

Determinants of Willingness to Pay for Fecal Sludge Management Services and Knowledge Gaps: A Scoping Review

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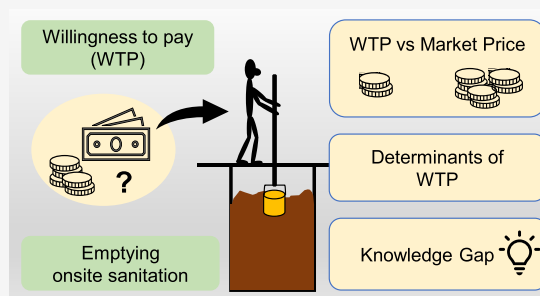
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ABSTRACT: Achieving universal access to safely managed sanitation services is one of the Sustainable Development Goal 6 targets (SDG6.2). The cost and availability of services to ensure the safe management of on-site sanitation, such as pit latrines and septic tanks, can be major barriers for poor households. Particularly, fecal sludge emptying services have become increasingly important due to the growing urban population. This review aims to scope the literature on stated and revealed willingness to pay (WTP) for emptying on-site sanitation systems and to identify determinants of WTP and gaps in knowledge. We performed electronic searches of six databases. After deduplication, 1846 records were identified, of which 14 were included in the review. In these studies, we identified 26 distinct scenarios that reported mean or median WTP values for emptying services and their market price (i.e., price at which the services were provided). Among the 26 scenarios, 77% ($n = 20$) reported that WTP was lower than the market price. We identified 20 statistically significant determinants of WTP, which can be leveraged when developing or improving manual and mechanical emptying services to attract more customers. Future research should consider services that adopt flexible pricing or mobile money payment and optimize their emptying operations to increase WTP. Validating the effectiveness of such services in solving the WTP–market price imbalance is a significant knowledge gap.

KEYWORDS: on-site sanitation, SDG6, sludge removal, developing countries, operational cost, affordability, economic analysis, willingness to pay



INTRODUCTION

Sustainable Development Goal (SDG) 6 calls for universal access to water and sanitation by 2030. Improper sanitation services lead to fecal contamination of water and soil environments.¹ However, 3.5 billion people still lacked safely managed sanitation services in 2022.¹ This lack in services poses considerable public health risks.²

On-site sanitation facilities, such as pit latrines and septic tanks, are facilities that store or treat excreta at the point where they are generated.³ They were used by 43% of the global population in 2020 and their use is increasing,³ especially in rural or low-income urban settings where sewer systems are financially or technically unfeasible.⁴ On-site sanitation systems require fecal sludge management (FSM), which involves a series of five key steps: (1) containment, (2) emptying, (3) transport, (4) treatment, and (5) reuse/disposal.^{5,6} FSM services are those that support the sanitation value chain and mostly begin at emptying. They can be provided by both the public and private sectors and vary in scale from the individual to organizational level.

Safe FSM requires that excreta are safely disposed on-site or transported and treated off-site.³ However, safe disposal of excreta on-site in densely populated areas is challenging due to

limited space for containment and treatment.⁷ Emptying and transporting the sludge to off-site treatment plants are therefore often the only viable solution in these densely populated areas such as urban slums.⁷

Fecal sludge emptying and transport services are usually provided by the private sector in low-income settings—with or without public oversight and regulation—and the financial costs are met by the user, which is the household.^{8–10} In particular, the operational costs for emptying and transport of fecal sludge are often left to the household without public financial support.^{11,12} Furthermore, in open markets, the private sector may fail to provide safe and affordable services to all.^{10,11} Formal emptying services can be expensive for the poor if providers' primary market is better-off people with septic tanks.¹⁰ Consequently, financial constraints faced by the household can be a major barrier to ensuring safely managed

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sanitation services.⁷ Low-income areas are usually served by informal, often manual, emptying services, which are relatively cheap, but often carried out without protective gear, resulting in illegal sludge disposal.¹³ Such informal services are harmful to both public health and environment and pose a threat to competing formal services.^{7,8} Moreover, such informal services are often not recognized by national or local governments. Therefore, the enabling environment for FSM services such as regulation in the low-income areas is prone to be weak and presents complex political economy challenges,¹⁴ which makes it difficult to create fair and competitive markets.⁸

To assess the financial viability of services, willingness to pay (WTP), the maximum amount that a consumer is willing to pay for a particular good or service, has been widely reported as a proportion of the actual price of the service.^{15,16} There are two types of WTP depending on methods of measurement: stated WTP and revealed WTP.¹⁵ Stated WTP is elicited by asking respondents about their valuation, while revealed WTP is estimated by observing actual behavior in a market.¹⁵

Both stated and revealed WTP can be compared with household income to interpret evidence on the affordability.¹⁵ This indicator is common across many sectors, including health, energy, and agriculture.^{17–19} In the water supply and sanitation sectors, WTP is used to determine the economic feasibility and sustainability of projects or interventions, rationale for prices at which services are provided in markets (hereafter, market prices), and policymaking, such as socially equitable subsidies and tariffs.^{7,10,20} Supporting Information 1 gives more details on WTP and the elicitation methods.

