Original research article

Unpacking healthcare waste management at rural village health clinics in the Ntcheu District (Malawi)

Short title: Rural healthcare waste management in Malawi

Madalitso Mmanga[a], Wales Singini[b], Veronica Di Bella[c], Mary Grace Flaherty[d] and Rochelle H. Holm[e*]

[a] Department of Water Resources Management and Development, Mzuzu University, P/Bag 201, Mzuzu 2, Malawi and Ministry of Health, National TB Control Program, Mtunthama Drive, Area 3, P/Bag 65, Lilongwe, Malawi

[b] Department of Fisheries, Mzuzu University, P/Bag 201, Mzuzu 2, Malawi

[c] CDC Group plc, 123 Victoria Street, London, SW1E 6DE, United Kingdom

[d] School of Information and Library Science, University of North Carolina at Chapel Hill, 100 Manning Hall, Chapel Hill, NC 27599-3360, United States

[e] Centre of Excellence in Water and Sanitation, Mzuzu University, P/Bag 201, Mzuzu 2, Malawi

*corresponding author, R. H. Holm (rochelle@rochelleholm.com), Phone +265992159079

Abstract

Management of healthcare waste in low- and middle-income countries lacks a straightforward solution, especially where rural services are provided. The purpose of our case study was to explore the knowledge and practices of health surveillance assistants operating at rural village health clinics in Ntcheu District, Malawi, with regard to the collection, segregation, transport, treatment, and disposal of healthcare waste. Data were collected from 81 clinics. The results indicated that while general gaps in both knowledge and practice were observed, sharps (e.g. needles) management was generally being done well. An opportunity for scale-up was found in one clinic, in which local materials had been used to construct a low-cost innovative sharps disposal receptacle that had been modified from a pit latrine design. This study recommends waste management training suitable for rural settings, the promotion of low-cost sharps disposal receptacles using local materials, further opportunities for low-cost incinerators, central waste collection, and encouraging grassroots innovation in healthcare waste management.

Keywords: government, healthcare waste, health clinic, knowledge, Malawi, rural, sharps management

Funding

This work was supported by Ntcheu District Health Office under the Ntcheu District Council.

Acknowledgements

The authors greatly appreciate the technical editing by Jake Stillwell.

Introduction

Globally, only 15% of total healthcare waste generated is hazardous; this may include infectious waste, sharps, pharmaceuticals or pathological waste, while the remaining waste is general healthcare waste that does not pose biological, chemical, radioactive or physical hazards (World Health Organization [WHO] 2017). In low- and middle-income countries, healthcare waste is a known challenge; it is reported that only 39% of healthcare facilities have appropriate storage of infectious waste, 61% have appropriate disposal of infectious waste and 75% have appropriate storage areas for sharps waste (e.g., sharps boxes) (Harhay *et al.* 2009; Cronk & Bartram 2018). However, in this environment, most healthcare waste is either incinerated or disposed of at sites including dump sites, controlled landfills, pits, or sanitary landfills (Diaz *et al.* 2005). When not managed properly, infectious waste and sharps generated from healthcare activities can lead to adverse health effects, including hepatitis B, hepatitis C and human immunodeficiency virus among health workers (Chartier *et al.* 2014).

The WHO has standards for the safe management of wastes from healthcare activities (Chartier *et al.* 2014), including practical guidelines for rural areas of low-income countries. In Malawi, the health sector is decentralized, whereby health services in the districts are operated by the Ministry of Health together with the local government, Christian Health Association of Malawi or private agencies. Most of the population in Malawi lives in rural areas (Malawi Government 2009). In addition, in most rural areas, health services are generally provided at small rural village clinics that are overseen by the District hospital, which is operated by the Ministry of Health. For these hard to reach areas in Malawi, a program has been created by which government-funded community healthcare workers (health surveillance assistants, HSA) receive 10 weeks of training, after which they provide on-the-ground diagnostic and treatment services (Ministry of Health 2009) to children under-five and women of childbearing age. The

training manual for HSAs (Ministry of Health 2009) provides only basic guidance covering infectious waste and sharps and includes promoting visual aids for health education. There are no national legislative, regulatory, policy or training manuals for healthcare waste management for HSAs at rural village health clinics. Nationally, healthcare waste management training for doctors and nurses serving in district hospitals is available (Ministry of Health 2008). However, HSAs generate medical waste as a sole-provider at these front-line clinics while providing many of the same services (immunizations, family planning, malaria diagnosis, etc.) as facility-based doctors and nurses, but with limited resource and in hard-to-reach areas. In reference to HSAs, Gilroy *et al.* (2013) note that the "lowest cadre of paid health workers in Malawi was able to perform at levels similar to facility-based health workers." In the absence of national standards, our study clinics were assessed based on WHO standards (Chartier *et al.* 2014).

