weight scale, drug box, and abdominal tape). Non-medical equipment includes tablet computers for CHWs, laptops for the supervisors, accessories (eg, tablet covers and screen protectors), and attire for fieldwork (ie, raincoats, backpacks, and freezer suits). The project accountant was not considered in the routine model and instead 10% was added onto personnel salaries to cover for administrative services. Accordingly, the project manager would be replaced in a routine setting by a local coordinator. On-site supervision of CHWs includes personnel and transport cost of supervisors to support CHWs if issues arose. All expenses were rounded to the nearest whole number and converted to US$ using the LSL to US$ average exchange rate for 2023 as reported by the World Bank (LSL1=US$0·05424).[23] CHW=community health worker. LSL=Lesotho Loti. NA=not applicable.

Table 1: **Summary of start-up and yearly running costs**

Statistical analysis

Costs and absolute numbers of individuals screened and diagnosed were summarised descriptively. Total costs for the project or routine model were divided by the number of villages served, CHWs trained and equipped, and individuals screened and diagnosed to estimate mean (SD) unit costs. As each CHW was assigned to one village, the fixed cost per CHW was used as a proxy for cost per village. In an additional analysis, we provide the range of per-village cost

Project model	Routine model
Start-up phase	
Recruitment of CHWs	No recruitment of CHWs (pre-existing network)
Project training (including research-specific training)	Proportion of training dedicated specifically to service delivery (screening and diagnosis; 0·5)
Project supervision: salaries of four nurses, four nursing assistants, one data officer, and two coordinators (including research-specific supervision)	Proportion of supervision: salaries of two nurses, two nursing assistants, one data officer, and one coordinator (excluding research-specific supervision)
Overhead costs	
Salary of project manager (Swiss salary)	Salary of coordinator (local salary)
Salary of project accountant	10% overhead on personnel salaries
Running phase	
Cohort enrolment and enumeration	No cohort enrolment or enumeration
76% of CHW working time for 17 months	100% of CHW working time for 6 months

Figure 2: **Differences between costing models**
The project model includes research-related costs (eg, questionnaires and blood tests for endpoint collection of cluster-randomised trials following screening and diagnosis). The 76% figure represents the weighted average of the days CHWs spent on screening activities over a 17-month period. The routine model only accounts for the resources needed to implement the screening in a real-world routine setting. Training costs were adjusted to reflect the smaller clinical team and then multiplied by 0·5 (proportion of training concerning screening and IT practicalities). Furthermore, CHWs were assumed to start the screening simultaneously in all villages and not be delayed by maternity, sickness, or deferred training sessions. In view of this, they were expected to dedicate 100% of their working time for 6 months. The proportion of screening-specific training and the routine equivalent of the project manager were established through interviews with programme coordinators with regard to the existing health-care infrastructure in Lesotho. The 10% overheads for administrative services and downsizing of the clinical team were based on discussions with study personnel. CHW=community health worker.

by proportionally allocating total programme costs across villages on the basis of the number of individuals screened per village.

Screening coverages were estimated through marginal predicted risks by use of a mixed logistic regression model adjusted for age and sex and accounting for village clustering as a random intercept. Sex was self-reported with the options male and female; sex was used for model adjustment. As there was one CHW per village, we did not additionally adjust for CHW clustering. Age was standardised before inclusion in the logistic regression model. We used a bootstrap procedure based on 1000 samples to obtain percentile-based 95% CIs. Marginal predicted risk represents the mean probability of the outcome across the study population, standardised to the covariate distribution of the sample (appendix 2 pp 3–4). All analyses were done in R version 4.3.3.

The study population reflects all eligible individuals who entered the cohort before or during the observation period. The overall sample size of the ComBaCaL cohort was determined by the planned trials within the cohort assessing CHW-led care for hypertension and is explained in detail elsewhere.[20] No formal sample size calculation was done for this cost–consequence analysis. The study population had no missing data as the documentation of relevant baseline variables for this analysis, such as age and sex, was mandatory for enrolment into the ComBaCaL cohort.

