

A comparison between paper-based and m-Health tools for collating and reporting clinical cases of lymphatic filariasis and podoconiosis in Ethiopia

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Background: Lymphatic filariasis (LF) and podoconiosis are disabling diseases, endemic in Ethiopia. The main clinical manifestations include lymphoedema from LF and podoconiosis, and hydrocoele from LF. To ensure access to morbidity management and disability prevention (MMDP) services, data on patient numbers in each implementation unit (IU) is required. House-to-house census is considered the gold standard for determining patient numbers, and data are usually collated and reported using paper-based methods. However, often there are delays in data reaching the regional and central level, which leads to subsequent delays in rolling out and prioritising MMDP services. The increase in mobile phone mHealth tools offers an alternative, potentially more rapid and cost-effective approach.

Methods: As part of an LF and podoconiosis burden assessment conducted in Hawella Tula and Bensa districts in Ethiopia, this study compared the standard paper-based methods with the new MeasureSMS-Morbidity tool for clinical cases data collation and reporting. Health extension workers (HEWs) were trained on both methods. Comparisons were made on patient information; age, gender, location (i.e., kebele), condition, severity of condition and acute attacks. Data were analysed for trends, including the differences in ranking the villages in each district based on the highest to lowest number of cases. In addition, financial and human resource requirements were compared.

Results: In total, 59 HEWs (19 from Hawella Tula; 40 from Bensa) collated and reported a similar number of cases by paper-based (n=2,377) and SMS (n=2,372) methods. Significant correlations were found between the two methods for all cases and lymphoedema cases in both districts, and for hydrocoele cases in Bensa district only. The total cost of paper-based reporting was 13.7% more expensive than SMS reporting due to costs associated with data collection and entry.

Conclusions: The rank correlation showed the same villages would be prioritised for delivery of MMDP services, with time and cost-savings observed using SMS reporting, suggesting it is an effective and efficient alternative tool to help facilitate care to those who need it most.

Keywords: Lymphatic filariasis (LF); podoconiosis; Ethiopia; neglected tropical diseases (NTDs); lymphoedema; hydrocoele; mhealth; patient searching

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Introduction

Lymphatic filariasis (LF) and podoconiosis are neglected tropical diseases (NTDs) endemic to Ethiopia which cause chronic and debilitating swelling of the limbs. In podoconiosis (non-filarial lymphoedema), the swelling is primarily of the lower limbs and is caused by chronic long-term exposure to irritant red clay soils (1). Conversely, LF is a mosquito-borne parasitic disease, caused by *Wuchereria bancrofti* in Ethiopia, which can lead to hydrocoele (scrotal swelling) and lymphoedema; the latter most commonly of the leg but also the arms, breast and genital organs (2).

The debilitating chronic conditions caused by both LF and podoconiosis can result in an enormously complex range of physical, social, economic and psychological hardships. In Ethiopia, it is estimated that podoconiosis patients lose 45% of total working days per year (3) and suffer from discrimination and prejudice so severe that over 50% of the patients consider suicide (4). Similarly, for LF, studies in Malawi have shown that those affected by LF lymphoedema experience a lower quality of life as confirmed by both subjective and objective mobility measures, and a lower income, in comparison to their unaffected peers (5). Earlier studies in Haiti and Ghana have also shown that the risk of dysfunction and unhappiness is greater in marriages where the female partner was the one who had the physical manifestations of LF (6,7). With an estimated 36 million people worldwide thought to be disfigured by LF (8) and an estimated 4 million cases of podoconiosis worldwide (9-11), a rapid and cost-effective tool may be a valuable method of obtaining clinical cases estimates.

In Ethiopia, there are 70 LF endemic woredas (districts), 345 podoconiosis endemic districts, and 29 co-endemic districts (12). With geographical overlap of both diseases, and a similar clinical presentation of lymphoedema, the Federal Ministry of Health (FMOH) promotes integrated morbidity management and disability prevention (MMDP) services for LF and podoconiosis patients. Such MMDP services aim to provide access to basic recommended care for all people with lymphoedema, as required by the Global Programme to Eliminate LF (GPELF) (2). This includes simple hygiene measures such as basic skin care to prevent acute attacks (acute inflammatory episodes) and to prevent

progression of lymphoedema to elephantiasis (hardening and thickening of the skin), as well as psychological and socio-economic support to ensure all clinical cases have equal opportunities for health, education and income (2). Hydrocoele patients should have access to safe surgery (2). As a pre-requisite to equitable and accessible patient care, information on the number of patients (lymphoedema and hydrocoele) in each implementation unit (IU) or similar health administrative unit is essential and part of the World Health Organisation (WHO) dossier requirements (13,14).

