Pit emptying subsidy vouchers: a two-phased targeting and structuring experiment in Blantyre, Malawi

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ABSTRACT
The removal of excreta or faecal sludge from full pit latrines – pit emptying – is essential to extend the life of the sanitation technology, especially for the millions of users living in the dense, urban areas of the Global South. Unfortunately, pit-emptying is rarely practiced due to factors related to accessibility, disgust, and importantly, cost. We examined the impact of two different types of vouchers distributed in Blantyre, Malawi, to understand if and how subsidies could increase the practice of pit emptying in low-income areas. We found that pit emptying businesses were able to game the system to charge more money on top of the discount in the first study in which 21% vouchers were redeemed from 252 distributed. In a follow-up study, 25% vouchers were redeemed from 400 distributed with more rigorous subsidy targeting and structuring. We discuss why complex drivers for subsidy adoption among low-income households require further research.

1 Introduction
Sixty-one per cent of the global population continues to lack access to safely managed sanitation (WHO & UNICEF 2017). Access to safely managed sanitation is particularly challenging in urban areas where the demand for sanitation is increasing with the growing rate of urbanisation (UN-Habitat 2014). Sub-Saharan Africa has one of the highest urbanisation rates in the world at 4.1% per year (Saghir and Santoro 2018). Provision of safely managed sanitation is a major challenge in many African cities with, on average, 60% of urban dwellers living in informal or unplanned peri-urban areas in sub-Saharan Africa (UN-Habitat 2014; Lall et al. 2017).

Informal or unplanned settlements usually lack access to sewer-based sanitation systems; therefore, the use of onsite sanitation technologies such as pit latrines and septic tanks is common (Nakagiri et al. 2016; Cummings et al. 2016). Pit latrines are essentially (semi-porous) containers for faecal sludge, and without emptying, they fill up over time. Though pits are a simple, affordable, and generally acceptable technology, there is rarely sufficient, unused space to dig new pits in dense unplanned settlements therefore the full pits are left to overflow or flood during rain events thus discharging the faecal matter into the environment (Jenkins et al. 2015; Chunga et al. 2016). Faecal sludge in pits may also contaminate groundwater sources (Chunga et al. 2016). Therefore, there is a need to safely manage the faecal sludge that accumulates in onsite sanitation technologies in order to prevent the environmental and health externalities that may be caused by exposure to faecal matter (Strande et al. 2014; Nakagiri et al. 2016; Berendes et al. 2017).

Safely managing sanitation in this context is achieved through faecal sludge management (FSM), which is the proper containment, emptying, collection, transport, treatment, and disposal or safe reuse of sludge from onsite sanitation systems (Strande et al. 2014). FSM may help address the sanitation...
challenges faced in unplanned urban areas such as space constraints and human or environmental exposure to faecal matter because with FSM construction of new replacement toilets is avoided and the overflowing of sludge is prevented (Strande et al. 2014; Peal et al. 2014). Furthermore, FSM can enable the recovery of energy and nutrients from faecal sludge, therefore creating a circular economy value chain for sanitation (Strande et al. 2014).

Sludge is emptied from the pits by either formal emptying service providers with safe technologies or informal emptiers who manually remove the sludge (Peal et al. 2014). The sludge is collected in drums or tanks and transported by trucks to treatment sites though some companies or emptiers may dispose of the sludge into surrounding environments such as rivers (Strande et al. 2014; Peal et al. 2014). Treatment sites are usually operated by local governments or utilities and a dumping fee may apply to discharge the sludge for treatment. Therefore, the availability and affordability of pit emptying services is crucial in order to collect faecal sludge from the onsite sanitation technologies and transport it to a treatment facility where it can be disposed of safely after treatment or processed into sludge-based products such as compost (Strande et al. 2014).

Pit emptying services are mostly provided by private enterprises that set their prices independently (Burt et al. 2019; Yesaya and Tilley 2020; Peletz et al. 2020b). Where pit emptying services are available, affordability remains a challenge particularly for low-income households (Tsinda et al. 2013; Cummings et al. 2016). Since residents of unplanned peri-urban areas are usually low-income households, and prices set by pit emptying service providers are subject to complex market forces, many households who require pit emptying cannot afford the service. Nonetheless, subsidies could provide supplemental costs to ease the economic burden of pit emptying.

Unlike in other sectors such as education, healthcare and agriculture where subsidies have been extensively tried and used to supplement costs for the provision of services or infrastructure (for example to improve school attendance (Kremer and Holla 2009), in malaria prevention campaigns that distribute mosquito nets (Holla and Kremer 2009; Whittington et al. 2012), in water treatment (Whittington et al. 2012; Dupas et al. 2016), and to provide farm inputs to low-income households (Jayne et al. 2018), sanitation subsidies have not been extensively tested. Water and sanitation subsidies primarily target network services such as sewerage systems (Andres et al. 2019).

Previously, the focus of subsidies for onsite sanitation has been on infrastructure to cover the costs of building materials for improved toilets to increase the adoption and coverage of improved sanitation, for instance to encourage people to switch from open defaecation to building and using pit latrines (Guiteras et al. 2015; Briceño and Chase 2015). For example, a subsidy trial was run in rural Tanzania to measure demand for hygienic latrine slabs with the goal of investigating mechanisms to increase coverage of improved sanitation facilities (Peletz et al. 2017).