All CHWs in the project operated within Lesotho's routine health system and received the standard government stipend of LSL800 per month ($43 per month). Given the wide variability in CHW salaries across southern Africa, we also conducted a sensitivity analysis to assess how different monthly wages would affect overall costs, using estimates of Masi and colleagues[6] who estimated that monthly wages ranged from $7 to 208 in 2019. We adjusted these estimates for inflation using 2023 World Bank estimates, such that we estimated the effect of different stipends ranging from $0 (ie, voluntary CHW work) to $9, $43 (the average stipend used in our study scenario), $45, and $267—the highest salary offered. We added the scenario of CHWs working as volunteers as is common practice in some LMICs.[6] We adjusted the stipend range for inflation using Lesotho's consumer price index figures, according to the World Bank for 2023.[24,25] Additionally, we conducted a second sensitivity analysis varying the overhead and management cost-driver rate (appendix 2 p 4).

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

The ComBaCaL cohort consists of 103 villages with a median of 49 households (IQR 41–61), comprising a median of three members (IQR 2–4). The baseline clinical and sociodemographic characteristics of the open ComBaCaL cohort, including baseline care-cascade indicators before CHW-led screening and diagnosis, have been published separately.[16] For this cost–consequence analysis of CHW-led screening and diagnosis, data were censored on June 30, 2024. By then, a total of 5274 households comprising 16 461 individuals of all ages were approached for consent. Of these, 11 households (31 individuals; 0·2%) declined participation. Among the remaining 16 430 individuals from 5263 households, 272 participants (1·7%) did not provide individual consent.

Among the 16 158 consenting participants, 6937 were not included as they were younger than 18 years. 9221 were aged at least 18 years and eligible for hypertension screening and diabetes screening (diabetes screening only if BMI $\geq$25 kg/m^2 or aged $\geq$40 years) between the start of enrolment on Feb 1, 2023, and censoring on June 30, 2024, of whom, 168 (1·8%) were excluded from the hypertension screening analysis: 91 (1·0%) of 9221 participants were screened outside the 6-month village study window and 77 (0·8%) exited the cohort before the start of the screening (61 moved away, nine died, six withdrew consent, and one unspecified). A total of 9053 (98·2%) participants were eligible and included in the final hypertension screening analysis; 5175 (57·2%) of 9053 participants were female and 3878 (42·8%) were male (appendix 2 p 4). Of the 9221 enrolled participants, 6345 (68·8%) were aged at least 40 years or were aged at least 18 years with BMI of at least 25 kg/m^2. Of these 6345, 300 (4·7%) participants were excluded from the diabetes screening analysis: 253 (4·0%) of 6345 were screened outside the 6-month village study window and 47 (0·7%) exited the cohort before the start of the screening (32 moved away, eight died, six withdrew consent, and one unspecified). A total of 6045 (95·2%) of 6345 participants met eligibility criteria and were included in the final diabetes screening analysis; 3873 (64·1%) of 6045 participants were female and 2172 (35·9%) of 6045 were male (appendix 2 p 4). 14 (13·5%) of 103 CHWs were replaced during the running phase.

During the 6-month observation period across 103 villages, 13 213 individual screening procedures were completed. At 6 months, 7706 (85·1%) of 9053 eligible participants were screened for hypertension, corresponding to an estimated coverage of 88% (95% CI 87–89, figure 3, appendix 2 p 3). The probability of being diagnosed with hypertension was 15% (95% CI 14–16; 1411 [15·6%] of 9053). At 6 months, 5507 (91·1%) of 6045 eligible participants were screened for diabetes, corresponding to an estimated coverage of 95% (95% CI 94–96, figure 3, appendix 2 p 3). The probability of being diagnosed with diabetes was 3% (95% CI 2–3; 234 [3·9%] of 6045).

In the project model, the annual intervention cost was estimated at $451 697 (table 1), considering the local CHW stipend of $43 per month (table 2). This translates to an annual cost of $4385 per CHW ($2268 excluding start-up costs), $332 per diagnosis, and $41 per person screened (table 2). In the routine model, the annual intervention cost was estimated at $315 027 (table 1), which translates to an annual cost of $3059 per CHW ($1743 excluding start-up costs), $137 per diagnosis, and $17 per person screened. Estimated village-level costs, derived by proportionally allocating total programme costs on the basis of the number of individuals screened in each village, are provided in appendix 2 (pp 5–6).

