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Barriers and enablers for group-based manual emptying services for onsite sanitation facilities in Nairobi, Kenya: a qualitative study

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ABSTRACT

Onsite sanitation, such as pit latrines, is essential to achieving universal access to safe sanitation, as outlined in Sustainable Development Goal target 6.2. However, manual emptying for pit latrines in low-income areas is often unhygienic, posing health and environmental risks. Enhancing the safety of these services increases costs, yet affordability for customers is essential. Thus, reducing service costs is a key priority. Group-based approach, where emptiers visit multiple toilets consecutively, has potential to improve both service efficiency and affordability. However, few studies have investigated its applicability to manual emptying. This paper aims to identify barriers and enablers for group-based manual emptying services in low-income neighbourhoods of Nairobi. We conducted 12 focus group discussions with landlords, tenants, and manual emptiers in the Korogocho informal settlement in Nairobi and interviewed 20 key informants from relevant sectors in Kenya. We identified five categories of barriers and enablers that affected general and group-based manual emptying: 1) funding, 2) expertise and equipment, 3) social and commercial habits, 4) physical conditions, and 5) regulatory systems. Of these, a norm that pits are not emptied until they get full, operating time constraints, fair and transparent pricing, and an organiser who can arrange group-based emptying from Category 3, and transport capacity from Category 4 specifically affected group-based manual emptying. Given that the barriers have a cascade structure, addressing some primary barriers such as capacity building and recognising manual emptiers' role in the sanitation policies could be effective ways to ensure safe and affordable emptying services.

1. Introduction

Universal access to safe sanitation is an important global challenge as recognized by Sustainable Development Goal target 6.2 (UNICEF & WHO, 2023). Poor management of sanitation facilities poses health risks to local communities and causes environmental problems (Graham and Polizzotto, 2013; Wolf et al., 2023). However, the progress of SDG 6.2 varies widely by region. In particular, coverage of safely managed sanitation services in Sub-Saharan Africa was as low as 24 % in 2022, which was far below the global average of 57 % (UNICEF & WHO, 2023).

Onsite sanitation systems, such as pit latrines and septic tanks, are the most common type of sanitation in Sub-Saharan Africa, used by 72%

of the population (Greene et al., 2021). When an onsite sanitation facility gets full, users must empty it, or seal and abandon it and build a new one (Strande et al., 2014). However, in densely populated urban areas, including informal settlements, emptying and transporting faecal sludge to a treatment facility is crucial since constructing a new containment chamber is challenging given space constraints (Akumuntu et al., 2017; Yesaya and Tilley, 2021). In addition, more than 40 % of onsite facilities in Sub-Saharan Africa cannot be emptied by mechanised methods (e.g. vacuum pump) and can only be emptied by manual ones due to road accessibility or presence of solid waste, which blocks pumps (Greene et al., 2021). Therefore, manual emptying services are essential in communities relying on onsite sanitation.

There are numerous challenges with manual emptying. First, safely

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operated manual emptying services are often higher than people's willingness to pay (Tomoi et al., 2024). Second, manual emptying is sometimes operated unhygienically regardless of whether the service is provided by a formal or informal service provider (Mallory et al., 2021; Simiyu et al., 2021). Some manual emptiers work without personal protective equipment (PPE) and dump collected faecal waste into the open environment rather than a sludge treatment facility (Mallory et al., 2021; Simiyu et al., 2021). Making those operations hygienic increases costs for PPE and other tools, which can be unaffordable for some low-income customers (Wilcox et al., 2023).

For more feasible emptying services, some business models have been proposed: scheduled emptying, call centre, and transfer station models (Rao et al., 2016). Scheduled emptying is a model where a local authority collects emptying costs from households as a tax and sets up a mandatory scheduled emptying date for multiple households or neighbourhoods, so that these are serviced consecutively in one day (Rao et al., 2016; Singh et al., 2022). By grouping households, service providers can efficiently transport waste thereby reducing costs, and the costs are shared by the households (Burt et al., 2019). This group-based approach is likely to be applicable to manual emptying.

The basic operation of group-based manual emptying mirrors that of mechanical emptying. A service provider manually collects faecal sludge, transports it in drums or a tank by vehicle, and repeats this process at multiple locations, before delivering the sludge to a safe discharge point within a day (Fig. 1). This approach reduced costs as capital expenses (e.g. vehicle loan) are shared among households using the service on the same day (Tomoi et al., 2025). Transport costs (e.g. fuel cost) per household are also lower when the grouped households are in proximity, compared to a single household requesting the service alone (Tomoi et al., 2025).