However, subsidies to investigate pit emptying or maintenance (beyond adoption of improved infrastructure) are emerging. Some research has been developing on investigating and establishing willingness to pay (WTP) for toilet use services such as pit emptying (Burt et al. 2019; Peletz et al. 2020a, 2020b). Pit emptying subsidies have been implemented to test the adoption of safer emptying services over unsafe emptying methods or services (Lipscomb and Schechter 2018; Peletz et al. 2020a). For example, a study in Rwanda issued subsidies to determine WTP for improved pit emptying services over the use of informal manual pit emptying (Burt et al. 2019).

However, issues of how to structure and target subsidies to ensure that subsidies benefit intended populations and achieve successful outcomes are unclear. The targeting and structuring of subsidies is particularly important given that, according to the World Bank, sanitation subsidies, in general, rarely reach the poorest who need the support most (Andres et al. 2019). One study focused on an entire population regardless whether the participants’ pits were full or not (Burt et al. 2019), while some have attempted to include participants with full pits either through participant or household reported data or observations (not quantification or measurement) of full pits by enumerators (Peletz et al. 2020b).

Subsidies for pit emptying may contribute to the elimination of environmental externalities and promotion of public health (Evans et al. 2009) but there is also a moral argument that sanitation should be accessible to everyone and not to be treated as a private or commercial good, which subsidies can help to achieve (Evans et al. 2009).
If subsidies could make pit-emptying services more accessible to low-income households that cannot otherwise afford the full cost of services, pit-emptying rates may increase thereby increasing the volume of safely managed sludge (Balasubramanya et al. 2017; Tsinda et al. 2013; Murungi and van Dijk 2014; Cummings et al. 2016; Simiyu et al. 2017; Lipscomb and Schechter 2018; Burt et al. 2019). However, research findings have also shown that even with subsidies applied, pit emptying services remain relatively expensive for low-income informal settlement residents (Peletz et al. 2017, 2020b; Burt et al. 2019). But, because subsidy structuring and targeting methodologies vary, it is important to investigate whether targeting those needing emptying with full pits (through measurement) improves subsidy outcomes more than targeting pits of any fullness. Furthermore, there is a need to investigate and establish a subsidy price point at which the majority of the households willing to use pit emptying services can be serviced. Therefore, this study aimed to understand how cost influences the rate of pit emptying with the goal of proposing a subsidy structure to achieve the most cost-effective rate of emptying in unplanned settlements, focusing on the city of Blantyre in Malawi.

To achieve the aim of the study, two subsidy trials were done in Blantyre. The first trial was structured as a broad-targeted subsidy experiment without specific criteria of pit fullness. The first subsidy trial determined the public’s awareness and interest in pit emptying services, and the willingness to use subsidy discount vouchers for pit emptying services. Following the first trial, we conducted a second, more specific experiment targeting only those with full pits, and with a strict subsidy structure and criteria that were well communicated with stakeholders. The objective of the second subsidy trial was to determine the optimum subsidy structure for unplanned settlements at a fixed pit emptying service price per sludge volume.

2 Materials and methods

2.1 Study area context

Blantyre, Malawi’s second largest city, has a population of about one million (National Statistical Office of Malawi 2018), of which about 70% live in unplanned settlements (UN-Habitat 2011), and most pit emptying services are privately run (Yesaya and Tilley 2020). Like in other cities in low- and middle-income countries where the majority live in unplanned or informal settlements, Blantyre’s sanitation planning (done by the Blantyre City Council (BCC)) is focused on sewer-based systems. Because Blantyre’s unplanned settlements have onsite sanitation technologies (primarily pit latrines but also some septic tanks (Collet et al. 2016)), the responsibility of managing these sanitation facilities lies with users while pit emptying services are provided by private companies and other informal emptying service providers to those who may pay for the service. Blantyre’s pit emptying service providers set their prices independently on a case-by-case basis, based on sludge volume emptied and distance from emptying site to the dumping (or treatment) site (Yesaya and Tilley 2020). However, the pit emptying service providers formed an association called Tipope Pit Emptiers Association (TPEA), and through this association, they set industry standard prices; nonetheless, the price charged for each pit emptying event is at the discretion of each service provider.

2.2 Subsidy trial 1

The first subsidy trial was done in 13 low- to mid-income areas of the city of Blantyre. The trial included a short survey, and respondents were offered random discount vouchers of various amounts to have their pit latrine or septic tank emptied, if they reported that they wanted pit emptying services.

The survey was conducted as a census in 13 areas of the city. The questionnaire addressed socio-economic aspects of the households, sanitation technologies used by the households, and the fullness of the pit latrines and septic tanks. After administering the questionnaire, an information sheet was handed out describing the various emptying technologies available and contacts for each of the participating pit emptying operators. The technologies from which the voucher recipients could choose were the Gulper (manual hand pump), vacuum truck or a mobile desludging unit (micro-vacuum truck).

The households that received vouchers contacted the service provider of their choice (from the list provided on the information sheet) when they wanted to use the voucher. The vouchers were categorised by five discount amounts that were handed out randomly. The discount amounts were 5,000 MWK, 10,000 MWK, 15,000 MWK, 20,000 MWK, and 25,000 MWK (at the rate of 1 USD = 750 MWK). The discounts applied only to the emptying of 1 m³ of
sludge, which typically costs 35,000 MWK. However, as we were to discover, this rate was not clearly communicated to the voucher recipient (only the discount price was printed on the voucher) and as a result, each service provider set his own fee (i.e. not always 35,000 MWK). The value of the discount vouchers presented by the household was deducted from the fee charged by the emptying service provider, which varied based on the emptying service provider’s subjective expert reasons.