Few studies have explored rural healthcare waste management practices in detail within sub-Saharan countries. There are some existing, and generalized, nationwide data from monitoring reports and/or peer-reviewed literature (Cronk and Bartram 2018; Harhay *et al.* 2009; Haylamicheal & Desalegne 2012). The 2013-2014 nationwide survey of healthcare facilities conducted in Malawi (Ministry of Health and ICF International 2014) did not account for these rural village health clinics, having only considered larger healthcare facilities. Other work uses small study sizes, such as the work by Longe (2012) in Nigeria, which was limited to only 20 healthcare facilities, and which focused on facilities located in urban areas. Abrampah *et al.* (2017) reports on a situational assessment of 63 healthcare facilities, including healthcare waste management, in Liberia during and after the 2013–2016 Ebola virus disease outbreak. Work by Mbongwe *et al.* (2008), which was carried out in Botswana, included a training needs assessment of 500 healthcare workers covering current practices in healthcare waste management, but a linked observation of the respondents' practices was not conducted. This underresearched theme lacks concrete data on the actual situation. The present case study starts to provide data on the link between

knowledge and observed waste management practices for rural village health clinics, which serve the majority of the population with front-line services in low- and middle-income country settings.

The purpose of our case study was to explore the knowledge and practices of HSAs on collection, segregation, transport, treatment, and disposal in rural village health clinics in Ntcheu District, Malawi, to identify opportunities for improved sustainable management. Such an assessment would have the potential for the identification of best practices to make recommendations for national programs based on local context.

Materials and methods

Study site and population

The study was conducted in rural areas of Ntcheu District, in the central region of Malawi (Fig. 1). This district covers 3,424 km^2, with a reported population in the 2008 census of 470,000 (Malawi Government 2009). In the study area, there is one district hospital, 2 rural hospitals, 27 health centers (with maternity services), 7 dispensaries (with no maternity), and 2 health posts. Of these, 15 are operated by the Christian Health Association and 24 by the government. The private agencies operating in the district have a focus on reproductive health (personal communication with representative from Ntcheu District Hospital on 12 January 2019).

In the study area, the Ministry of Health is the sole implementer of rural village clinics for integrated management of front-line health services at a community level. At the time the study was designed, there were 121 village clinics in the district operated by the government, with the oldest clinic having

opened in 2007. Out of these 121 village clinics, only those that were functional (considering 'functional' clinics where outpatients were present and medical equipment was available) and staffed were sampled for the study. Researchers only considered clinics that had been in operation 5 years or longer. Each of the 81 (81/121) clinics that qualified or met this criterion were sampled for the study, and all report to Ntcheu District Hospital.

We did not include the hospitals, health centers, dispensaries, health posts, or the private agencies operating reproductive health service facilities, all of which would generally be considered to be larger and offer more services than would the rural government operated village health clinics, which were included in this study.