In the project model, the cost per participant screened would range from $37 if CHWs worked as volunteers to $65 if CHWs received the monthly salary equivalent of $267. The annual cost per CHW would be $3965 under the volunteer scenario and $6545 under the highest monthly wage scenario. In the routine model, the cost per participant screened would be $15 if CHWs worked as volunteers and $30 if CHWs received the equivalent of $208. The annual cost per CHW would be $2462 under the volunteer scenario and $6129 under the highest monthly wage scenario (table 2). Considering the ratio between the ComBaCaL expenses and the overall budget of SolidarMed we calculated a cost-driver rate for overheads of 36%, which was used for the standard analysis. Additionally, in the project model, the cost per participant screened would range from $36 with 10% overhead costs to $58 with 100% overhead costs. The corresponding annual cost per CHW would be $3092 under the 10% scenario and $6025 under the 100% scenario. In the routine model, the cost per participant screened would be $16 with 10% overhead costs and $21 with 100% overhead costs. The corresponding annual cost per CHW would be $2903 under the 10% scenario and $3893 under the 100% scenario. The effects of varying proportions of overhead costs are detailed in appendix 2 (p 4).

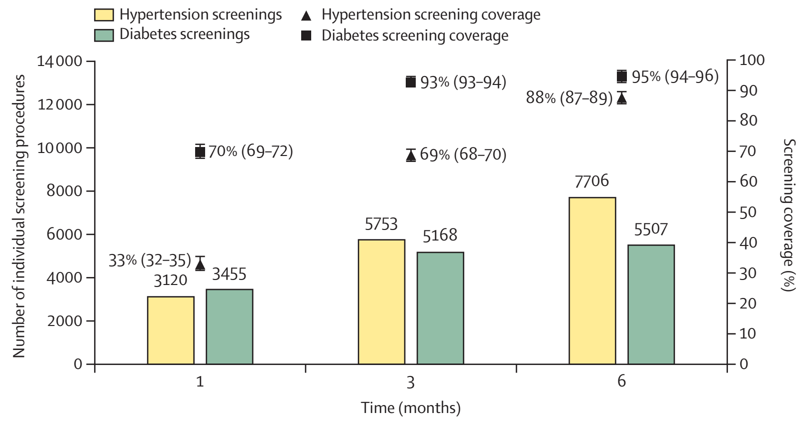

Figure 3: **Cumulative number of screening procedures for diabetes and hypertension and disease coverage numbers at 1, 3, and 6 months**
Data are mean probability (95% CI) of the outcome across the study population, standardised to the covariate distribution of the sample, unless otherwise specified.

	Cost per CHW (project model)	Cost per CHW (routine model)	Cost per person screened (project model)	Cost per person screened (routine model)
Stipend of $0 per month	$3965	$2462	$37	$15
Stipend of $9 per month	$4052	$2585	$38	$15
Stipend of $43 per month*	$4385	$3059	$41	$17
Stipend of $45 per month	$4400	$3079	$41	$17
Stipend of $267 per month	$6545	$6129	$65	$30

The median monthly salary for CHWs in southern Africa was US$35 (range 7–208) in 2019. These values were adjusted for inflation to 2023 and used as the basis for our analysis alongside the $43 per month stipend provided in our study. A stipend of $0 reflects the scenario of CHWs working as volunteers. All expenses were rounded to the nearest whole number and converted to US$ using the LSL to US$ average exchange rate for 2023 as reported by the World Bank (LSL1=US$0·05424).[23] CHW=community health worker. LSL=Lesotho Loti. *Reference value.

Table 2: **Sensitivity analysis of varying CHW monthly stipend inputs on costs**

Discussion

This study assessed the coverage and costs of CHW-led screening for hypertension and diabetes in remote villages in Lesotho, supported by a tablet-based clinical decision support application. After 6 months, CHW-led screening had a coverage of 88% (95% CI 87–89) for hypertension and 95% (95% CI 94–96) for diabetes, at the cost of $17 per person screened and $137 per person diagnosed in the routine model.

Existing evidence supports the effectiveness and cost-effectiveness of CHW-led interventions in addressing NCDs in LMICs.[8,10,11] However, the extent of health-care access, measured by the proportion of the eligible population reached, is rarely reported. A retrospective cohort study in Hyderabad, India, reported that digitally supported CHWs could feasibly screen and treat individuals for hypertension and diabetes.[12] However, the authors did not specify the proportion of the population reached through screening, nor did they report costs. In Nairobi, Kenya, a study of a community-based intervention described the costs and outcomes of hypertension screening and care.[9] This study reached 60% of the target population at a cost of $17 per person. Although the cost per person screened was similar to ours, the proportion of the target population reached was considerably lower.