2.3 Subsidy trial 2

The second trial was designed to address the shortcomings of the previous study. The new trial was targeted specifically to pit latrines because the previous study established that households with septic tanks were aware of, or had previously engaged emptying services, which was not the case with pit latrine owners. Pit latrines were also chosen because they don’t require water to operate, the same way septic tanks do, and thus the owners of pits were therefore less likely to be able to afford the full cost of pit emptying (i.e. if they could afford the water for a septic tank, they could likely afford to pay for pit emptying). Therefore, the second study area was a low-income area with a high density of pit latrine users.

2.3.1 Study area: Chirimba

The second trial was conducted in Chirimba, a high density, unplanned settlement in Blantyre. The part of Chirimba selected was not included in the previous study (Figure 1). Furthermore, Chirimba is located near the Chirimba Wastewater Treatment site, which does not charge the pit emptiers a dumping fee (most treatment works charge based on the volume of sludge delivered (Yesaya and Tilley 2020)) making it convenient for the pit emptying service providers to dump there. The treatment site is not more than 5 kilometres from the furthest household in the study (compared to the next nearest dumping site at Zingwangwa Wastewater Treatment plant, which charged a dumping fee and is at least 10 kilometres from the nearest household in the study). Chirimba is divided by a main road, which leads to the dumping point (treatment site). The division of the study area made it possible to conduct a split-sample design in order to test the impact of providing airtime in addition to the vouchers (i.e. to call the emptying contractor).

2.3.2 Intervention co-design

TPEA, the local association of emptying service providers in Blantyre, was consulted while structuring the second set of subsidies and the method of delivery. All members were invited to a discussion at the University and invited to stay for lunch; no transport or ‘sitting fees’ were provided (Nkamleu and Kamgnia 2014). The Association members were eager to provide their input as there had been misunderstandings during the first round, among themselves and the voucher recipients. The consultation resulted in several changes to the intervention delivery: (1) members defined minimum pit latrine standards in order to ensure that they could safely and easily empty the pit and (2) members agreed to charge a standard fee per cubic metre of sludge to avoid the rent-seeking that occurred in the previous trial. In this way, the vouchers offered would not be ‘discount vouchers’ off a variable price, but rather a ‘special price’ offer that would be non-negotiable to either the recipient or the provider.

Minimum standards were implemented because in the previous trial, emptiers had encountered pits that they were either unable or unwilling to empty. In Trial 2, TPEA required that each latrine had a concrete slab (which was viewed as being a suitable proxy for a lined pit, which could not be easily assessed visually through the slab), and a floor-to-roof height of not less than 1.8 metres, to allow for the use of the Gulper (a manual hand-pump that is about 2 metres long). Shorter roof heights mean that the Gulper is either difficult to get into the pit or in some cases impossible; manouevring the Gulper into short rooms had, in the past, caused damage to the roof. An agreement was made that households that did not meet these criteria would not be given a voucher but would be given the information sheet with the emptying service providers’ contact information and the information about their latrine would be recorded for this study’s dataset. Though we did not collect information from these households about whether or not they contacted a company, it is highly unlikely that, even if they did, the emptier would have serviced the latrine due to the constraints that had been identified and which disqualified the latrine from the programme.

2.3.3 Voucher prices

The full cost of pit emptying was set at the slightly higher-than-normal price of 40,000 MWK per 1 m³ sludge emptied. Internally, the subsidy values were set at 5,000 MWK, 15,000 MWK, 25,000 MWK, or 35,000
MWK to have 1 m$^3$ of sludge emptied but the household was only informed about the price that they were required to pay, i.e. their ‘special price’ (Table 1).

Four-hundred pit-emptying vouchers were issued in total: 100 of each value. The participating pit emptiers were paid the difference between what the recipient paid and the agreed fee of 40,000 MWK. The number of vouchers handed out was limited by the available funding.

All 400 vouchers were shuffled manually. A single voucher was then randomly selected from the shuffled pile (one by one) and put into a sealed envelope, making the voucher values anonymous to the survey enumerators. The value of the voucher was recorded and linked with a unique code which was written on the outside of the envelope. Enumerators had to enter the envelope code into the survey platform when they handed over the voucher. By anonymising the vouchers, we hoped to eliminate the preferential distribution of high-valued vouchers and to ensure that no trading or swapping of vouchers took place between enumerators.

2.3.4 Questionnaire

A questionnaire was used to solicit household demographic and sanitation information, but also to assess the minimum standards as agreed with the Association. Upon arrival at a household, and following the signing of consent forms, the enumerator (1) recorded the household’s location, (2) asked if the household had a pit latrine, then (3) asked what material their slab was, and the enumerator visually inspected the slab to make the determination. The slab material was entered in the questionnaire. The households without a concrete slab were excluded from the study. Thereafter, the enumerator recorded (4) the fullness of the pit. The pit fullness criterion was a distance of 75 cm or less from the drop hole in the slab to the top of the sludge and was selected to indicate a level that is normally regarded as a full pit that requires emptying. The distance was measured using a laser metre (model: Truper MELA-40) that was put on the drop hole perpendicular to the slab and the laser was shot at the sludge to record the distance. The detected distance was entered on the questionnaire.