Unlike the other business models, group-based emptying requires coordination of emptying dates between multiple households and the service provider (Tomoi et al., 2024). This complexity in service provision may hinder its implementation. However, to the best of our knowledge, no study has explored enabling conditions of the group-based manual emptying in real markets in urban informal settlements. Identifying barriers and enablers for group-based manual emptying could help practitioners improve and implement this approach.

Therefore, the objective of this study is to identify barriers and enablers to provide safe and affordable group-based manual emptying services in informal settlements, particularly among major stakeholders including landlords, tenants, service providers, and the public sector.

2. Methodology

2.1. Study site

This study was conducted between December 2023 and September

2024 in the Korogocho informal settlement in Nairobi, Kenya (Fig. 2). Nairobi is the capital city of Kenya with a population of approximately 4.4 million in 2019, 60 % of which lives in informal settlements (Kenya National Bureau of Statistics, 2019; UN-HABITAT, 2023). Korogocho is one of the biggest informal settlements in the city with an area of about 1 km² located between two rivers and adjacent to the Dandora dumping site (African Population and Health Research Center (APHRC), 2020). It is comprised of eight villages where 34,000 people are estimated to reside (Iddi et al., 2021). A majority (77.6 %) of the population use unimproved onsite sanitation facilities such as pit latrines without slabs as the sewer network covers very limited areas of settlement (Iddi et al., 2021).

2.2. Study design

We conducted focus group discussions (FGDs) and key informant interviews (KIIs) in a semi-structured format. We first asked about general barriers and enablers for manual emptying and then asked specific ones for group-based manual emptying. To complement the information on emptying practices obtained from FGDs and KIIs, two emptying events were observed on separate days to understand the operation of manual emptying in Korogocho. We have followed the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Tong et al., 2007).

2.3. Participant selection

For FGDs, tenants, landlords, and manual emptiers in Korogocho were purposively recruited from each of the eight villages in Korogocho by a trained research assistant who lives locally and speaks Swahili. As for tenants and landlords, households with toilets that cannot contain faecal sludge (e.g. directly connected to a river or a sewer pipe) and households without toilets were excluded since they have no chance to use emptying services. To recruit tenants and landlords, the research assistant visited houses of potential participants and asked their monthly household income so that at least one participant was recruited from each income group: <5000 KES (<36 USD), 5000-7000 KES (36-50 USD), 7000-10,000 KES (50-71 USD), and >10,000 KES (>71 USD). The average exchange rate during the study period was 139.8 KES per USD (Xe, 2025). The income ranges were decided based on a study in Kenya (Peletz et al., 2020) and a consultation with the research assistants. One person who could make a decision on emptying (i.e., an adult household member who paid for or was familiar with emptying) was recruited from each household by directly asking it. For manual emptiers, informal workers were randomly selected at places where emptiers usually gather in Korogocho. Those under 18 years of age, the adulthood age in Kenya, were excluded from this study.

For KIIs, participants were recruited from the public, private and academic sectors and non-governmental organisations (NGOs) by a



Fig. 1. Overview of group-based manual emptying.



Map data © 2022 Google, Airbus, Maxar Technologies

Fig. 2. Location of the Korogocho informal settlement in Nairobi.

snowball sampling method (Kirchherr and Charles, 2018). Starting from the Nairobi City County Government, which is responsible for sanitation issues in Nairobi, each interviewee was asked to suggest at least one interviewee who seemed to be able to provide insights based on the topic guide. There was no relationship established between the interviewer and participants prior to the interview.

2.4. Ethical considerations

Ethical approval was obtained from the London School of Hygiene & Tropical Medicine Research (LSHTM) Ethics Committee (Ref No. 29690) and Amref Health Africa's Ethics & Scientific Review Committee (Ref No. P1547/2023). The study was approved by the National Commission for Science, Technology & Innovation (NACOSTI) of Kenya (Ref. 815914). The participant information sheet was shared and reviewed with each potential participant in Swahili, and they were given time to ask questions. If agreeing to participate and voice-recording, written consent was obtained from each participant. For anonymity, participants were called by codes (e.g., P1) during FGDs.

2.5. Data collection

As preparatory work, we observed two emptying events conducted by manual emptiers in Korogocho in a non-structured manner to understand how their operation was done. We recorded the volume of sludge removed (counted by the number of 200L-drums), personal protective equipment used, and the vehicle used to transport the drums were noted.