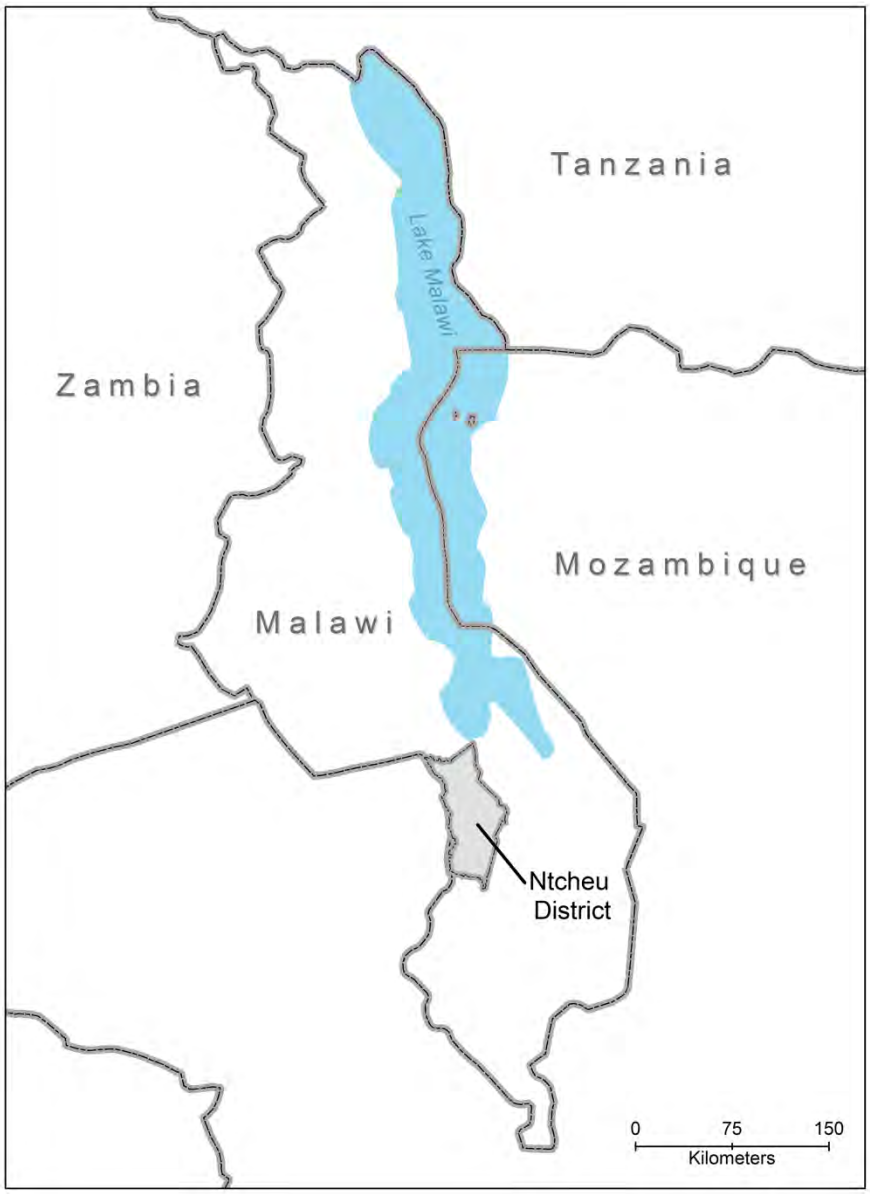

Fig. 1 Map of Malawi showing study site, Ntcheu District

Study design

First, an observation checklist was used to assess healthcare waste management practices. This was followed by an interview with the HSAs managing these clinics to assess their knowledge of healthcare waste management. This allowed us to determine the ordinary behavior of HSAs in the clinics.

Sampling and recruitment

Data were collected from October to December 2017, during the dry season. Participants were selected among the HSAs who were currently responsible for the operation of a rural village health clinic that had opened between 2007-2012. Each clinic is overseen by one HSA. One 'story of change' interview was completed covering an innovative low-cost sharps pit modified from a pit latrine design built by one HSA, no other local innovations in waste management approaches were identified in the study. Our goal was to gather a comprehensive overview in an attempt to identify common aspects and differences in addition to identifying best practices.

Data collection tools

The tools we used were intended to capture actual practices and general healthcare worker waste management knowledge based on the WHO standards (Chartier *et al.* 2014). A clinic observation checklist was created by the first author (MM) to assess HSA practices and included details of waste management facilities and processes. In practice, color coding includes black receptacles for noninfectious dry waste, green for noninfectious wet waste, yellow for infectious and pathological waste, yellow marked with a black band for chemical waste, red for sharps generated at the clinic, and orange for radioactive waste. A good-quality temporary storage area was one that had separated

infectious and other hazardous waste, was of appropriate volume and had access restrictions. The HSA interview guide included the type of healthcare services provided at this clinic, plus waste facilities, equipment, practices and training. Additionally, one 'story of change' interview was completed with one HSA who was using an innovative waste management approach. We did not survey patients or other stakeholders. At each clinic, the observations and HSA interview guide were done on the same day. Observations and interviews were conducted by representatives from the Ntcheu District Health Office under the Ministry of Health or by the first author who is affiliated with Mzuzu University.

Tools were developed in English, translated and piloted prior to starting. Interviews were conducted orally in either English or the local language of Chichewa, which were recorded and transcribed.

Data analysis

Clinics were categorized into older (2007 to 2009; *n*=27) and newer (2010 to 2012; *n*=54) clinics, based on a community size of <2000 people (smaller community; *n*=50) and >2000 people (larger community; *n*=31), and those which had reported <500 patients seen in the last quarter of October to December 2016 (smaller clinics; *n*=39) and >500 patients seen (larger clinic; *n*=42). Researchers hypothesized that these categories could potentially influence waste management knowledge and practices; for example, smaller communities where clinics see fewer patients may generate less waste at the clinic and may have better management, and older clinics may have greater institutional knowledge and more established management systems in place. Relationships among knowledge and practice variables were tested using Fisher's Exact Test using the R Project 3.3.2 statistical package (Vienna, Austria). If the p-value was less than the significance level 0.05, we concluded that there were significant differences between the treatment groups.

177

178

179

Results

This section outlines the analysis based on responses of the knowledge and practices of healthcare waste management by the HSAs, who are the daily operators of the clinics. A portion of the clinics provide family planning to mothers and women of child-bearing age (53/81; 65%), immunizations to children under five years of age (20/81; 25%), and/or growth monitoring to children under five years of age (16/81; 20%). All (81/81; 100%) of the clinics provide diagnostic services, such as malaria rapid testing, treatment of pneumonia or cough, and the management of diarrhea. These healthcare services contribute to the total waste stream of generated healthcare waste in these clinics, specifically to include sharps (needles), pharmaceutical waste and infectious blood swaps. Radioactive waste was not mentioned as having been generated in any village health clinic (0/81).