Figure 1. Map of Blantyre showing the study area and the trial 2 demarcation between households.
form. If the sludge was greater than 75 cm from the slab, the household was excluded from the survey. If the pit was sufficiently full, the enumerator then recorded (5) the height of the toilet structure above the pit’s slab. The laser metre was put on the slab against the toilet wall, and the laser was shot to the roof to record the distance. Toilet structures without a roof automatically qualified for the manual pit emptying requirements, but those roofs that were less than 1.8 metres were excluded from the study.

Additional questions related to (6) the presence of hygiene facilities on site such as a hand washing system, (7) the ownership of the property (i.e. owned by the household or rented), and (8) the history of the latrine use and whether or not the pit had filled up before and if it was emptied or not, were also recorded.

Once the survey was complete (measurements and questionnaire), the information sheet with the contact details of seven different pit emptying service providers that agreed to participate in the subsidy trial was given along with a voucher. The recipient household could contact any emptying service provider from this list if or when they wanted to empty their pit.

### 2.3.5 Airtime vouchers

Half of the households given vouchers were also issued airtime phone cards to use when calling the pit emptying service providers while the other half did not receive phone airtime. This split-sample design was done to investigate if the provision of phone airtime would affect the use of the subsidy vouchers by further reducing the financial burden of engaging an emptying service provider.

The airtime vouchers were given to a total of 200 households: 50 households in each subsidy voucher value category. All 200 households handed a voucher to the west of the main road in Chirimba were not given airtime while all 200 households given vouchers to the east of the main road (areas shown in Figure 1) also received airtime vouchers to control for spillover effects.

### 2.3.6 Household and pit data collection

The household data were collected using a questionnaire in Kobo Collect (www.kobocollect.org). Data collection began on 18 November 2019 in the area to the west of the main road in Chirimba. The data collection was conducted as a census in the area. Only one toilet was eligible for assessment per household’s property. It is important to note that the term ‘household’ in this research (both Trial 1 and Trial 2) has been used to refer to ‘a data point’, which is a pit latrine (and/or septic tank in Trial 1). Therefore, ‘household’ is used for the collective users of the latrine whether living in a single house or in multiple houses sharing the toilet.

Households that met all requirements (fullness, slab and height criteria) were issued the voucher, whereas if the house did not meet at least one criterion, the survey was ended and the enumerator proceeded to the following household. For the qualifying households, the enumerator would explain how the vouchers worked including the validity period for the use of the vouchers and that only the emptying service providers listed on the information sheet were participating in the voucher trial. Data collection proceeded in the area until 200 households (50 vouchers of each subsidy value) qualified to participate in the subsidy trial.

After 200 households qualified in the western area, data collection moved to the area east of the main road. In this area, households that qualified to participate in the subsidy trial were also given a 100 MWK phone airtime voucher of the phone service provider of their choice. Data collection proceeded on this side until 200 vouchers were given to qualifying households. The last voucher was given on 18 December 2019. In total, 1235 households were visited, 417 households qualified to participate in the trial, but 400 accepted the subsidy voucher. Though we cannot confirm it through any official registry or map, we are confident that the 1235 households visited represented a near census of the area and very few, if any, households were skipped.

### 2.3.7 Voucher redemption and tracking

When the participating households selected and contacted the service provider, the service provider would go to the household to empty 1 m³ of sludge from the household’s pit. The household would pay the amount printed on the voucher (the remaining cost after the subsidy), and hand the voucher to the emptying service provider. The service provider

| Household Pays (MWK) | Subsidy (MWK) | Subsidy % |
|----------------------|--------------|-----------|
| 5,000                | 35,000       | 87.5%     |
| 15,000               | 25,000       | 62.5%     |
| 25,000               | 15,000       | 37.5%     |
| 35,000               | 5,000        | 12.5%     |
would discharge the sludge at the Chirimba treatment site where the used voucher was stamped by the on-duty manager to verify use. The service provider would then send a photo of the stamped voucher to the researchers who would then pay the subsidy amount to the emptying service provider (directly to their bank account via online transfer), and update the data set to indicate that the household that used it redeemed the voucher. Though it may have been possible to falsify both the voucher and the stamp, we doubt this possibility and are very confident that all vouchers redeemed were legitimate. Similarly, it is possible, though highly unlikely, that a family handed over a voucher but did not actually have their pit emptied. In Trial 1, the service providers had to wait until the end of the study to receive payment; the use of photo verification and direct payments significantly improved the satisfaction of the service providers in the study.

The vouchers were valid for use until the 29th of February 2020 (approximately 10 weeks after the last voucher was dispensed). After this deadline the households that did not use their vouchers were called and informed of the extended (late) deadline of 15 March 2020. The households called were also asked questions about the reasons they were unable to use the voucher. The responses to this second questionnaire were included in the data set.

2.3.8 Follow-up questionnaire
After the redemption period ended, all households (those that used their vouchers and those that did not) were called with a follow-up questionnaire. For those who did not use their vouchers, we asked about the reasons why and asked for suggestions on how to change the scheme such that the respondent would be more likely to participate in the future. For those who used their vouchers, we asked about the challenges they encountered in the process of using the vouchers as well as whether they would use the vouchers again in the future.

2.3.9 Data analysis
The data from households were collected and managed in Kobo Toolbox, downloaded to Excel and imported to Stata for data analysis. T-tests were run to determine whether there were statistically significant differences among comparison groups (i.e. those given phone airtime vouchers and those not given). Regression models were run to test which variables were significant in predicting voucher redemption.