Although no previous cost data for CHW-led NCD interventions in Lesotho exist, our study aligns with general CHW-programme cost estimates from the region. In southern Africa, excluding start-up costs, the median annual programme cost per CHW is $2574 (range 567–7751), whereas models including start-up expenses report annual costs between $3610 and $3750 per CHW.[6,13,26] We incurred annual costs of $4385 per CHW in the project model and $3059 in the routine model. When excluding start-up costs, these figures decreased to $2268 and $1743, respectively. In Lesotho, the national CHW programme's expenditure in 2024 was estimated at LSL217 699 536 (approximately US$11·8 million). Considering there were 7784 active CHWs in 2022–23, the cost per CHW per year equates to about $1517.[18] Although this is lower than our routine estimate of $3059 per CHW, we included more comprehensive start-up costs, such as training, which are not typically incurred at this scale every year.

In southern Africa, the median monthly salary for CHWs is $35 (ranging from $7 to $208 in 2019), yet, by 2021, over 3·7 million CHWs across Africa were working as volunteers.[6] In our model, considering the cost per CHW per year, relying on volunteer work would reduce costs by only 10% in the project model and 20% in the routine model compared with the current stipends of $43 per month. Inadequate compensation might lead to subpar work performance, increased burnout risk, and increased costs associated with higher turnover of CHWs.[27] However, financial incentives alone are not sufficient and opportunities for career advancement consistently rank among the strongest motivators for employed CHWs.[28] CHWs manage multiple responsibilities, which can result in unrealistic workload if additional tasks are added. Sustained overworking contributes to fatigue, burnout, and reduced job satisfaction, ultimately leading to decreased effectiveness and higher attrition rates—factors that have both human and financial costs. Ensuring realistic workload distributions, appropriate compensation, and adequate support structures is essential to safeguard CHW wellbeing and to maintain programme performance over time. Future CHW programme evaluations should account for the full cost of attrition when a CHW leaves the workforce, including additional procedural costs, effects on health outcomes, and productivity losses.

Lesotho has outlined a 5-year roadmap (2025–30) to strengthen community health services.[18] The roadmap advocates for a shift from vertical models (ie, models that are disease-specific, time-limited, and externally funded) to horizontal or polyvalent models, in which CHWs are well integrated into the local network and trained to deliver a broad package of integrated services across health conditions. Within this context, our routine implementation model appears to be a strategic investment, particularly with potential scale-up efficiencies and more streamlined cost if hypertension and diabetes screening are integrated into existing CHW responsibilities. Early detection of hypertension and diabetes can substantially reduce long-term morbidity and mortality and its associated costs. Furthermore, in underserved and remote settings, community-based screening not only addresses a crucial gap in care but also promotes health equity by bringing essential services to populations that would otherwise face major barriers to access. These broader societal benefits further strengthen the case for investing in CHW-led hypertension and diabetes screening in LMICs worldwide.[29]

The results of our study are generalisable to other resource-limited settings in southern Africa and beyond, where CHWs form the backbone of primary care delivery. Lesotho's systemic challenges, such as difficult terrain, dispersed populations, and poor access to facility-based services, are shared by many LMICs. However, generalisability to urban or peri-urban areas might not be feasible. Future research should evaluate similar interventions in such settings. Understanding cost variations across settings can support more effective planning, budgeting, and scale-up of CHW programmes in diverse environments.

Our study has several limitations. First, the budgetary data were collected to track project expenses, which might have led to an overestimation of costs due to the challenge of separating individual items within a cost category. Additionally, we provide a mean cost per participant screened or diagnosed across the entire study area and these values might be sensitive to outliers. However, screening procedures for hypertension and diabetes in Lesotho are standardised, with little risk of substantial outliers in time and cost. Second, the overhead cost-driver rate and management cost-driver rate introduce some uncertainty, as the expense proportions of different projects within an organisation might not accurately reflect their respective activity levels. The effect of this uncertainty on the study results was explored through a sensitivity analysis. Third, we did not do context-specific opportunity–cost analysis and, given the intrinsic difficulties of decision making in low-resource settings (ie, what do we choose to prioritise and why), this is an important direction for future research. Fourth, because we did not do time-and-motion assessments, we had to make assumptions about the proportion of working time that CHWs dedicated to the screening. During the screening intervention, CHWs also provided care for people with hypertension or diabetes as part of the nested trial activities and also completed their routine activities spanning from prevention of infectious diseases to reproductive, maternal, neonatal, and child health, all of which were outside the study scope. Nevertheless, we conservatively allocated 76% of their salary in the project model and 100% in the routine model to the hypertension and diabetes screening—values that probably overestimate the actual time spent on these activities. If integrated into the overall service package provided by CHWs, the cost of adding hypertension and diabetes screening is likely to be lower than in our estimates.