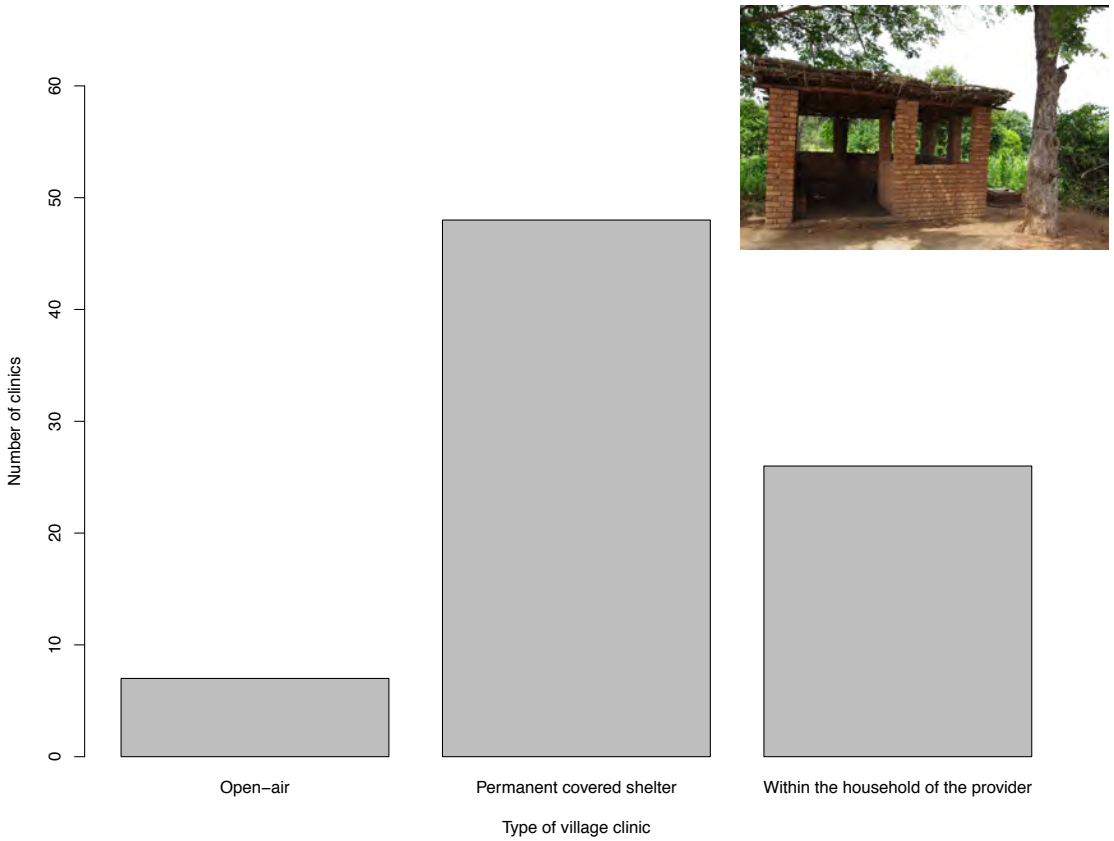

Fig. 2 Setting of village health clinic sites under study. The inset shows a permanent covered village health clinic structure.

Fig. 2 shows that in 59% (48/81) of clinics, services are delivered under a permanent or semi-permanent shelter; in 32% (26/81), they are delivered within the household of the provider; and in 9% (7/81), they are delivered in an open space (such as under a community tree).

Knowledge of healthcare waste management at village health clinics

The reported knowledge of healthcare waste management among HSAs was ranked based on questions in seven categories. Most of the HSAs were doing well in terms of reported knowledge of how healthcare wastes are categorized (76/81; 94%), how waste is disposed of (77/81; 95%), and the risks posed by healthcare waste (78/81; 96%). The lowest reported knowledge concerned proper procedures for color coding healthcare waste receptacles (32/81; 40%).

The knowledge of HSAs was determined as follows: those HSAs with knowledge in five or more categories of general healthcare waste management activities at the clinic ranked as having better waste management practice knowledge (65/81; 80%), while those with knowledge in four or fewer of these categories were ranked as having low practice knowledge (16/81; 20%).

The results show that most (80/81; 99%) HSAs in our survey reported they had not received any formal training in healthcare waste management to support their clinical work beyond the general HSA training. However, it was reported that during routine supervision by Ntcheu District Hospital, healthcare waste management was often (53/81; 65%) covered as practical on-the-job training. Only one quarter (20/81; 25%) of HSAs reported they had job aids for healthcare waste management, such as instructions on how malaria rapid diagnostic testing kits can be disposed of or posters or handbooks concerning the generation and management of healthcare waste in their clinic. While each malaria rapid diagnostic testing kit has a user manual from the manufacturer that guides HSAs in how to carry out the procedure according to WHO recommendations, there is also a specific job aid for healthcare workers to guide how to manage waste generated from these procedures. None (0/81; 0%) of the respondents reported having had healthcare waste management guidelines or manuals, such as WHO or country-specific guidelines, at their clinics to guide them in their day-to-day operations.