2.3.10 Ethics approval
This research was assessed for ethical considerations and approved by the (Malawi) National Commission for Science and Technology’s National Committee on Research in the Social Sciences and Humanities. The study’s ethics approval permit number P.09/19/415 was granted before the study commenced.

All activities in this research followed ethical guidelines prescribed in the conditions of the permit mentioned above and followed all other applicable ethics standards that included obtaining prior consent from participants and allowing them to revoke their consent at any time afterwards.

3 Results
3.1 Subsidy trial 1
Data were collected from 4407 households of which 75.24% (n = 4317) used pit latrines and the rest used septic tanks or had a sewer connection; 49.12% (n = 3247) of pits latrines were lined. Of households visited 20.79% were in areas classified as planned, 51.08% owned their property, 46.99% shared latrines, and 28.72% (n = 3370) reported having full pits. From all households visited 28.34% were interested in pit emptying, enumerators made a judgment based on visual observations of fullest pits to distribute 252 vouchers; 53 were redeemed (21.03% voucher usage).

Regression analysis of the data collected on the voucher use (factoring out the actual subsidy values) established property ownership and latrine-sharing as statistically significant factors (in some models) that affected the use of the discount vouchers (Appendix A). However, as we briefly mentioned above, the emptying service providers were charging inflated prices to the households with vouchers, so that although the discount applied, the discounted price was still higher than the regular charge for the same pit emptying service. Since the discount did not apply at a pre-set or consistent charge, the value of the subsidy given to households also varied. Because we cannot fully verify either the price quoted or the
price paid, the results are not reliable. This outcome also reflects the lack of comprehensive consultations with the service providers before starting the trial. Although the service providers intentionally gamed the system, they also reported incidents of confusion with the voucher redeeming process because they lacked complete information about how the discounts worked.

Additionally, the service providers were unable to work at certain households because the sanitation technologies did not meet the minimum requirements of a safe structure to do the work. For example, 50.88% of the pit latrines in the sampled households were reported to be unlined which may collapse during an emptying event therefore the emptying service providers preferred not to empty such structures, and in some cases refused to do so.

### 3.2 Subsidy trial 2

In total, 1235 households were visited of which 4 did not have a pit latrine on their property; 522 households’ pit latrines met the fullness criterion; 438 pit latrines met the concrete slab criterion; 417 pit latrines met the roof height criterion; 400 households accepted the subsidy. Those who did not accept the vouchers cited that they would not be able to use them because they perceived the ‘special price’ amount they were required to pay still expensive despite the subsidy offered. Out of the 400 vouchers, 99 were redeemed (Table 2).

Based on our tracking, we determined that 66.67% of the redeemed vouchers were used by the intended recipient while 33.33% gave away the vouchers they received and were therefore redeemed by other households such as neighbours in the same study area.

Overall, the results did not indicate any statistical differences between the comparison groups of vouchers given with airtime and vouchers given without airtime (Table 3). However, at an accepted minimum level of significance of 90% (p < 0.1), some differences were observed that included the number of houses using a latrine, number of children per household, toilet wall material, presence of a handwashing facility with soap, and the past fate of full pits where they were drained or were reported to have never filled before.

The differences between comparison groups for the number of houses using a latrine were expected because shared toilets in the study area are common and the number of houses sharing a toilet may vary. In the study area, the toilet wall materials varied in composition but mostly people used mixed materials to build toilet walls. Although the households visited reported that they washed their hands after using the toilet, only 11.87% (n = 438) of the households had hand-washing facilities. A hand washing facility depends on availability of a water source, and while some households in the area had onsite water connections, communal water points were the main source of water in the area. The difference between comparison groups for the full pits fate, where they were drained or had never filled, is because the variable had five responses and households in either group may responded to one of the other three options: apply chemicals, call pit emptier, or demolish and build new one (Table 3). The statistical differences for the variables assessed do not show systematic differences between the comparison groups that may prevent analysis of voucher redeeming predictors between those given phone airtime and those without airtime.

Ownership of the property may have an impact on voucher use and it is important to note that 60.75% of voucher recipients owned their properties while 39.25% were renting. Furthermore, 12% of the voucher recipients reported that they had used pit-emptying services before receiving the voucher: on average, 3 years prior.

The regression models (Table 4) show that the subsidy value was a predictor of voucher use though a β-coefficient of essentially 0. The structure of the toilet (roof height) as well as number of people (per household) using a latrine were far more important predictors of voucher redemption. The provision of phone airtime did not significantly influence on the use of the pit emptying vouchers. Furthermore, ownership of property did not predict voucher use. Pit fullness did not predict voucher redemption, which

| Table 2. Summary of vouchers redeemed | With airtime | Without airtime | Total |
|--------------------------------------|-------------|----------------|-------|
| Vouchers given                        | 200         | 200            | 400   |
| Vouchers redeemed                     | 55          | 44             | 99    |
| Redeemed 5,000 MWK subsidy            | 6           | 4              | 10    |
| Redeemed 15,000 MWK subsidy           | 7           | 5              | 12    |
| Redeemed 25,000 MWK subsidy           | 18          | 20             | 38    |
| Redeemed 35,000 MWK subsidy           | 24          | 15             | 39    |
Table 3. T-tests for variables between groups of those given airtime and those without airtime