In Ethiopia, health extension workers (HEWs) are at the frontline of community-based preventative and curative services. HEWs are largely female, salaried employees of the FMOH, who are recruited from their local community and trained to deliver sixteen packages of care focussed on family health, disease prevention and control, and hygiene and environmental sanitation (15,16). Working at the community-level, with an average of two HEWs per health post, together serving an average population of 5,000 individuals (16), HEWs play a crucial role in the delivery and uptake of services and represent an important opportunity for gathering information directly from local communities.

As part of their support to the LF Programme at the FMOH in Ethiopia, the Centre of Neglected Tropical Diseases (CNTD) at the Liverpool School of Tropical Medicine (LSTM) supported a morbidity burden assessment by HEWs in twenty LF and podoconiosis co-endemic districts in the Southern Nations, Nationalities, and Peoples' Region (SNNPR) and Amhara Region in collaboration with the National Podoconiosis Action Network (NaPAN) (17). This study was conducted using a standard paper-based method of data collection which can be both time consuming and costly. With the rapid increase in mobile phone usage and accessibility across the world, mHealth approaches offer an exciting alternative to the standard, paper-based patient identification to provide real-time validated data for prompt response and delivery of MMDP services (18,19).

The SMS mHealth tool 'MeasureSMS-Morbidity' has been developed by the CNTD, and is used to collate and report morbidity information, collected by community health workers, including lymphoedema and hydrocoele cases at the village and health post level (20,21). Therefore, to pilot the feasibility of using this mHealth tool in Ethiopia





No assessment (0)	Mild (1)	Moderate (2)	Severe (3)
Hydrocele or breast lymphoedema	Slight swelling of leg/ arm	Enlarged leg/ arm with shallow folds	Greatly enlarged leg/ arm, with deep folds
			

Figure 1 Hydrocoele and lymphoedema staging and related SMS code for severity of condition.

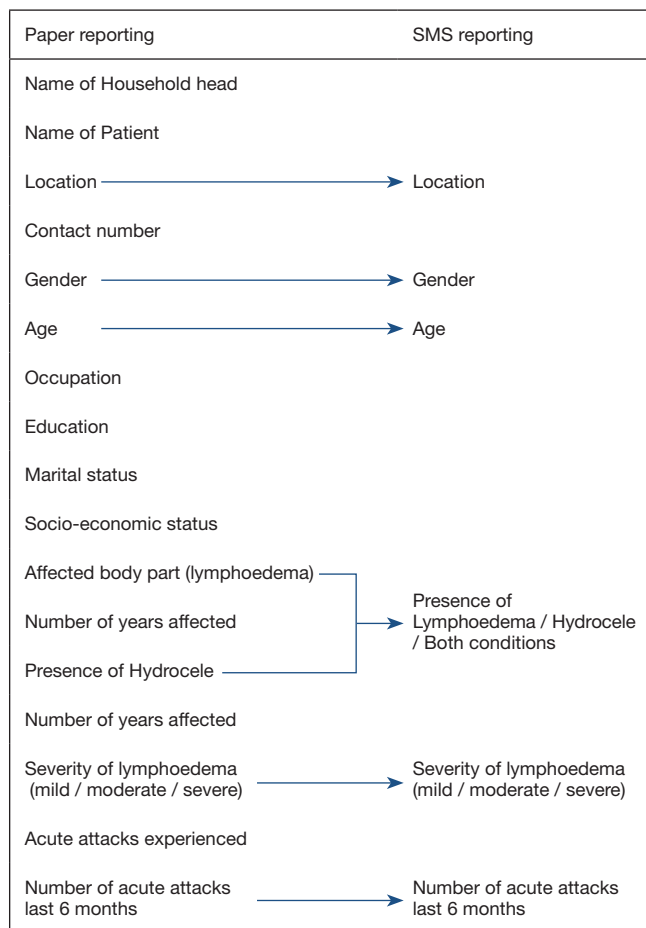


Figure 2 Data flow of information summarised from paper form in SMS.

and to compare its utility with the standard, paper-based method of reporting patients, a study of the ‘MeasureSMS-Morbidity’ tool was conducted concurrently in two districts with the paper-based burden assessment study (17).