Table 1 Reported knowledge by health surveillance assistants on healthcare waste management

HCWM characteristic	Village clinics (*n*=81)	Older clinics (2007-2009) (*n*=27)	Newer clinics (2010-2012) (*n*=54)	Smaller community <2000 people (*n*=50)	Larger community >2000 people (*n*=31)	Patient volume <500 last quarter (*n*=39)	Patient volume >500 last quarter (*n*=42)
Categorization	94%	96%	93%	92%	97%	97%	90%
Segregation	81%	89%	78%	80%	84%	85%	79%
Color coding	40%	41%	39%	40%	39%	44%	36%
Collection and storage	74%	78%	72%	76%	71%	74%	74%
Treatment	77%	74%	78%	80%	71%	85%	69%
Disposal	95%	93%	596%	96%	94%	92%	98%
Health risk	96%	100%	94%	96%	97%	95%	98%

When comparing older and newer clinics (Table 1), there was no difference in terms of the HSAs' reported waste knowledge for categorization (p=0.66), segregation (p=0.36), color coding (p=1), collection (p=0.79), treatment (p=0.78), disposal (p=0.60), or health risks (p=0.55). This implies that there is no relationship of clinic age with waste management knowledge of the HSAs.

When comparing communities of more than to fewer than 2000 people, there was no difference in terms of the HSAs' reported waste knowledge on categorization (p=0.64), segregation (p=0.77), color coding (p=1), collection (p=0.61), treatment (p=0.42), disposal (p=0.63), or health risks (p=1). This implies

237 that there is no relationship between the community size and waste management knowledge of the
238 HSAs.
239
240 When further comparing clinics that saw a patient volume per quarter of fewer than 500 people and
241 those that saw more than 500 patients, the results show there was no difference in terms of the HSAs'
242 reported knowledge of waste categorization (p=0.36), segregation (p=0.57), color coding (p=0.50),
243 collection (p=1), treatment (p=0.12), disposal (p=0.35), or health risk (p=0.61). This implies that there is
244 no relationship with patient volumes and waste management knowledge of the HSAs.
245
246 Although not a significant difference (p=0.56), more of the older clinics were ranked as having better
247 healthcare waste management knowledge (23/27; 85%) than the newer clinics (42/54; 78%). There was
248 also no difference in HSA knowledge between the clinics that served more than or fewer than 500
249 patients per quarter (p=0.41) or between clinics with a community population of more than or fewer
250 than 2000 people (p=0.78). This indicates that the HSAs ranked more knowledgeable were not
251 necessarily posted in larger communities or at newer clinics, nor did they serve more patients.
252
253 Practices in healthcare waste management at village health clinics
254 Observation of practices (Table 2) showed that the most basic management practice of waste being
255 segregated according to categories and types was being performed by more than half (48/81; 59%) of
256 HSAs. Generally, there was a low proportion of clinics that were observed to use or have color-coded
257 receptacles for collection and segregation of healthcare waste (29/81; 36%). Most (59/81; 73%) used
258 appropriate storage of sharps waste (e.g. sharps boxes). In all of the clinics, waste was collected and
259 temporarily stored for final treatment and disposal at the end of the shift. Although not a treatment

method, open burning or dumping on the land (not a sanitary landfill) or dumping in a shallow pit was the final disposal method for most (80/81; 99%) clinics.

Table 2 Observations of healthcare waste management practices by health surveillance assistants compared to ranked knowledge

HCWM characteristic observed	Village clinics (*n*=81)	Older clinics (2007-2009) (*n*=27)	Newer clinics (2010-2012) (*n*=54)	Smaller community <2000 people (*n*=50)	Larger community >2000 people (*n*=31)	Patient volume <500 last quarter (*n*=39)	Patient volume >500 last quarter (*n*=42)	Better HSA knowledge of HCWM (*n*=65)	Lower HSA knowledge of HCWM (*n*=16)
Segregation	59%	63%	57%	54%	68%	54%	64%	60%	56%
Color-coding	36%	30%	39%	38%	32%	31%	40%	38%	25%
Appropriate use of safety boxes	73%	56%	81%	78%	65%	79%	67%	72%	75%
Management of good-quality temporary storage areas	57%	48%	61%	62%	38%	59%	55%	63%	31%
Good-quality on-site treatment	43%	33%	48%	44%	42%	38%	48%	48%	25%

When comparing older and newer clinics, there was no difference in terms of observed waste practices for segregation (p=0.81), the presence of color-coded receptacles (p=0.47), good-quality temporary storage sites (p=0.34), or the presence of good-quality on-site treatment (p=0.24). However, there was a significant difference (p=0.018) in the appropriate use of safety boxes for the collection of sharps. This implies that in newer clinics, safety boxes were used in a more appropriate way (observed to be in use at 44 newer clinics and 15 older clinics).