Contributors

NS conceptualised the cost analysis and wrote the first draft of the manuscript. FG and NDL supervised the project, provided critical reviews, and edited the manuscript draft. RG and GS-S collected the clinical and costing data, which NS and GS-S analysed. NS and FG accessed and verified the data. AWC, TT, FR, PS, AA, and PG reviewed and contributed to the manuscript revisions. FC contributed to the statistical analysis. NDL and AA are the co-principal investigators of the ComBaCaL cohort study and secured funding. RG and PG oversaw the local implementation of the cohort study. MMat, TK, MMok, MMap, MMol, MK, MMot, SM, MB, MPS, RM, and RK were responsible for the local execution of the intervention and cohort study. LS, MT, and ML coordinated study activities at the Ministry of Health level. All authors had full access to the study data, approved the final manuscript, and had responsibility for the decision to submit for publication. AA and NDL are the co-principal investigators of the ComBaCaL project.

Declaration of interests

The salary of NS was funded by the TRANSFORM grant of the Swiss Agency for Development and Cooperation (project number 7F-10345.01.01). NDL received funding for conference attendance from ViiV Healthcare (CROI 2024) and Gilead Sciences (Glasgow HIV 2024). FG received a personal MD and PhD career grant from the Swiss National Science Foundation, covering salary expenses from September, 2021, to August, 2024 (grant number 323530_207035). AA was supported by a grant from the Swiss National Science Foundation (Postdoc.Mobility grant number P500PM_221961). All other authors declare no competing interests.

Data sharing

The dataset generated and analysed for the current study including anonymised village data is available following publication from the corresponding author upon reasonable request. The study protocol can be accessed via ClinicalTrials.gov, NCT05596773.

Acknowledgments

The ComBaCaL project is funded by the TRANSFORM grant of the Swiss Agency for Development and Cooperation (project number 7F-10345.01.01) and a grant by the World Diabetes Foundation (WDF-1778). We are grateful to all the community health workers and participants who took part in this study. We thank our partner organisations for their invaluable support: the Ministry of Health of Lesotho, the local health facilities, and SolidarMed. The study benefited from logistical and human resource support provided by these organisations. During the preparation of this work, the authors used ChatGPT in order to improve language style and readability, but not for analysis or content creation. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

References

1 Bigna JJ, Noubiap JJ. The rising burden of non-communicable diseases in sub-Saharan Africa. *Lancet Glob Health* 2019; **7:** e1295–96.

2 Institute for Health Metrics and Evaluation. GBD results. 2024. https://www.healthdata.org/data-tools-practices/interactive-visuals/gbd-results (accessed Nov 25, 2024).

3 Our World in Data. Number of deaths from hypertension. 2024. https://ourworldindata.org/grapher/deaths-due-to-high-blood-pressure?tab=table (accessed Jan 22, 2025).

4 Asamani JA, Zurn P, Pitso P, et al. Health workforce supply, needs and financial feasibility in Lesotho: a labour market analysis. *BMJ Glob Health* 2022; **7** (suppl 1): e008420.

5 Vaughan K, Kok MC, Witter S, Dieleman M. Costs and cost-effectiveness of community health workers: evidence from a literature review. *Hum Resour Health* 2015; **13:** 71.

6 Masis L, Gichaga A, Zerayacob T, Lu C, Perry HB. Community health workers at the dawn of a new era: 4. Programme financing. *Health Res Policy Syst* 2021; **19** (suppl 3): 107.

7 Gerber F, Tahirsylaj T, Lejone TI, et al. eConsent administered by community health workers in a study using the trials within cohorts (TwiCs) design—experiences from the Community-Based chronic Care Lesotho (ComBaCaL) project. *Digit Health* 2024; **10:** 20552076241288757.

8 Gaziano T, Abrahams-Gessel S, Surka S, et al. Cardiovascular disease screening by community health workers can be cost-effective in low-resource countries. *Health Aff (Millwood)* 2015; **34:** 1538–45.

9 Oti SO, van de Vijver S, Gomez GB, et al. Outcomes and costs of implementing a community-based intervention for hypertension in an urban slum in Kenya. *Bull World Health Organ* 2016; **94:** 501–09.