Methods

Study site characteristics

The pilot study was conducted in Bensa and Hawella Tula districts of SNNPR. SNNPR is administratively divided into nine zones and 77 districts, and has borders with Kenya in the South, the Republic of Sudan in the South-West and the Ethiopian regional states of the Gambella Peoples’ in the North-West and Oromia in the North and East. Bensa and Hawella Tula are both located in the Sidama zone of SNNPR. The population of Bensa and Hawella Tula districts are 307,878 (50.6% male) and 152,844 (50.4% male); respectively (22,23).

Study design and tools

The community-based cross-sectional survey was conducted over a ten-day period using HEWs to identify all cases of lymphoedema and hydrocoele (17). A household registration form was completed to ensure all households and kebeles (the smallest administrative unit of Ethiopia) were covered in each district. If a patient was identified, a paper-based standard patient information collection form was used to record patient information by the HEWs. This included general demographic information such as the name, age, gender, location (i.e., kebele), occupation, education, marital and socio-economic status of the patient. It also included clinical information such as the condition (lymphoedema, hydrocoele or both conditions), affected body part of the lymphoedema swelling, number of years affected by condition, severity of condition, experience and number of acute attacks in the last six months. As LF and podoconiosis have different methods of staging the severity of lymphoedema (24,25), for simplicity, the HEWs staged lymphoedema severity as either mild, moderate or severe using the pictorial depiction shown in *Figure 1*, and did not stage hydrocoele.

To pilot the feasibility of MeasureSMS-Morbidity as a reporting tool, following the completion of the standard paper-based patient identification form, selected information was transferred to a SMS reporting form, including the location (i.e., kebele), gender, age, condition, severity of condition and number of acute attacks in the last six months (*Figure 2*). HEWs were instructed to send this information by SMS using their own mobile phones, and were provided with enough airtime to cover the cost. The MeasureSMS-Morbidity tool was able to validate the data

reported by SMS by sending an automated response to the data reporter (i.e., the HEW) indicating whether or not the message had been sent in the correct format (20). The tool also allowed the rapid collation of data, which was accessible via a web browser and could be monitored in real-time.

Training

One HEW per kebele and two district health office staff per district attended the one-day training session. The training was conducted in the local language by country-based collaborators, with the support of staff from the collaborating institute (CNTD, LSTM). The attendees were trained on: (I) different causes and forms of lymphedema and staging lymphedema; (II) identifying people affected by lymphoedema (both LF and podoconiosis) and hydrocoele; (III) recording patient information on paper forms; (IV) transferring selected information onto the SMS reporting forms; (V) reporting information by SMS (including practical exercises); and (VI) advising patients on managing their condition, including health centre referrals. All written training material was provided in the local language.

Data collection and analysis

In the days following the training, the HEWs returned to their respective catchment areas to identify all people affected by lymphoedema and hydrocoele. The two health office staff per district were responsible for overseeing the data collection, and acting as a point of contact if any problems were encountered. The paper-based standard patient information forms were collected at the end of the activity, and collated at central level. The SMS reports received were monitored via the MeasureSMS-morbidity server web browser in real-time by a central level supervising team, allowing any data reporting inaccuracies to be identified and rectified immediately.

The data recorded on the paper-based forms were entered into Microsoft Excel Version 12.3.6 (Microsoft Corp., Redmond, VA, USA), and the data from the SMS reporting were downloaded from the web browser. To compare the reported cases by each method, both datasets were disaggregated by gender, condition, severity of condition, and analysed for trends using IBM SPSS Statistics 32 (IBM Corp., Armonk, NY, USA). The Chi-squared test (P value >0.005 significant) was calculated to determine whether there was a significant difference between the reporting

methods for the total cases reported and each condition (lymphoedema, hydrocoele and both). Prevalence estimates (per 10,000 total population) for each condition were also calculated from population estimates (22,23).