| Variable Description                                      | Units | n  | With Airtime (mean) | Without Airtime (mean) | p [diff != 0] |
|-----------------------------------------------------------|-------|----|---------------------|------------------------|--------------|
| Distance from drop hole to sludge                         | m     | 400| 0.551               | 0.562                  | 0.479        |
| Number of houses using a latrine                          |       |    | 3.121               | 2.630                  | **0.015**    |
| Number of people per household                            |       |    | 12.020              | 10.900                 | 0.186        |
| Number of children per household                          |       |    | 5.140               | 4.424                  | **0.070**    |
| Ownership of property: owned/rented                       |       |    | 0.625               | 0.590                  | 0.475        |
| Bricks wall                                               | yes=1, no=0 | 400| 0.980               | 0.940                  | **0.041**    |
| Other wall materials                                       | yes=1, no=0 | 400| 0.202               | 0.060                  | **0.041**    |
| Roof material: malata/iron sheets                         | yes=1, no=0 | 400| 0.860               | 0.850                  | 0.777        |
| Other roof material                                        | yes=1, no=0 | 400| 0.140               | 0.150                  | 0.777        |
| Distance from floor to roof                               | m     | 354| 1.893               | 1.886                  | 0.583        |
| Wash hands after using the toilet                         | yes=1, no=0 | 400| 0.995               | 0.985                  | 0.316        |
| Hand-washing facility present                             | yes=1, no=0 | 400| 0.065               | 0.180                  | **0.000**    |
| Water at the hand-washing facility                        | yes=1, no=0 | 49 | 0.769               | 0.917                  | 0.171        |
| Soap at the hand-washing facility                         | yes=1, no=0 | 49 | 0.231               | 0.833                  | **0.000**    |
| Full pit's fate: apply chemicals                          | yes=1, no=0 | 400| 0.045               | 0.020                  | 0.159        |
| Full pit's fate: call pit emptier                         | yes=1, no=0 | 400| 0.105               | 0.125                  | 0.357        |
| Full pit's fate: demolish & build new one                 | yes=1, no=0 | 400| 0.045               | 0.070                  | 0.284        |
| Full pit's fate: dig draining hole beside                 | yes=1, no=0 | 400| 0.265               | 0.085                  | **0.000**    |
| Full pit's fate: never filled                             | yes=1, no=0 | 400| 0.540               | 0.690                  | **0.002**    |
| Number of full pits at the property                       |       | 93 | 1.194               | 1.290                  | 0.413        |
| Amount charged for previous emptying                      | MWK   | 30 | 17.000              | 17.471                 | 0.924        |
| Pit was fully emptied                                     | yes=1, no=0 | 48 | 0.619               | 0.630                  | 0.942        |
| Number of years since last emptying                       | Years | 48 | 2.810               | 3.074                  | 0.758        |
| Number of times latrine has been emptied                  |       | 47 | 1.619               | 1.808                  | 0.694        |
| Number of years latrine has been used                     | Years | 230| 7.118               | 6.867                  | 0.764        |
can be attributed to the narrow range of pit fullness measurement values; as an eligibility criterion all households given vouchers had fairly full pits (with a distance of 0.75 m or less between sludge and the drop hole in the slab of the toilet) and the range of depths was therefore constrained between 0.01 m and 0.75 m. Households with high latrine roofs were more likely to use the vouchers. Latrine roof height could be correlated with income since richer households may be more likely to build larger structures. Due to the cultural taboo and previous difficulties in quantifying income, we did not ask respondents this question. The findings show that previous pit emptying experience was not a significant predictor of voucher redemption.

Following up on those who used the vouchers (including those who bought or were given their voucher from an enrolled household), 96.23% (n = 55) reported that they would use the vouchers again in the future, and while the majority of voucher users did not report any challenges during the process, 3.85% (n = 52) reported that they struggled to pay the required fee.

Close to half (43.37%; n = 166) of those who did not use their vouchers blamed the service fee. Respondents said that reducing the supplement, i.e. increasing the subsidy value (30.46% of voucher non-users (n = 151)), extending the voucher use period (6.62%), providing reminders for the use of vouchers (9.27%), and involving landlords (6.62%) in case of rented properties would increase the likelihood of using a voucher in the future.

4 Discussion

The results have shown that while an increase in subsidy value predicted voucher use, the general uptake of vouchers was still low. However, the provision of phone airtime did not significantly influence voucher use but the height of the toilet structure did. We hypothesise that toilet height is a proxy indicator for income, i.e. richer families can afford to build bigger toilets or to rent properties with bigger (possibly better) toilet facilities as a way of explaining why these families, with more disposable income, were more likely to use the vouchers than those with shorter toilets. The number of people using a latrine also predicted voucher redeeming. With many people using a toilet, households may have had the urgency to empty to avoid overfilling the latrine because of higher filling rates. Nevertheless, considering the objectives of the research of determining an optimum subsidy structure for low-income unplanned settlements, further discussion will be made on: (1) How the differences in targeting criteria between Trial 1 and 2 informs how specificity helps to better structure subsidy interventions. (2) How there is a need for further investigation on toilet users’ perceptions of full pits that need emptying or abandoning. (3) How assumptions of economic burden made when structuring the subsidy are contested by the results of this research and similar studies, and the implications for future pit emptying subsidy structuring overall. (4) The limitations of this study with regards to households’ income data, the timing of the voucher use period, and geographical concentration of the study area in Trial 2. (5) Key messages and conclusions that can be drawn from the study, and recommendations for policy and further research.