When comparing communities of more than or fewer than 2000 people, there was no difference in terms of observed waste practices for segregation (p=0.25), the presence of color-coded receptacles (p=0.64), the appropriate use of safety boxes for the collection of sharps (p=0.21), good-quality temporary storage sites (p=0.26), or the presence of good-quality on-site treatment (p=1). This implies that there was no relationship between the size of the communities and the practices of the HSAs.

When comparing clinics with a patient volume of more than 500 patients to those with fewer than 500 patients per quarter, there was no difference in terms of observed waste practices for segregation (p=0.37), the presence of color-coded receptacles (p=0.49), the appropriate use of safety boxes for the collection of sharps (p=0.22), good-quality temporary storage sites (p=0.82), or the presence of good-quality on-site treatment (p=0.50). In clinics with lower patient volume, it was not necessarily easier to practice good healthcare waste management.

Additionally, no (0/81) clinic was observed to have health education materials about healthcare waste management. Healthcare waste education materials were expected to be posted on the clinic walls for public viewing or as a guide for HSAs giving health talks to the patients who had visited the clinics.

There was no difference when comparing HSAs who reported having knowledge versus the observed practices for waste segregation (p=0.38), good-quality temporary storage sites (p=0.20), or the presence of good-quality on-site treatment (p=0.30). However there were differences when comparing HSAs who reported to have knowledge versus those observed having in place and practicing placing waste in color-coded receptacles (p=0.01).

At one clinic, innovation in healthcare waste management was observed by researchers. The innovation was created by an HSA who had designed and installed a low-cost sharps pit to safely dispose of sharps and syringes that were generated at his village health clinic (Fig. 3). The lined sharps pit was 1 m deep and covered with a nearly 20-year-old precast concrete pit latrine slab and drophole cover, which was discarded and repurposed for the sharps pit. The innovation reportedly occurred because the HSA noted that family planning services generate a high volume of needles, which contribute to the total stream of waste generated at the clinic. However, the HSA reported not to have been formally trained in

healthcare waste management. The HSA did not have cement for an onsite disposal system, which necessitated the use of a local system. Furthermore, when asked if his innovation had been implemented by neighboring clinics, he said it had not.

A B

Fig. 3 Low-cost sharps pit modified from pit latrine design A.) Surface of the pit as covered with a repurposed precast pit latrine slab and drophole cover. B.) Inside the unlined pit showing segregation of sharps.

Discussion

Although the specific context is extremely important, our study considered government workers' healthcare waste knowledge and practice at rural community village health clinics in a low-income country. The Ntcheu District could be considered as an appropriate study area for developing plans that are sustainable for rural healthcare waste management. We did not find a direct correlation when comparing knowledge versus practice category by category.

Our study showed that the surveyed clinics could generate more than one category of waste, both infectious and noninfectious waste, and that healthcare waste management was required for operation at all the clinics. This was the case because the clinics provide not only curative services but also preventive maternal and child health services. The key to waste minimization and effective management of healthcare waste is the segregation of waste according to categories by the waste producer. While

most (76/81; 94%) HSAs reported knowing how to categorize waste, the practice of segregation of waste was observed at lower rates (48/81; 59%). Although color coding is not included in HSA training (Ministry of Health 2009), our study observed that 36% (29/81) of the clinics had color-coded receptacles present. This indicates that practical on-the-job training as part of routine supervision by Ntcheu District Hospital on healthcare waste management was working to promote categorization and color coding of waste at least in some clinics but could be expanded. Despite the lack of formal training, the HSAs demonstrated satisfactory practices in sharps management. Furthermore, the lack of national guidelines and relevant HSA training negatively impacts practices in terms of healthcare waste management. Our study might be a first step in advocating for a national program based on local context. This might be built upon a Liberian model where, in response to healthcare facilities having improper disposal for infectious waste, the Liberian health ministry held multi-stakeholder meetings that led to national environmental health train-the-trainer courses (Abrampah *et al.* 2017). In Nigeria, although only 32% of rural healthcare facilities reported to have sent staff to healthcare waste management trainings (Oyekale and Oyekale 2017), at least sending a portion of staff for healthcare waste management trainings in our study area could be adopted as an improved initial approach.

The healthcare waste management gaps for village health clinics in Malawi are not unique on a sub-Saharan Africa scale. For clinics where the HSA is operating from a household or under a tree, this informal set-up makes it difficult to practically implement healthcare waste management practices. In addition, although not statistically significant, some of the HSAs are seeing thousands of patients a month on their own, which may mean some HSAs have too many patients to effectively manage their waste. Our findings concur with the challenges in Botswana that were reported by Mbongwe *et al.* (2008). They found that color-coded receptacles for segregation of healthcare waste were not being used properly and that there was a lack of awareness of health education materials on healthcare waste

management. Similar to recommendations from Ethiopia (Haylamicheal & Desalegne 2012), legislation and policy documentation on healthcare waste management and improved training of healthcare workers is needed in Malawi. A lack of treatment systems and segregation practices for healthcare waste has also been observed in Nigeria urban clinics (Longe 2012).