In addition, the kebeles in each district were ranked based on the highest to lowest number of lymphoedema, hydrocoele and total cases reported to identify if a similar ranking was observed for both reporting methods, which has important implications in the prioritisation of resources. Further, to examine the association between the paper-based and SMS ranking order of each kebele, the Pearson's product-moment correlation was used with a range from -1 (negative association) to +1 (positive association) and correlations being significant at the 0.01 level (two-tailed).

In addition, the overall costs of the two methods were compared. Costs were compared for all elements from training, data collection and data entry and included the following cost areas: printing; training; fieldwork; supervision; data collection; collecting the completed paper based forms; data entry; phone purchase and credit. Additionally, human resource implications were also considered.

Results

Summary of reported data

In total, 59 HEWs (40 from Bensa, 19 from Hawella Tula) and four district health office staff were trained on patient identification and reporting. The data collection period was completed within ten days in July 2015, with one HEW reporting per kebele. *Table 1* presents the number of cases of each condition reported for both districts, aggregated by gender and severity (for lymphoedema only). In total, 2,377 clinical cases were reported by the paper-based form and 2,372 clinical cases by SMS in both districts. Of these, 96% (2,289/2,377) of paper-based reported cases and 93% (2,196/2,372) of SMS reported cases were lymphoedema. A summary of the daily cumulative responses reported by SMS and received by the online server for Bensa and Hawella Tula are shown in *Figure 3*.

Data reported from Bensa district

For all conditions reported in Bensa, five additional cases were reported by the paper-based forms (n=1,967) in 38 kebeles, compared to by SMS (n=1,962) in 39 kebeles, however the difference in the total number of cases

Table 1 Summary of reported cases by paper-based and SMS forms

Variable	Bensa Woreda		Hawella Tula Woreda	
	Data reported by paper based form	Data reported by SMS	Data reported by paper based form	Data reported by SMS
Lymphoedema				
Total cases reported	1,884	1,812	405	384
Number of cases reported (male)	897 (47.6%)	826 (45.6%)	181 (44.7%)	170 (44.3%)
Number of cases reported (female)	987 (52.4%)	986 (54.4%)	224 (55.3%)	214 (55.7%)
Number of cases not staged*	2	65	0	5
Number of mild cases reported	1,171 (62.2%)	1,116 (63.9%)	235 (58%)	231 (60.9%)
Number of moderate cases reported	566 (30.0%)	540 (30.9%)	146 (36%)	128 (33.8%)
Number of severe cases reported	145 (7.7%)	91 (5.2%)	24 (6%)	20 (5.3%)
Mean age of reported cases	45.27	45.02	46.24	46.04
Prevalence of cases per 10,000 total population	61.19	58.85	26.50	25.12
Hydrocele				
Number of cases reported (male)	54	112	4	22
Mean age of reported cases	45.78	44.83	46.51	46.03
Prevalence of cases per 10,000 male population	3.46	7.18	0.52	2.85
Both conditions				
Number of cases reported (male)	29	38	1	4
Number of cases not staged	0	6	0	0
Number of mild cases reported	17 (58.6%)	16 (50%)	1 (100%)	1 (25%)
Number of moderate cases reported	10 (34.5%)	15 (46.9%)	0 (0%)	1 (25%)
Number of severe cases reported	2 (6.9%)	1 (3.1%)	0 (0%)	2 (50%)
Mean age of reported cases	45.80	45.19	81.00	45.86
Prevalence of cases per 10,000 male population	1.86	2.44	0.13	0.52
All conditions				
Total cases reported	1,967	1,962	410	410
Number of cases reported (male)	980 (49.8%)	976 (49.7%)	186 (45.4%)	196 (47.8%)
Number of cases reported (female)	987 (50.2%)	986 (50.3%)	224 (54.6%)	214 (52.2%)
Mean age of reported cases	45.37	45.02	46.24	46.04
Prevalence of cases per 10,000 total population	63.89	63.73	26.82	26.82

*, breast lymphoedema were severity was not staged.

reported was not significant ($P=0.936$). For both reporting methods, the mean age of reported cases was 45 years with a prevalence of 64 per 10,000 of total population. Additionally, for both reporting methods, the gender of reported cases was equally 50% male and 50% female.