4.1 Subsidy structuring and targeting criteria

Setting criteria for targeting a subsidy is important to ensure that a subsidy benefits the intended population. Corruption and transparency issues have emerged in various subsidy schemes (Andres et al. 2019), which have affected the effectiveness of the interventions. This study has shown that by making targeting criteria more specific and clearly communicating the criteria to all stakeholders (as done in Trial 2 unlike in Trial 1), loopholes for confusion and/or corruption are avoided and integrity in the subsidy scheme is ensured.

Infrastructure plays a big role in FSM and emptying, and therefore should be integral to considerations when setting up subsidy criteria. If subsidies are set to target the adoption of safe, hygienic pit emptying, the consideration that hygienic emptying technology requires specific improved toilet structures should be made. Therefore, in this case of improved hygienic emptying, targeting a subsidy to low-income households may end up presenting unexpected or unintended outcomes because the subsidy could be going to households that cannot use the service. Therefore, to increase coverage of pit emptying, targeting of the poorest should first include checking if they have appropriate infrastructure otherwise a subsidy may apply for construction of improved latrines (for example as done by Guiteras et al. (2015) and Peletz et al. (2017)).
Table 4. Regression models for the dependent variable of vouchers redeemed

| Variable Description                  | Units       | 1 $\beta$ (p) | 2 $\beta$ (p) | 3 $\beta$ (p) | 4 $\beta$ (p) | 5 $\beta$ (p) | 6 $\beta$ (p) | 7 $\beta$ (p) |
|--------------------------------------|-------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
| Airtime given                        | yes=1, no=0| 0.055 (.184)  | 0.049 (.23)   | 0.027 (.548)  | 0.056 (.174)  | 0.024 (.594)  |               |               |
| Subsidy value                        | MWK         | 0.000 (.000)  | 0.000 (.000)  | 0.000 (.000)  | 0.000 (.000)  | 0.000 (.000)  |               |               |
| Number of houses using latrine       | #           | -0.017 (.215) | -0.004 (.794) |               |               |               |               | -0.012 (.414) |
| Number of people per household       | #           | 0.012 (.001)  | 0.012 (.001)  |               |               |               |               | 0.011 (.761)  |
| Number of children per household     | #           | -0.003 (.727) | -0.006 (.482) |               |               |               |               | -0.002 (.455) |
| Ownership of property: owned/rented  | owned=1, rented=0 | 0.041 (.333) | 0.031 (.484)  |               |               |               |               | 0.035 (.403)  |
| Distance from drop hole to sludge surface | m           | -0.171 (.242) | -0.208 (.167) | -0.130 (.376) |               |               |               |               |
| Wall material: bricks                | yes=1, no=0 | 0.177 (.248)  | 0.299 (.055)  | 0.169 (.265)  |               |               |               |               |
| Roof material: malata/iron sheets    | yes=1, no=0 | -0.101 (.415) | -0.050 (.696) | -0.102 (.403) |               |               |               |               |
| Roof height from floor               | m           | 0.558 (.003)  | 0.493 (.012)  | 0.518 (.007)  |               |               |               |               |
| Full pit’s fate: call pit emptier    | yes=1, no=0 | -0.006 (.899) | -0.102 (.091) | 0.130 (.007)  | -1.006 (.020) | -0.802 (.072) | -0.013 (.790) | 0.044 (.491)  |
| Constant                             |             |               |               |               |               |               |               |               |
| $N$                                  |             | 400           | 397           | 397           | 354           | 354           | 400           | 351           |
| $R$-squared                          |             | 0.090         | 0.123         | 0.037         | 0.106         | 0.033         | 0.091         | 0.134         |
4.2 Perceptions of pit emptying urgency

The pits selected in Trial 2 of this study were considered full when sludge could be seen from the drop hole, and sludge was measured to be less than 75 cm from the drop hole. The assumption here was that these were pits requiring emptying, and therefore households would go for the subsidy because it offered the opportunity to empty the pits at a relatively lower cost than market prices. But the results do not support this hypothesis. We did not observe a significant change between the first trial, which did not have a strict pit fullness criterion for subsidy recipients with 21% of households redeeming vouchers, and the second strict fullness requirement trial, with 25% redeeming. This observation agrees with research findings that show that there is a lack of understanding of the real drivers and motivations for sanitation improvements by households in informal settlements (Burt et al. 2019; Isunju et al., 2011).

Other pit emptying subsidy studies have also relied on the assumption that when pits are full, households would find subsidies as an opportunity for pit emptying, however, the studies have not focused on understanding how pit users perceive full pits worthy emptying or abandoning (Lipscomb and Schechter 2018; Burt et al. 2019). However, there are still indications that emptying is a favoured strategy for dealing with full pits (Chunga et al. 2016), and some studies have looked at understanding how easy or hard it can be to empty pits (Chirwa et al., 2017), while further exploration is needed to understand the circumstances that motivate households to empty pits.

It is important to understand the perception of households towards pit emptying urgency. A study in Mzuzu, Malawi, noted that even when facing high water tables, households were not willing to empty their pits (Chirwa et al., 2017). Households’ urgency towards pit emptying should be further explored.