There were some good practices observed that deserve attention. The clinics performed well with sharps, both with the use of sharps boxes and the innovative sharps pit. This may also be because of a high level of local awareness of human immunodeficiency virus infection and the acquired immune deficiency syndrome (HIV/AIDS) in Malawi.

One effective example that can be shared and further scaled up is the successful modification of materials that are used for pit latrines to construct a sharps pit. Construction of the pit and slab would cost approximately USD$15 for materials with labor provided in-kind by the community. This could provide the means by which to dispose of sharps for service priority areas, such as clinics that offer diagnostic and immunization services. This method of disposal was observed to be largely in-line with the minimum requirements (Chartier *et al.* 2014) for the disposal of hazardous healthcare waste, which ensures that environmental pollution is minimized. The pit sides were covered with a low permeability material with narrow access for sharps. The pit provides a simple intervention for sharps designed for short- to medium-term use within the local context. Most importantly, there was active evidence that it was in use and that it was only being used for sharps and no other noninfectious waste. Because the system is based on existing local knowledge of pit latrines, which are the primary household sanitation facility for rural areas in Malawi, it seems reasonable to expect that word-of-mouth promotion of the sharps pit model would have increased the number of sharps pits in use by other HSAs. However, this has not occurred in the two years since the pit was built, and there was no other evidence of this system

in the other 80 clinics in this study. This may also be an issue, whereby the culture does not acknowledge or reward competence and conscientiousness, at least not in rural government service. Other appropriate disposal facilities are available in the district, specifically an incinerator at the district hospital, but there are logistical challenges by the HSA in transport of waste, as most operate by walking, bicycle or motorcycle. Open burning of healthcare waste is not appropriate.

Although not a direct comparison, when our clinics are compared to the larger Malawi healthcare facilities included in the 2013-2014 nationwide survey (Ministry of Health and ICF International 2014), appropriate use of safety boxes at 73% by village health clinics in this study compares similarly to 76% nationwide across facility types. While a good-quality temporary storage area was present at 57% of village health clinics compared to the appropriate storage of infections waste at 28% nationwide across facility types (Ministry of Health and ICF International 2014).

Overall, there is a need for more evidence on the actual practices and what works most effectively for rural healthcare waste management practices. There is an opportunity to replicate the methods used in this study within other low- and middle-income country settings by Ministry of Health officials as a low cost and rapid evaluation tool.

Based on our findings, the following local recommendations are made from this case study:

- Train all HSAs serving village health clinics on waste management suitable for their setting.
- Promote ending open burning on the land and instead use small-scale low-cost double-chamber incinerators.
- Modify materials used for pit latrines and use them to construct sharps pits.
- Encourage grassroots innovation and sharing in healthcare waste management among HSAs.

- Develop relevant central waste collection points for all village health clinics along the continuum of permanent structure to use of an open space.

Study Limitations

Participant observations were prearranged and were performed by representatives from Ntcheu District Health Office or Mzuzu University, whose presence may have changed the typical practices of the HSAs. However, our study also had important strengths. By studying each clinic with a minimum 5-year operational history within a district, we aimed to remove the perception that individual HSAs were being assessed. Some clinics may perform better or worse based on seasonal variations. For example, malaria cases are higher in the rainy season and would generate more sharps from malaria testing kits.

Conclusion

Healthcare waste management in low-income countries is needed, just as in any global health facility; however, our study found gaps in both knowledge and practice for rural village health clinics. This study provides new evidence for an underresearched theme. Even if HSAs may know the ideal waste management scenario, they may not have put it into practice, practically speaking, for example, when holding a clinic under a tree. This failure may be linked to gaps in knowledge that are related to communication or dissemination factors, practical options, or insufficient local resources. The criterion least often met was the segregation of waste according to color codes. Mixed waste is harder to manage, and segregation is the first practical way to reduce waste. Rural village health clinics sort out and store syringes particularly well. An important step in segregation was observed in the case of one low-cost local solution that could be shared more widely and would likely work well for scale-up, as each HSA

within our study is working in a similar environment, both in terms of environmental conditions and in terms of limited financial resources. Rural clinics are expected to do the front-line services work of hospitals, but the requisite waste management support is not provided.

Ethical approval

Ethical clearance for the study was approved by the Malawi Government, National Commission for Science and Technology (Protocol Number P09/17/210 on 26 September 2017). Informed consent was obtained from all individual participants who were included in the study.

438 **References**

439 Abrampah, N. M., Montgomery, M., Baller, A., Ndivo, F., Gasasira, A., Cooper, C., Frescas, R., Gordon, B.,
440 & Syed, S. B. (2017). Improving water, sanitation and hygiene in health-care facilities, Liberia. *Bull*
441 *World Health Organ.,* 95, 526–530. https://doi.org/10.2471/BLT.16.175802.