When comparing the number of cases of each condition reported by the two methods of reporting (lymphoedema,

hydrocele or both) there were no significant differences in the number of lymphoedema cases ($P=0.235$), and patients with both conditions ($P=0.271$). Significant differences were observed in reported cases of hydrocele, with over twice as many cases of hydrocele reported by SMS ($n=112$) than by the paper-based forms ($n=54$) ($P<0.001$) (*Table 1*).

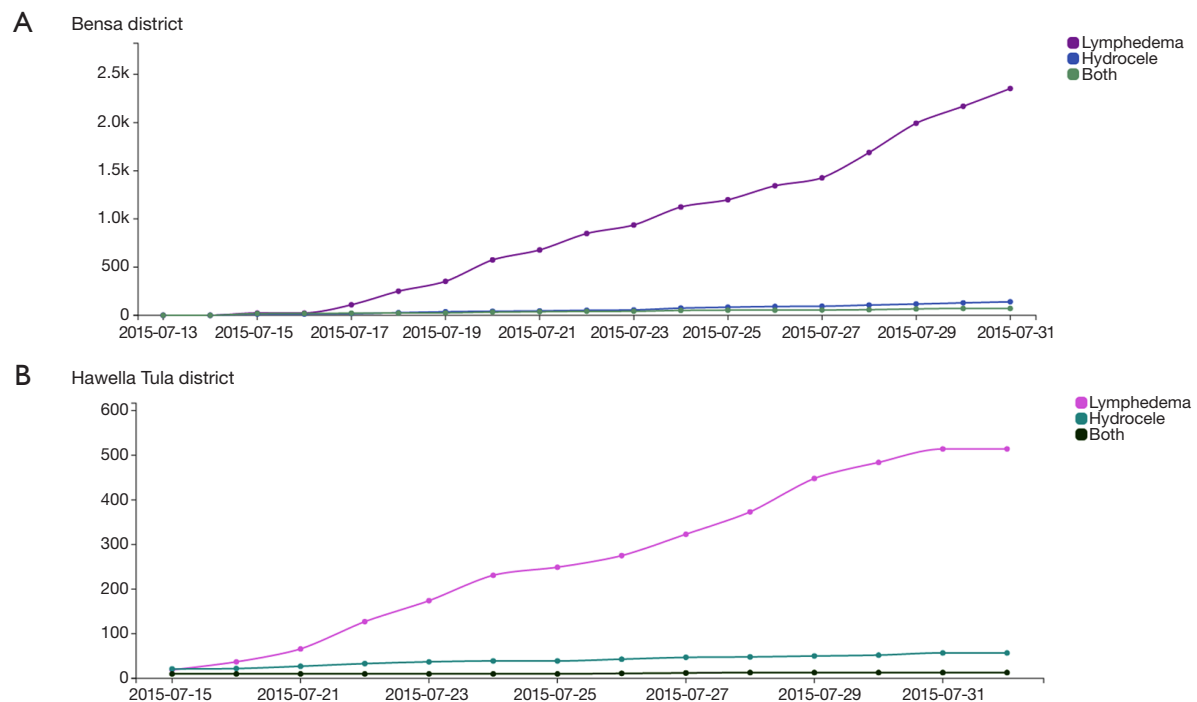


Figure 3 Summary of the daily cumulative responses reported by SMS via the online server. (A) Bensa district; (B) Hawella Tula district.

Table 2 Correlation between ranking of *kebeles* for paper-based and SMS reporting of lymphoedema, hydrocoele and all conditions

Variable	Bensa district	Hawella Tula district
Lymphoedema		
Pearson correlation coefficient	0.947	0.856
Significance (2-tailed)	0.000*	0.000*
N	38	18
Hydrocoele		
Pearson correlation coefficient	0.848	0.127
Significance (2-tailed)	0.000*	0.615
N	38	18
All conditions		
Pearson correlation coefficient	0.924	0.860
Significance (2-tailed)	0.000*	0.000*
N	42	18

*, correlation is significant at the 0.01 level (2-tailed).