FGDs were held at the African Population Health Research Centre (APHRC) Korogocho Office which is within walking distance of the Korogocho informal settlement. Each FGD consisted of seven or eight participants. Participants were not segregated by gender since using emptying services is a gender-neutral topic. All FGDs were conducted in Swahili by a male and female moderators (JO and EO), who had experience in FGDs with residents in informal settlements in Nairobi. They were in charge of the moderator and assistant moderator in turns, and notes were taken by the assistant moderator. Two researchers (HT and BBI) attended the FGDs as observers. The FGDs lasted for at least 1 h and compensation was provided for travel.

KIIs were conducted by the lead author (HT) in English at the participant's office or online, and lasted for at least 1 h. Notes were taken by the interviewer.

FGDs and KIIs were recorded using a voice recorder and were conducted using topic guides (Supplementary Information 1). The topic guides included questions on barriers and enablers that participants face when using or providing existing manual emptying services, and expectations and potential challenges if group-based manual emptying was introduced. The moderator or the interviewer explained the idea of group-based emptying showing a short video to the participants during the sessions (Tomoi, 2024). Data collection ended when data saturation occurred, meaning that additional data collection did not generate new findings nor further themes (Hennink and Kaiser, 2022).

2.6. Data quality control

Before data collection and participant mobilisation, the researchers and research assistants were trained for four days. The training included sessions on the overview of this study, pre-testing of the topic guides, information sheet and consent forms, and role-playing of the entire data collection process. After each FGD, research staff gave feedback to each other on the new findings and facilitation techniques to be improved. Transcribing the FGD recordings was performed by the assistant moderator. Transcripts obtained from FGDs were not returned to participants for logistics reasons. Recordings of KIIs were transcribed by the interviewer and returned to each interviewee for accuracy and validity.

2.7. Data management and analysis

We adopted thematic analysis and followed the six phases of analysis by Braun and Clarke (2006). The audio files were transcribed and translated into English by a professional translator when original conversation was done in Swahili. The transcripts were imported into Nvivo 14 (QSR International, Australia) for coding (Dhakal, 2022). An initial list of codes was inductively developed by HT from several transcripts. New codes were added to the list while analysing the remaining transcripts. The list was double-checked by another co-author (HM), allowing some modifications of codes until the last updated list of codes was applied to all transcripts. The final codes were grouped into "themes". Data saturation was deemed to have reached at the time that no more codes were identified (Hennink and Kaiser, 2022).

3. Results and discussion

3.1. Characteristics of participants

In total, 12 FGDs with tenants, landlords and emptiers were conducted (Table 1). Ninety-four participants took part in the FGDs, of whom 61 were men and 33 were women. None of the participants were acquainted with the moderators, but the field supervisor was wellknown in the local community due to previous research projects in Korogocho. In total, 32 landlords were recruited for the FGDs, but as two landlords did not appear at the scheduled time, only 30 took part in the

Table 1

Summary of the focus group participants.

	Tenants	Landlords	Emptiers	Total
No. of FGD	4	4	4	12
No of participants	32	30	32	94
of which male	20 (63	9 (30 %)	32 (100	61 (65
	%)		%)	%)
of which female	12 (37	21 (70 %)	0	33 (35
	%)			%)
Any family member having a mobile phone	32	30	NA	-
of which having mobile money	31 (97	30 (100	21 (88	-
(Mpesa)	%)	%)	%) ^a	
Monthly household income (self-reported)				
<5000 KES (36 USD)	7 (22 %)	7 (23 %)	13 (41 %)	27 (29
				%)
5000–7000 KES (36–50	7 (22 %)	6 (20 %)	7 (22 %)	20 (21
USD)				%)
7000–10,000 KES (50–71	14 (44	9 (30 %)	7 (22 %)	30 (32
USD)	%)			%)
>10,000 KES (71 USD)	4 (12 %)	8 (27 %)	5 (15 %)	17 (18 %)

NA: Not Applicable.

^a 24 emptiers were asked if they accept payment by Mpesa.

discussions. All emptiers who joined the FGDs were male as no female emptiers were found.

All tenants and landlords had at least one family member with a mobile phone, and 97 % of tenants and all landlords had access to mobile money, Mpesa. Of the 24 emptiers who we asked if they accept payment by Mpesa, 21 emptiers answered "yes". Other characteristics of participants including age and education level are available in Supplementary Information 2.

Twenty KIIs with sanitation stakeholders were recruited through the snowball sampling (Table 2). One interviewee refused to be voice-recorded, so only notes of the conversation were taken.

3.2. Summary of emptying practices in Korogocho

Onsite sanitation facilities used by landlords and tenants include dry pit latrines and pour-flush latrines connected to a pit or septic tank. All landlords and tenants had one latrine in their plot, except one tenant having three. On average, eight households shared one toilet.