10 Alaofè H, Asaolu I, Ehiri J, et al. Community health workers in diabetes prevention and management in developing countries. *Ann Glob Health* 2017; **83:** 661–75.

11 Whittington MD, Goggin K, Tsolekile L, et al. Cost-effectiveness of Lifestyle Africa: an adaptation of the diabetes prevention programme for delivery by community health workers in urban South Africa. *Glob Health Action* 2023; **16:** 2212952.

12 Deo S, Singh P. Community health worker-led, technology-enabled private sector intervention for diabetes and hypertension management among urban poor: a retrospective cohort study from large Indian metropolitan city. *BMJ Open* 2021; **11:** e045246.

13 McCord GC, Liu A, Singh P. Deployment of community health workers across rural sub-Saharan Africa: financial considerations and operational assumptions. *Bull World Health Organ* 2013; **91:** 244–53B.

14 Kostova D, Spencer G, Moran AE, et al. The cost-effectiveness of hypertension management in low-income and middle-income countries: a review. *BMJ Glob Health* 2020; **5:** e002213.

15 Sharma M, John R, Afrin S, et al. Cost-effectiveness of population screening programs for cardiovascular diseases and diabetes in low- and middle-income countries: a systematic review. *Front Public Health* 2022; **10:** 820750.

16 Gerber F, Sanchez-Samaniego G, Tahirsylaj T, et al. Cohort profile: the open, prospective Community-Based chronic Care Lesotho (ComBaCaL) cohort—design, baseline chronic disease risk factors and hypertension and diabetes care cascades. *BMJ Open* 2025; **15:** e093852.

17 WHO. Health workforce thresholds for supporting attainment of universal health coverage in the African region. 2021. https://iris.who.int/bitstream/handle/10665/348854/9789290234579-eng.pdf?sequence=1&isAllowed=y (accessed Sept 19, 2025).

18 Ministry of Health of Lesotho. *Community-based Health Services Strategy 2024/25–2029/30* 2024.

19 Ministry of Health of Lesotho. *The Village Health Programme Policy* 2020.

20 Ministry of Health of Lesotho. Standard Treatment Guidelines for Lesotho. 2022. https://de.scribd.com/document/757586149/LS-Standard-Treatment-Guideline (accessed Nov 19, 2024).

21 Gerber F, Gupta R, Lejone TI, et al. Community-based management of arterial hypertension and cardiovascular risk factors by lay village health workers for people with controlled and uncontrolled blood pressure in rural Lesotho: joint protocol for two cluster-randomized trials within the ComBaCaL cohort study (ComBaCaL aHT Twic 1 and ComBaCaL aHT TwiC 2). *Trials* 2024; **25:** 365.

22 Gerber F, Gupta R, Lejone TI, et al. Community-based type 2 diabetes care by lay village health workers in rural Lesotho: protocol for a cluster-randomized trial within the ComBaCaL cohort study (ComBaCaL T2D TwiC). *Trials* 2023; **24:** 688.

23 Špacírová Z, Epstein D, García-Mochón L, Rovira J, Olry de Labry Lima A, Espín J. A general framework for classifying costing methods for economic evaluation of health care. *Eur J Health Econ* 2020; **21:** 529–42.

24 World Bank Group. DataBank: Global Economic Monitor. https://databank.worldbank.org/source/global-economic-monitor (accessed Nov 27, 2024).

25 Turner HC, Lauer JA, Tran BX, Teerawattananon Y, Jit M. Adjusting for inflation and currency changes within health economic studies. *Value Health* 2019; **22:** 1026–32.

26 Tani K, Exavery A, Baynes CD, et al. Unit cost analysis of training and deploying paid community health workers in three rural districts of Tanzania. *BMC Health Serv Res* 2016; **16:** 237.

27 United States Agency for International Development. Developing and strengthening community health worker programs at scale. 2014. https://chwcentral.org/wp-content/uploads/2018/02/pdf.usaid.gov_pdf_docs_pa00jxwd.pdf (accessed Feb 25, 2025).

28 Ajisegiri WS, Peiris D, Abimbola S, et al. It is not all about salary: a discrete-choice experiment to determine community health workers' motivation for work in Nigeria. *BMJ Glob Health* 2022; **7:** e009718.

29 Mukherjee J, Lindeborg MM, Wijayaratne S, Mitnick C, Farmer PE, Satti H. Global cash flows for sustainable development: a case study of accountability and health systems strengthening in Lesotho. *J Health Care Poor Underserved* 2020; **31:** 56–74.