Data reported from Hawella Tula district

For Hawella Tula, the total number of all cases reported in the 19 *kebeles* was the same for both reporting methods (n=410), with 52% (214/410) of cases reported by SMS and

55% (224/410) of cases reported by the paper-based method being female. For both reporting methods, the mean age of reported cases was 46 years with a prevalence of 27 per 10,000 of the total population.

When comparing the number of cases of each condition reported by the two methods of reporting, the difference observed was not statistically significant for lymphoedema (P=0.3454) or both conditions (P=0.180). When comparing hydrocoele cases reported, over five times as many hydrocoele cases were reported by SMS (n=22) than by the paper-based forms (n=4) (P<0.001) (Table 1).

Ranking of sub-district (*kebeles*)

In Bensa, a significant positive correlation was found between paper-based and SMS reporting methods for the total reported cases (r=0.924, n=42, P<0.01), lymphoedema cases (r=0.947, n=38, P<0.01), and hydrocoele cases (r=0.848, n=38, P<0.01) (Table 2). In Hawella Tula, a significant positive correlation was found for the total reported cases (r=0.860, n=18, P<0.01) and lymphoedema cases (r=0.856, n=18, P<0.01) (Table 2). For hydrocoele cases, the rank correlation was weak and not significant (r=0.127, n=18, P=0.615) (Table 2).

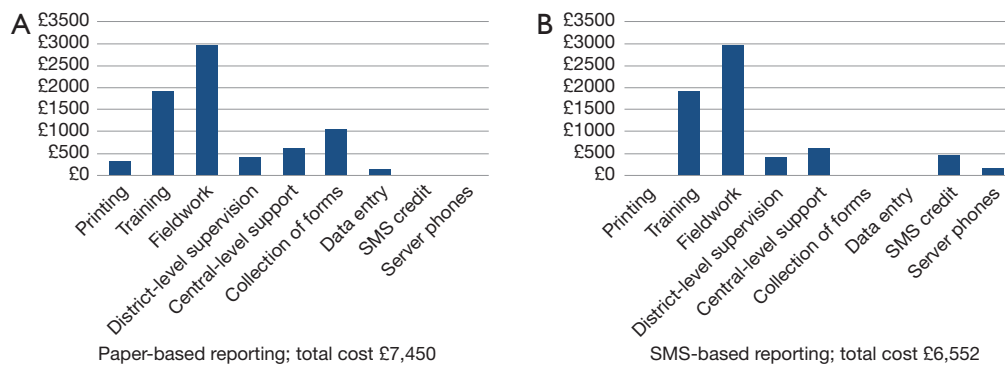


Figure 4 Costs associated with the different reporting systems. (A) Paper-based reporting; total cost £7,450; (B) SMS-based reporting; total cost £6,552.

The rankings of the total number of all cases reported per kebele in Bensa, found that seven of the 36 kebeles remain in the top rankings for both the paper-based and SMS report rankings. Similarly, the same seven kebeles were found in the top ranking when considering only lymphoedema cases, while for only hydrocoele cases, five kebeles were found in the top ranking.

The rankings of the total number of all reported cases per kebele in Hawella Tula, found that four of the 18 kebeles remain in the top rankings for both paper-based and SMS reporting, and six kebeles remain in the top rankings for lymphoedema only. Due to the low number of hydrocoele cases reported in Hawella Tula, the ranking for only hydrocoele cases shows no clear trend in this district.

Cost comparison

For both methods of data reporting, the costs such as the training of HEWs, fieldwork costs (per diem for patient searching), district-level supervision and central-level support remain the same regardless of the reporting method used. The additional costs associated with paper-based reporting are the printing of the data collection tools, the physical collection of the paper forms and manual data entry. These costs are not required for SMS-based reporting, however, additional costs related to the SMS reporting are the purchasing of SMS credit for HEWs and supervisors, and the purchasing of two phones to act as MeasureSMS server phones (one phone per district) and SMS credit for both server phones. A summary of the costs associated costs with both methods of reporting are shown in *Figure 4*.

The total cost of paper-based reporting (£7,450) was

13.7% more expensive than the SMS-based reporting (£6,552). This is largely due to the costs associated with data collection and data entry. For SMS reporting, no physical collection or collation of data was required as this was done automatically via the MeasureSMS-morbidity server meaning that the results were available immediately after the five-day data reporting period. However, unanticipated challenges including network issues and power 'black-outs' lasting several days occurring during the reporting period. These issues left HEWs unable to charge their phones and send the SMS for periods of time during the survey. For the paper-based data entry, it took two staff six days to collect the forms from the two districts and further time to double-enter the data from the paper-based forms.