442 Chartier, Y., Emmanuel, J., Pieper, U., Pruss, A., Rushbrook, P., Stringer, R., Towned, W., & Zghondi, R.
443 (eds) (2014). Safe management of waste from health-care activities. Second edition. Geneva:
444 World Health Organization.

445 Cronk, R., & Bartram, J. (2018). Environmental conditions in health care facilities in low- and middle-
446 income countries: Coverage and inequalities. *International Journal of Hygiene and Environmental*
447 *Health,* 221(3), 409-422. https://doi.org/10.1016/j.ijheh.2018.01.004

448 Diaz, L. F., Savage, G. M., & Eggerth, L. L. (2005). Alternatives for the treatment and disposal of
449 healthcare waste in developing countries. *Journal of Waste Management,* 25, 626-637.
450 https://doi.org/10.1016/j.wasman.2005.01.005

451 Gilroy, K. E., Callaghan-Koru, J. A., Cardemil, C., Nsona, H., Amouzou, A., Mtimuni, A., Daelmans, B.,
452 Mgalula, L., & Bryce, J. (2013). Quality of sick child care delivered by Health Surveillance
453 Assistants in Malawi. *Health Policy and Planning,* 28, 573–585.
454 https://doi.org/10.1093/heapol/czs095

455 Harhay, M. O., Halpern, S. D., Harhay, J. S., & Olliaro, P. L. (2009). Health care waste management: a
456 neglected and growing public health problem worldwide. *Tropical Medicine and International*
457 *Health,* 14, 1414–1417. https://doi.org/10.1111/j.1365-3156.2009.02386.x

458 Haylamicheal, I. D., & Desalegne, S. A. (2012). A review of legal framework applicable for the
459 management of healthcare waste and current management practices in Ethiopia. *Waste*
460 *Management & Research,* 30(6), 607–618. https://doi.org/10.1177/0734242X11419891

Longe, E. O. (2012). Healthcare waste management status in Lagos State, Nigeria: a case study from selected healthcare facilities in Ikorodu and Lagos metropolis. *Waste Management & Research,* 30(6), 562–571. https://doi.org/10.1177/0734242X11412109

Malawi Government. (2009). Malawi Population and Housing Census 2008. Zomba, Malawi: National Statistics Office.

Mbongwe, B., Mmereki, B. T., & Magashula, A. (2008). Healthcare waste management: Current practices in selected healthcare facilities, Botswana. *Waste Management,* 28, 226–233. https://doi.org/10.1016/j.wasman.2006.12.019

Ministry of Health (MoH) [Malawi] and ICF International. (2014). Malawi Service Provision Assessment (MSPA) 2013-14. Lilongwe, Malawi, and Rockville, Maryland, USA: MoH and ICF International.

Ministry of Health. (2008). *Training manual on health care waste management for qualified health workers*. Lilongwe, Malawi: Malawi Government.

Ministry of Health. (2009). *Health surveillance assistant facilitator's guide*. Lilongwe, Malawi: Malawi Government.

Oyekale, A. S. & Oyekale, T. O. (2017). Healthcare waste management practices and safety indicators in Nigeria. *BMC Public Health*, 17:740. https://doi.org/10.1186/s12889-017-4794-6

World Health Organization (WHO). (2017). Safe management of wastes from health-care activities: a summary. Geneva: World Health Organization.

Supplementary Material: Observation of healthcare waste management practices

The checklist needs to be filled while the provider is attending clients through observation. Responses should reflect the situation at the time of the checklist (today).

1. Do you see that waste is being segregated according to categories and types? Yes () or No (). If YES, how is this done?_____
2. Are color-coded receptacles for segregation of medical waste present today? Yes () or No()
3. Are safety boxes being used for sharps waste? Yes () or No ()
4. Appropriate use of safety boxes for sharps waste? Good () or Bad ()
5. Is personal protective equipment being used by the provider? Yes () or No ()
6. Appropriate use of personal protective equipment by the providers? Good () or Bad ()
7. Management quality of temporary storage area? Good () or Poor ()
8. Storage period of medical waste in temporary storage area before treatment or disposal_____
9. On-site treatment? Yes () or No (). If NO go to question 12
10. If yes, method of on-site treatment:
    - Incineration ()
    - Open burning ()
    - Disinfection ()
    - Landfill ()
    - Other, specify_____
11. Quality of on-site treatment? Good () or Bad ()
12. Final disposal methods
    - Landfill ()

- Rubbish pit ()
- Pit-latrine ()
- Open dumping ()
- Other, specify----------

13. Availability of health education materials on HCWM? Yes () or No (). If NO, go to question 15.

14. List the available health education materials_____

15. Handwashing station with soap is functioning? Yes () or No ()

16. Condition of the pit latrines? Good () or Bad ()