In Korogocho, landlords and tenants noted that most households only used informal manual emptying services due to access, while vacuum trucks were used at schools, churches and a limited number of households close to wide roads. They also noted that informal emptiers worked in teams of three to four and formed village-level groups, whereas there were no formal ones certified by the local authorities.

Informal emptiers used a handcart attached to a 200 L-drum, which was the only means of transport used to carry faecal sludge. The drum was covered with plastic sheets and rubber bands when carrying sludge, but could not be sealed tightly. Once the drum was filled with sludge, three or four workers pushed and carried the handcart to a nearby river where the sludge was disposed of. While they shuttled between the

Table 2

Summary of the key informants.

Sector	Affiliation of the KII Participants
Public sector & utility	Ministry of Water, Sanitation and Irrigation, Nairobi Rivers Commission, Nairobi City County Government, National Environment Management Authority, Water Services Regulatory Board, Kisumu Water and Sanitation Company
Private sector	Pan-African Association of Sanitation Actors, Sanergy
Academia	APHRC, Meru University of Science and Technology
NGO	Water & Sanitation for the Urban Poor, Women in Water &
	Sanitation Association Kenya, Umande Trust
International organisation	UN-HABITAT, UNICEF

household and the river, one emptier continued removing sludge using buckets and a stick. For both two emptying events, it took approximately 80 min to collect four 200L-drums of sludge and most of that time was spent carrying the handcart, suggesting that there is room for improving transport efficiency by using a motorised vehicle. Since a household empties five 200L-drums of sludge (median) per pit in Korogocho (Tomoi et al., 2025), visiting multiple households seems manageable for emptiers if some barriers described below (i.e. working time rule, transport capacity) are overcome. Five out of eight emptiers we observed had no protective equipment, while two were wearing gumboots, and one wearing gumboots and globes.

An emptying fee was based on volumetric pricing: the fee was calculated by multiplying a rate per drum by the number of drums transported. The rate per drum depended on the distance from the river, workload (e.g., whether water is needed to soften the sludge, the slab needs to be removed), and negotiation between emptiers and customers. While payments were usually made in cash, mobile money (i.e., Mpesa) was also used when landlords lived outside the informal settlement or customers preferred it.

3.3. Barriers and enablers for safe and affordable manual emptying services

In this study, we defined barriers as anything that prevents the provision of safe and affordable group-based manual emptying services, and enablers as anything that already exists in Korogocho or other parts of Kenya and makes the service provision possible. Twenty-four barriers and 12 enablers were identified through the study, and they were classified into five categories (Figs. 3 and 4): funding, expertise and equipment, social or commercial habits, physical conditions and regulatory systems. The identified barriers often revealed an interlinking cascade structure as Fig. 3 shows.

3.3.1. Funding

Financial constraints were a common barrier for all sanitation stakeholders in Korogocho. There were no subsidies to support households although 46 % of the households reportedly have 7500 KES (56 USD) of monthly income (= less than 2 USD/day) (Tomoi et al., 2025). While landlords are generally responsible for arranging emptying and the costs in Kenya (Simiyu et al., 2017), rental income was the main funding source for the landlords in Korogocho. Landlords reported that maintaining sanitation facilities for rented accommodation was financially challenging because tenants, who were usually casual workers, sometimes failed to pay their rent.

Landlords and tenants admitted the benefit of emptying smaller amounts of sludge rather than emptying a whole pit.

"Some may opt for complete emptying, and others may find it more manageable to contribute small amounts for regular emptying." (FGD, male landlord)

However, monthly payment, an emerging idea to spread out the emptying cost over several months and thereby reduce the one-off payment (Peletz et al., 2020), was not preferred by landlords and tenants in Korogocho since their income was unstable and unpredictable.

"We have to contribute that money every end of the month because they [service providers] don't entertain the idea that we don't have it ... Therefore, I believe this requirement [monthly payment] is unavoidable, and this is where I foresee challenges for our village. (FGD, female tenant)"

For the same reason, landlords and tenants did not prefer groupbased emptying in a mandatory manner or so-called scheduled emptying where emptying dates are designated by a local authority.



Fig. 3. Barriers to safe and affordable group-based manual emptying services in Korogocho. The grey boxes represent the barriers (solid line boxes are specific to group-based emptying), and the arrows describe the linkages between the barriers.



Fig. 4. Enablers for safe and affordable group-based manual emptying services in Korogocho. The solid line box shows enablers specific to group-based emptying and the dotted line boxes show enablers common with ordinary and group-based manual emptying.