Discussion

This study highlights the value of the use of the MeasureSMS reporting tool to report clinical cases of LF and podoconiosis. When comparing the total cases reported, lymphoedema and both, the two reporting methods showed no significant difference. Similarly, the ranking and correlation shows that the kebeles with the highest burden of lymphoedema - the top seven highest burden kebeles in Bensa, and the top six highest burden kebeles in Hawella Tula - remain the same for both reporting methods. For hydrocoele, despite significant differences in the total number of cases reported in both districts, the top six highest burden kebeles remain the same for both reporting methods in Bensa, however due to the low prevalence in Hawella Tula, the ranking showed no clear trend.

As the areas with the highest burden of disease would be prioritised for MMDP services, these results show that both

reporting methods allow the identification of the highest burden kebeles, meaning that limited resources would be targeted in the same way. This is particularly important for lymphoedema services in which the basic package of managing lymphoedema is traditionally delivered at the community level with support from HEWs, where sub-district prioritisation is essential for delivery of accessible services; unlike hydrocoele surgery which is performed at district-level hospitals (2).

Following on from experiences of using the MeasureSMS-morbidity mHealth tool in Malawi, Ghana and Tanzania (21,26), new challenges were observed in Ethiopia such as network issues and power ‘black-outs’ lasting several days which left HEWs unable to charge their phones and send the SMS. Also, unlike previous studies in Malawi where 96% of data reporters stated that they did not have any difficulty in submitting data by SMS (21), a higher proportion of HEWs in Ethiopia had problems sending the data via SMS. To overcome these issues in future deployments of mHealth tools for NTD activities in Ethiopia, it would be recommended to employ a ‘two-tier’ reporting system in which HEWs collect the patient data, but the data itself is collated and reported by SMS at the health-facility level by a more senior health worker (27). This approach has been successfully used in a large urban area of Tanzania (26), and would help reduce the risk of community health workers losing confidence in the SMS reporting system when faced with challenges, the negative implications of which could be under-reporting.

Although challenges were encountered sending the data via SMS, the mHealth tool allowed the rapid collation of data throughout the activity, allowing easier monitoring and supervision of data reporting from anywhere in the world. On the other hand, the paper-based forms, although allowing more information to be collected, required manual collection and collation which required greater human and financial resources.

Conclusions

In summary, this study highlights the first pilot of mHealth tools for integrated NTD MMDP case reporting in Ethiopia. Notwithstanding some the phone network challenges, the SMS reporting tool was shown to be an equitable, time- and cost-effective reporting tool to enable resources to be allocated to those most in need quickly, and at low cost.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: Ethical approval for this study was obtained from the Research Ethics Committee at the Liverpool School of Tropical Medicine, UK, and the Amhara and SNNP Regional Health Bureaus in Ethiopia. Informed consent was obtained from all household heads and patients involved in the study.

References

1. Price EW, Plant DA. The significance of particle size of soils as a risk factor in the etiology of podoconiosis. *Trans R Soc Trop Med Hyg* 1990;84:885-6.
2. WHO. Lymphatic Filariasis: managing morbidity and preventing disability. An aide-mémoire for national programmes managers. 2013.
3. Tekola F, Mariam DH, Davey G. Economic costs of endemic non-filarial elephantiasis in Wolaita Zone, Ethiopia. *Trop Med Int Health* 2006;11:1136-44.
4. Tora A, Franklin H, Deribe K, et al. Extent of podoconiosis-related stigma in Wolaita Zone, Southern Ethiopia: a cross-sectional study. *Springerplus* 2014;3:647.
5. Stanton MC, Yamauchi M, Mkwanda SZ, et al. Measuring the physical and economic impact of filarial lymphoedema in Chikwawa district, Malawi: a case-control study. *Infect Dis Poverty* 2017;6:28.
6. Coreil J, Mayard G, Louis-Charles J, et al. Filarial elephantiasis among Haitian women: social context and behavioural factors in treatment. *Trop Med Int Health* 1998;3:467-73.
7. Gyapong M, Gyapong JO, Adjei S, et al. Filariasis in northern Ghana: some cultural beliefs and practices