While some pit emptying subsidy studies have relied on emptying frequencies across study populations to determine urgency for emptying (Lipscomb and Schechter 2018), the results still do not explain the low subsidy uptake or the actual reasons why households decide to empty their pits. However, understanding the circumstances in which emptying occurs and households’ urgency to empty their pits in real time can reveal the characteristics of what is considered the right time to empty by the households. One study in Uganda, looking at sanitation activities in Kampala’s slums recognised the need to understand the problems or challenges faced that surround pit emptying and maintenance (Dijk, 2016). This right time to empty can be determined by interviewing households emptying their latrines at their own will (without subsidy), and observing, as well as measuring attributes of the latrine at the time of emptying in real time. Such findings of real-time pit emptying urgency can help inform subsidy structuring and targeting to include latrines and households that need emptying within a study population. Further research should establish whether specific targeting can reveal different outcomes about pit emptying subsidies.

Issues of household tenure security for rentals and how that may affect pit emptying urgency also need further investigation. In Dakar, Senegal, a study on the relationship between tenure security and sanitation investment established that the more secure a household’s rental tenure was, the more they were willing to pay for services such as pit emptying (Scott et al., 2013). Therefore, pit emptying urgency seems to be more complex to establish and may require interdisciplinary approaches.

4.3 Pit emptying economic burden: assumptions vs reality

The prediction of subsidy voucher redeeming by roof height in Trial 2 can be explained by higher levels of income, which agrees with other voucher studies in that disposable income influences voucher redeeming (Peletz et al. 2020b). However, this finding does not give the full picture. For example, an assumption was made that airtime could relieve the burden of calling an emptier but no influence was observed with the results. But also, although the higher subsidy vouchers had more uptake than the lower subsidies, there was a lack of statistical significance indicating that indeed voucher redemption would increase when the amount households pay is lowered.

Studies, including this one, have structured subsidies based on existing market prices and results seem to show that higher income predicts uptake (Peletz et al. 2017, 2020b; Lipscomb and Schechter 2018). However, overall, the results show low uptake of the subsidies in low-income unplanned or informal areas (Lipscomb and Schechter 2018; Burt et al. 2019; Peletz et al. 2020b). Even in cases where households have been offered various payment schemes such as using
mobile money or opening an earmarked savings account to deposit money for pit emptying, subsidy uptake has remained relatively low (Lipscomb and Schechter 2018).

While others argue that subsidies can minimise the need for innovation in sanitation (Evans et al. 2009), innovation should be explored to identify where and what to subsidise in the FSM value chain to achieve affordable market prices for the low-income unplanned areas. Further research should try to establish cost bottlenecks in the FSM chain that result in higher prices for emptiers, and in turn households, and try to target subsidies at that level. A study in Kisumu, Kenya, also noted that technological advancement in waste recovery and reuse such as container-based sanitation models could be a possible enabler for lowering costs for pit emptying (Peletz et al. 2020b). Other subsidy schemes explored or recommended include targeting networked sanitation customers with surcharges to supplement costs for onsite sanitation services such as pit emptying for the poor (Acey et al., 2019; Andres et al. 2019; Toubkiss, 2010). Community investment approaches for sanitation have also been shown to have an impact in lowering sanitation costs in informal settlements and subsidy interventions may also explore such approaches (Satterthwaite et al., 2015).

4.4 Study limitations

The findings of this research should be evaluated while acknowledging these limitations: (1) Income data were not collected, which could have provided a perspective on what fraction of the households’ earnings the subsidies or prices after subsidy were. (2) The timing of the voucher redemption period was at the beginning of the rainy season in Malawi, which has two implications on outcomes of the study. Firstly, households involved with agricultural activities usually prioritise the purchase of farm inputs such as seeds and fertiliser during this time, therefore, the subsidy may have been competing for the money prioritised for other activities. This timing limitation can be overcome in future research by conducting similar studies across the year to investigate seasonality in income; whether there is a certain period in the year when the prices offered could have been more affordable. Secondly, because the survey was towards the beginning of the rainy season, and some rains started towards the end of household data collection, the sludge levels may have been increased due to groundwater intrusion; knowing this cycle, the pit owners may also have known that the level would eventually decrease. (3) There was no mechanism established to determine the selling of vouchers or to take note of lost vouchers. (4) This study did not seek to establish whether households approached were responsible for pit emptying or maintenance as done by other studies (Lipscomb and Schechter 2018; Burt et al. 2019) especially on properties where there was no landlord on site. However, landlords were approached at properties where they were available. Finally, (5) the study was focused on the city of Blantyre in Trial 1, and there was a geographical concentration focus on the city’s Chirimba area in Trial 2. Therefore, there is no direct comparison with other areas, geographically and economically, implied by the findings. Rather, the findings reveal the situation in the study area.

5 Conclusions and recommendations

To achieve full coverage of pit emptying in low-income unplanned settlement settings, and in turn achieve SDG 6, a special focus should be put on supplementing costs for the poorest, as well as lowering the cost of pit emptying in general. In the current subsidy models that are structured based on existing market prices, significant subsidies would be required to increase the rate of pit emptying among the majority, while the poorest may require free services or other forms of incentives. Targeting and delivery innovation is required to identify suitable schemes for providing affordable pit emptying and enhancing FSM in low-income unplanned settings.

In terms of infrastructure, only 417 out of the 1235 toilets visited were considered by the emptiers’ own criteria to be suitable for emptying, i.e. they perceived the risk of collapse or necessary damage to be low and therefore worth servicing. Though we are hesitant to promote infrastructure upgrades, these results do point to the fact that the toilet quality does affect an emptier’s willingness to service it, and that unlike most commonly accepted theories, the pit emptier industry is not short of customers, but short of desirable customers. Further research therefore is required to better understand the explicit and implicit criteria that the
market uses to select customers and determine how this affects service levels and pricing.

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