"Some would claim that, at the agreed time and date, they have not received money yet. So, it [scheduled emptying] won't work well for everyone; some will lag behind. (FGD, male landlord)"

Manual emptiers noted that funding was a major barrier to sustainable operations as they could not afford PPE, vaccinations, or medical care when injured. Also, they could not afford emptying tools that would minimise environmental contamination such as sealable drums, thereby increasing the risk to the community.

Officials from the public sector and utilities noted that a lack of funding was one of the obstacles to constructing new disposal sites and providing support for manual emptiers. Three public officials saw financial contributions from international organisations and development banks as an enabler.

3.3.2. Expertise & equipment

Lack of expertise and equipment to operate manual emptying was a barrier to providing safe services. Landlords and tenants who joined the FGDs blamed informal manual emptiers for limited knowledge and skills to operate hygienically, resulting in low reputations for the service.

"When they empty there is a lot of spillage ... they use a sponge to clean the spillage. They dip it into the drainage, and remember that the sponge has faecal matter." (FGD, male landlord)

Emptiers noted that support from the public sector and NGOs including "training" for safe operation, "vaccinations", and "uniforms, like overalls, gumboots, gloves" (KII, female, NGO) would enable them to operate hygienically. Two emptiers reported having received PPE from a local NGO as part of a sanitation improvement project, but no one had received any training on emptying.

Four experts from NGOs noted that a lack of ability to manage or access finances, along with a lack of funding, was a root cause for emptiers continuing to use worn-out PPE and tools and non-motorised vehicles to carry sludge. One emptier mentioned his wish: "(we) could save and get a loan to improve ourselves. We could even have a truck to transport the waste instead of living with a cart." (FGD, male emptier). The ability to access finances is particularly important when implementing group-based emptying since large capital investments would be required to purchase a vehicle and establish a business model.

3.3.3. Social/commercial habits

The third category "social or commercial habits" indicated the complex dynamics in the community.

Landlords and tenants accused emptiers of their unprofessional behaviours such as consuming alcohol before working and cheating on the amount of work,

"... they (emptiers) arrive when intoxicated. They handle the waste so carelessly that sometimes the drums burst, and the waste spills everywhere." (FGD, male tenant)

"... they may take less than the agreed amount (of sludge), claiming to have emptied a certain number of drums." (FGD, female landlord)

Emptiers tried "to forget the smell, getting dirt or danger" (KII, local NGO) during work by consuming alcohol, but "it even leads to fights among the emptiers" (FGD, male tenant). Due to the working habits and unhygienic operation, emptiers were stigmatised in the community, being called "wa kairo (black people)" or "drunks". Emptiers mentioned that the stigma led to criminal acts against them: "We were confronted with knives ... They [some youths] demanded payment; 500 shillings. They claimed that we are polluting the river" (FGD, male emptier). Eight key informants from the public and private sectors and NGOs emphasised that sensitisation programmes in the community are important to improve the unsafe working environments for emptiers, but they also admitted that the scale was insufficient due to a lack of financial or human resources.

"The campaigns we have tried to kill the stigma that are considered loads of low-profile society. That is what we are scaling up. ... We still have a gap. We try as much as possible to engage and get support from various stakeholders." (KII, public official)

The relationship between landlords and tenants obstructed the regular uptake of emptying services. Even when tenants paid their rent, landlords' responses to the requests of emptying from tenants were delayed for various reasons. Some landlords, especially those who lived away from tenants, neglected the requests.

"He [a landlord] is still collecting money and is reachable by phone, but he refuses to empty the toilet." (FGD, female landlord)

Eleven landlords mentioned that they tried to collect contributions from tenants when their pits got full, which resulted in disputes with tenants who thought the emptying fee was included in their rent. To avoid the situation, five landlords and six tenants noted that they had agreed on emptying fees when the tenancy began, e.g. "We contribute money to have the pit emptied and deduct it from the rent." (FGD, female tenant).

Inappropriate toilet management by households also prevented safe emptying. Solid waste such as "*needles, bottles, and broken glass*" (FGD, male emptier) was disposed of in the pits, leading to more rapid fill-up and posing safety risks to emptiers, while hindering pump-emptying. Additionally, five tenants noted that they discharged faecal sludge into nearby ditches to avoid emptying fees. To prevent the inappropriate toilet management, the public sector, NGOs and international organisations, have provided households with education about "*the importance of WASH*" and "*why (households) need to pay for sanitation*" (KII, public officials).