- and their implications for disease control. *Soc Sci Med* 1996;43:235-42.
8. Ramaiah KD, Ottesen EA. Progress and impact of 13 years of the global programme to eliminate lymphatic filariasis on reducing the burden of filarial disease. *PLoS Negl Trop Dis* 2014;8:e3319.
 9. Davey G, Tekola F, Newport MJ. Podoconiosis: non-infectious geochemical elephantiasis. *Trans R Soc Trop Med Hyg* 2007;101:1175-80.
 10. Tekola Ayele F, Adeyemo A, Finan C, et al. HLA class II locus and susceptibility to podoconiosis. *N Engl J Med* 2012;366:1200-8.
 11. Deribe K, Wanji S, Shafi O, et al. Measuring elimination of podoconiosis, endemicity classifications, case definition and targets: an international Delphi exercise. *Int Health* 2015;7:306-16.
 12. Mengistu B, Deribe K, Kebede F, et al. The National Programme to Eliminate Lymphatic Filariasis from Ethiopia. *Ethiop Med J* 2017;55:45-54.
 13. WHO. 489 Global programme to eliminate lymphatic filariasis: progress report, 2014. *Wkly Epidemiol Rec* 2015;90:489-504.
 14. WHO. Validation of elimination of lymphatic filariasis as a public health problem. 2017.
 15. Medhanyie A, Spigt M, Kifle Y, et al. The role of health extension workers in improving the utilization of maternal health services in rural areas in Ethiopia: a cross sectional study. *BMC Health Serv Res* 2012;12:352.
 16. Mangham-Jefferies L, Mathewos B, Russell J, et al. How do health extension workers in Ethiopia allocate their time? *Hum Resour Health* 2014;12:61.
 17. Kebede B, Martindale S, Mengistu B, et al. Integrated morbidity mapping of lymphatic filariasis and podoconiosis cases in 20 co-endemic districts of Ethiopia. *PLoS Negl Trop Dis* 2018;12:e0006491.
 18. Brinkel J, Kramer A, Krumkamp R, et al. Mobile phone-based mHealth approaches for public health surveillance in sub-Saharan Africa: a systematic review. *Int J Environ Res Public Health* 2014;11:11559-82.
 19. Piette JD, Lun KC, Moura LA Jr, et al. Impacts of e-health on the outcomes of care in low- and middle-income countries: where do we go from here? *Bull World Health Organ* 2012;90:365-72.
 20. Stanton M, Molineux A, Mackenzie C, et al. Mobile Technology for Empowering Health Workers in Underserved Communities: New Approaches to Facilitate the Elimination of Neglected Tropical Diseases. *JMIR Public Health Surveill* 2016;2:e2.
 21. Stanton MC, Mkwanda SZ, Debrah AY, et al. Developing a community-led SMS reporting tool for the rapid assessment of lymphatic filariasis morbidity burden: case studies from Malawi and Ghana. *BMC Infect Dis* 2015;15:214.
 22. Ethiopia CSAo. Population and Housing Census Report-Country 2007.
 23. Bank W. Ethiopia population growth (annual %). 2016. Available online: <http://data.worldbank.org/indicator/SP.POP.GROW?locations=ET>
 24. McPherson T, Fay MP, Singh S, et al. Health workers' agreement in clinical description of filarial lymphedema. *Am J Trop Med Hyg* 2006;74:500-4.
 25. Tekola F, Ayele Z, Mariam DH, et al. Development and testing of a de novo clinical staging system for podoconiosis (endemic non-filarial elephantiasis). *Trop Med Int Health* 2008;13:1277-83.
 26. Mwingira U, Chikawe M, Mandara WL, et al. Lymphatic filariasis patient identification in a large urban area of Tanzania: An application of a community-led mHealth system. *PLoS Negl Trop Dis* 2017;11:e0005748.
 27. Mablesen HE, Martindale S, Stanton MC, et al. Community-based field implementation scenarios of a short message service reporting tool for lymphatic filariasis case estimates in Africa and Asia. *Mhealth* 2017;3:28.

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