Regarding enablers, accessibility to manual emptiers was high in Korogocho as a landlord admitted, "*I usually have their phone number and call them, telling them I need them the next day.*" (FGD, female landlord). Emptiers had "*a designated location where they operate from*" (FGD, female landlord). This network that enables timely service provision was an asset emptiers had built in the community. Therefore, recruiting the informal emptiers and transforming them into official workers would be meaningful from the perspective of utilising their networks.

Emptiers noted that there are between 70 and 80 informal emptiers operating in Korogocho. Competition contributes to keeping the market price low, whilst also raising concerns about the sustainability of emptying business due to excessive pressure.

"If one place[emptier] is charging 200, another might suggest 150. If some agree to 150, it disrupts the entire market." (FGD, manual emptier)

If conducting group-based emptying, community dynamics further exacerbate existing challenges in the service provision. First, residents in Korogocho had set an operating time limit for manual emptiers: "*they start their work around 4 a.m., finishing by around 9 a.m.*" (FGD, male tenant) so that food shops and restaurants were not affected by foul odour. As the time limit was a local rule, emptiers had to follow it to avoid conflicts. This time constraint was a barrier for group-based emptying as serving multiple households takes longer than serving one, and emptiers may not be able to finish the work within the time limit.

Secondly, there was a concern that some landlords would refuse to cooperate or pay even when households in a specific area are designated to be grouped. This reluctance stemmed not only from financial constraints but also from a common practice of waiting until pits were full before arranging for them to be emptied.

"You find one person's container is not full, and another person's is full. Now, the one whose container is not full won't agree to empty it." (FGD, male emptier)

Therefore, someone who organises group-based emptying by pooling requests and deciding the date and sites of emptying would be needed so that emptiers can smoothly visit several households that are ready to use and pay for the service.

"Getting landlords to agree individually is hard. But if they come together and agree as a group, we can get the job done." (FGD, male emptier)

A call centre operated by a private company could potentially play this role in Nairobi, but currently, the work was only for mechanical emptiers.

In a group emptying system, organisers may have greater influence over service quality by deciding which emptiers are dispatched. To enhance customer satisfaction, the organisers may voluntarily set Standard Operational Procedures (SOPs) or exclude emptiers who fail to comply with agreed-upon rules. If group emptying becomes widespread in a certain area, the SOPs could evolve into a defacto standard, potentially addressing key barriers such as "lack of standard" or "lack of professionalism". While this was not explicitly discussed in the FGDs, it represents a plausible mechanism through which group emptying could contribute to service improvements.

Landlords and tenants preferred fair and transparent pricing for group-based emptying. If grouped households evenly shared the emptying costs among themselves, the pricing could be unfair since the emptied volume can vary as "*mine is an eight-drum. ... another person has a little: two drums*" (FGD, female landlord). Volumetric pricing that charges per drum, a common practice in Korogocho, is an option for ensuring transparent and equitable pricing.

3.3.4. Physical conditions

Physical conditions of operational areas affected the provision of emptying services.

Various pit conditions hampered efficient emptying operation as emptiers had to use different emptying procedures based on the thickness of faecal waste or presence of solid waste. Water availability was essential to soften faecal waste when it was too dense to scoop.

Narrow roads prevented households from accessing larger transport vehicles, and rough roads made transporting waste inefficient.

Most FGD and KII participants mentioned that a lack of disposal sites near the community caused the illegal dumping of faecal waste into rivers as the nearest safe dumping site for manual emptiers is approximately 13 km away from Korogocho. Due to the lack of disposal sites, manual emptiers worked with other local community members, who were often the youth from the community. The youth had to be reimbursed for overlooking the dumping, and the cost was borne by households.

"You have to give them [young men near the river] some money to allow you to empty the drums. ... as the owner of the toilet, you are responsible for that. It's usually 100 shillings per drum." (FGD, male emptier)

The local government or utility has not actively contributed to developing sanitation infrastructure for onsite sanitation in informal settlements as those settlements are illegally occupied "government's lands" (KII, male, public official).

When conducting group-based emptying, limited transport capacity and speed were also barriers to carry sludge to a treatment facility as the informal manual emptiers in Korogocho only used a handcart with a 200-drum capacity. An emptier admitted "... *it [group-based emptying] can work if we empty and transport waste by car.*" (FGD, male emptier) since the approach assumes to visit multiple households in one trip.

3.3.5. Regulatory systems

Laws and regulations at different levels were identified as important for making manual emptying safe and feasible. As for the recognition of onsite sanitation, although the national policy had recognized onsite sanitation systems as one of the major sanitation options (Ministry of Health Republic of Kenya, 2016), the bylaws of Nairobi County had not authorised manual emptying. Therefore, the county government had no rationale or mandate to implement or support manual emptying.

"Our biggest challenge is a bylaw and our policy. If we can amend it in a way that they are flexible and in tandem with what is happening on the ground, like manual emptying, faecal sludge management can be much better." (KII, male, public official).

Eight key informants from the public sector and NGOs also pointed out that different departments of the national and county governments deal with sanitation policies with overlaps, leading to unclear mandates. It has resulted in incomplete or fragmented data on sanitation including the locations and number of onsite sanitation facilities, which are essential for effective policymaking.

A lack of standards on faecal sludge handling prevented manual emptying from becoming a legitimate business model. An official from the public sector noted that "setting a standard or having a formal way of providing service" (KII, male, public sector) is the first step to making the service formal. Seven key informants from the public sector, private sector and NGOs noted that, without a standardised way of manual emptying, authorities cannot regulate unhygienic operations and formalise the services. Six key informants from academia, the public and private sector also noted that a lack of standards on the pit structure leads to unsafe pit conditions for emptiers (e.g. unlined pit walls that can collapse while emptying) which require higher emptying skills and take longer time to empty.

Regarding enablers, a formalised community-based organisation (CBO) for manual emptiers has been established in Nairobi under the support of Sanergy and the county government (Brands et al., 2022). The county government had encouraged emptiers to organise into groups so that "they can access funding" and the government knows "which emptying group is providing the service to where" (KII, male, public official). Emptiers and NGOs also admitted that organising emptiers into a group would be beneficial as they "can call each other for work" (FGD, male emptier) and "it's easy to advocate for their rights" (KII, female NGO).

3.4. Small-amount emptying

For group-based emptying to be commercially viable, a sufficient density of emptying service requests is needed in a given area at a given time. If there are not sufficient requests, customers may have to wait longer periods until there is sufficient demand and the service provider responds. To address the drawback, accepting a small emptying amount could theoretically be useful to increase the frequency of emptying events and make the grouping arrangement easier (Tomoi et al., 2025).

Emptying little by little (hereafter, small-amount emptying) was seen as a method to reduce the payment per event, and it did work in Korogocho under a volumetric pricing scheme. However, some landlords, tenants and emptiers were concerned about future clogging of pits or tanks caused by emptying a part of the containment, stating that "the pit will eventually become clogged with hard, thick waste, rendering it unusable" (FGD, male emptier).

From an engineering perspective, the influence of small-amount emptying on sludge characteristics is unclear. In general, the sludge characteristics depend on various factors including containment facility types (e.g., lined or unlined pit, septic tank), groundwater, and sludge depth and age (Chirwa et al., 2017; Seleman et al., 2021). Pit filling rates and sludge accumulation rates also vary significantly by regions and usage (Nakagiri et al., 2016). That said, accumulated thick sludge can potentially hamper mechanical emptying or make manual emptying more difficult. Therefore, further research is needed on the impact of small-amount emptying on desludging efficiency. Also, innovations to empty pits with thick sludge more efficiently are necessary.

Some landlords were also concerned about more frequent emptying as a result of the small-amount emptying since it can increase burdens of their sanitation facility management, such as arranging the emptying, collecting contributions from tenants, and cleaning the floor after the emptying.

"If it's emptied all at once, it gives us more time ... without the burden of constant emptying." (FGD, female landlord).

Therefore, providing both the small-amount option and an emptyingat-once option would be more useful so that landlords can choose either one depending on their circumstances.

In Korogocho, most landlords knew how much volume of sludge their pits can contain as they empty them several times a year (Tomoi et al., 2025). In general, however, it could be difficult for some customers to know their pit capacities. Thus, accumulating data of emptied volume from pits within operational areas would be useful for customers when they request emptying. The data can also help service providers with their marketing (e.g., sending promotions to customers who are likely to request emptying given their emptying history).

A sanitation expert from the private sector was concerned about the impact of small-amount emptying on the increase in greenhouse gas emissions.

"If you prolong the emptying intervals, the chance to increase methane would go up" (KII, female, private sector)

Since CH_4 emission rates generated from septic tanks, a type of onsite containment facilities, positively correlate with emptying intervals (Moonkawin et al., 2023), shortening emptying intervals could be an intervention to reduce emissions from pit latrines as well. However, emptying a small amount rather than a whole pit also leads to a longer containment period for the remaining sludge at the bottom of the facility, which can contribute to an increase in emissions. Therefore, further research will be needed to assess the impact of partial and more frequent emptying on emissions.

3.5. Supply-based vs demand-based group emptying

Group-based emptying can be categorised into two sub-categories. First, demand-based (or bottom-up) emptying refers to a service where random households request emptying when needed and service providers coordinate the requests to optimise their transport and labour (Burt et al., 2019). In contrast, supply-based or so-called scheduled emptying refers to services where a local authority specifies an emptying date in a particular area and conducts the emptying in a top-down manner (Singh et al., 2021).

Our study implies that scheduled emptying needs to be done in

tandem with financial support (e.g., subsidies) as some low-income households might not be able to pay the fee in accordance with the top-down schedule. Alternatively, demand-based group emptying could be more feasible in Korogocho as customers can request emptying based on their budget and sludge volume they want to remove.

Service providers who implement the demand-based approach need to coordinate emptying requests, as it is difficult for customers to find other customers who need the service in the neighbourhood by themselves. Call centres can potentially serve as organisers by pooling the demand from customers and arranging a series of emptying events on behalf of emptiers. Given the high (97 %) mobile phone prevalence in Korogocho (Tomoi et al., 2025), the organiser's role could be digitised by an application with algorithms to match emptying requests with nearby emptiers and find the most optimal route.

3.6. Limitations

There were some limitations in the study design and methodology. First, our results are not necessarily generalisable to other settings or populations due to the nature of qualitative study. Although our study provides essential understanding and insights for practitioners who try to improve manual emptying services, especially when applying a group-based approach, the local context should be considered. Secondly, the economic feasibility of group-based emptying has not been fully explored. Further studies are necessary to determine the costeffectiveness and people's preference for the approaches in a quantitative manner.

4. Conclusion and recommendations

The study identified barriers and enablers to group-based manual emptying services. Various factors affected the services, including funding, expertise and equipment, social and commercial practices, physical conditions, and regulatory systems, which are organically linked. For example, "unsafe working environments" in the "social/ commercial habits" category were a barrier for manual emptiers since they faced violence and stigma. This barrier originated from emptiers' "unhygienic operation", which also had other root causes such as lack of "funding", "expertise and equipment", "professionalism", and "operational standards". This finding suggests that addressing some key barriers is an effective intervention as it could eliminate other relevant barriers.

Emptiers should utilise support from the public sector and other stakeholders to obtain skills and equipment for better sludge handling and financial management abilities. To do so, they should form a group so that they can effectively expand the scale of operation and stakeholders can more easily provide support. Within the group, emptiers should agree on and adhere to specific guidelines, such as refraining from consuming alcohol before work and maintaining honesty in their duties.

For landlords and tenants, establishing an agreement on payment for emptying arrangements before starting tenancy might mitigate future disputes when emptying is required. Understanding proper toilet management such as preventing solid waste from being disposed of into the pit would be useful for them. Collaboration with the solid waste management sector (e.g. having collection) should be facilitated.

The public sector must start by recognising manual emptiers in the national and sub-national regulatory systems. The Kenyan parliament is about to endorse a new National Sanitation Management Policy that recognises various FSM services across the value chain, including manual emptying, and defines standard operational standards (African Population and Health Research Center (APHRC), 2022). Building on that, there should be disposal sites accessible to manual emptiers at affordable fees instead of paying bribes and dumping waste illegally. Development banks, international organisations and other stakeholders have played a key role in addressing funding gaps. Each stakeholder

should also consider a business model that can work in informal settlements utilising, for instance, (cross-)subsidies (Acey et al., 2019).

Our findings suggest that relevant stakeholders' involvement and collaboration would be essential for providing safe and affordable group-based manual emptying services. As many cities in Sub-Saharan Africa hugely rely on onsite sanitation, just like the Korogocho informal settlement in Nairobi, our results provide valuable insights for practitioners in cities with similar characteristics.

CRediT authorship contribution statement

Hiroaki Tomoi: Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. Bonface Butichi Ingumba: Writing – review & editing, Supervision, Project administration, Data curation. Sheillah Simiyu: Writing – review & editing, Supervision, Project administration, Conceptualization. Evelyne Otteng: Writing – review & editing, Validation, Investigation. James Osewe: Writing – review & editing, Validation, Investigation. Hamilton Majiwa: Writing – review & editing, Validation, Formal analysis. Laura Braun: Writing – review & editing, Supervision, Methodology, Conceptualization. Oliver Cumming: Writing – review & editing, Supervision, Methodology, Conceptualization. Taeko Moriyasu: Writing – review & editing, Supervision, Methodology, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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H. Tomoi et al.

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