The global use of on-site sanitation systems and the world's urban population and density are projected to rise.^{3,21} Therefore, developing interventions for affordable and accessible FSM services based on robust evidence, such as WTP, will be essential for achieving SDG target 6.2. In that context, summarizing the methodology and findings of previous studies on WTP for emptying services and presenting a future agenda would benefit the private, public, and academic sectors. However, to the best of our knowledge, no previous review has synthesized WTP for FSM emptying services, in particular, the methods used to elicit WTP, the range of estimates, and determinants. Mapping those findings and identifying a future research agenda can support researchers and practitioners in closing WTP–market price gaps in emptying services.

MATERIALS AND METHODS

The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) Checklist and Explanation (Supporting Information 2).²² We also refer to the multistage methodological framework provided by previous studies.^{23–25} The protocol was preregistered with the Open Science Framework registry in February 2023.²⁶

Study Aim. The aim of this scoping review is to map the literature on WTP for emptying on-site sanitation facilities such as pit latrines and septic tanks and identify determinants of WTP and gaps in knowledge. Scoping reviews mainly focus on determining the scope of a given research topic with broad literature and identifying knowledge gaps, whereas systematic reviews focus on answering specific research questions and evaluating and synthesizing the results.²⁷ A scoping review was chosen because of its suitability of mapping existing findings,

exploring study gaps in the field, and integrating studies of various research methods.²⁸

Search Strategy. Electronic searches were conducted on 16 February 2023 across six databases: EconLit, PubMed, Scopus, Web of Science, WHO Global Index Medicus, and the World Bank Open Knowledge Repository. Search terms related to FSM and WTP were defined based on previous similar reviews (Supporting Information 3).^{29–32} Although the search was run in English, non-English papers were also included. Titles and abstracts were translated into English using DeepL Translator (DeepL GmbH, Cologne, Germany), a machine translator, to determine eligibility.³³ Reference lists of included papers were manually screened for the same eligibility criteria as those listed below to identify any additional relevant documents.

Eligibility Criteria. This review includes the literature that examines household WTP for fecal sludge emptying services. We excluded studies that do not have WTP data as the primary outcome. Papers that examined only WTP for infrastructure and services that do not relate to emptying services (e.g., WTP for a new pit slab) were excluded. However, sanitation services that integrate several components of the FSM value chain, such as emptying (e.g., container-based sanitation, or CBS), were included. There were no constraints on the publication date or language. Peer-reviewed and gray literature were included.

Study Screening and Selection. Search results were imported into Rayyan for deduplication.³⁴ After duplicates were removed, titles and abstracts were independently screened by two reviewers (H.T. and C.M.). Full text documents of the remaining articles were sought and independently screened by two reviewers (H.T. and C.M.). Data were independently extracted by two reviewers (H.T. and C.M.). Results were discussed between screeners at each step, with any discrepancies resolved with additional reviewers (O.C., T.M., and L.B.). A set of codes that classify the papers considering the eligibility criteria was developed to ensure transparent screening (Supporting Information 4). No methodological restrictions were set.

Extracting and Charting the Data. A standardized data extraction form was developed to extract data from included studies (Supporting Information 5). The mean and/or median WTP was extracted for each scenario. Several studies conducted bivariate and/or multivariate analyses using various models to identify explanatory variables (i.e., determinants) that were significantly associated with WTP amounts. Where applicable, we reported explanatory variables with a p value <0.05 as it was the smallest p -value threshold used in the included studies and it is a widely used threshold for statistical significance.³⁵

Quality assessment was carried out by applying five prespecified criteria to each included study. As there is no published quality assessment tool for WTP studies, we adopted a set of criteria adapted from a technical report for WTP studies in the water supply and sanitation sector published by the Asian Development Bank.²⁰ The five quality assessment criteria include the following: (i) survey design, including sample size calculation and bid distribution, (ii) instrument validation via pretest, focus group discussion, or similar, (iii) survey implementation, including quality control and data management, (iv) mean WTP elicitation, and (v) ex-post validity assessment on WTP.²⁰ This scoping review did not set exclusion criteria related to the quality of studies to allow as many studies as possible to be included. The quality

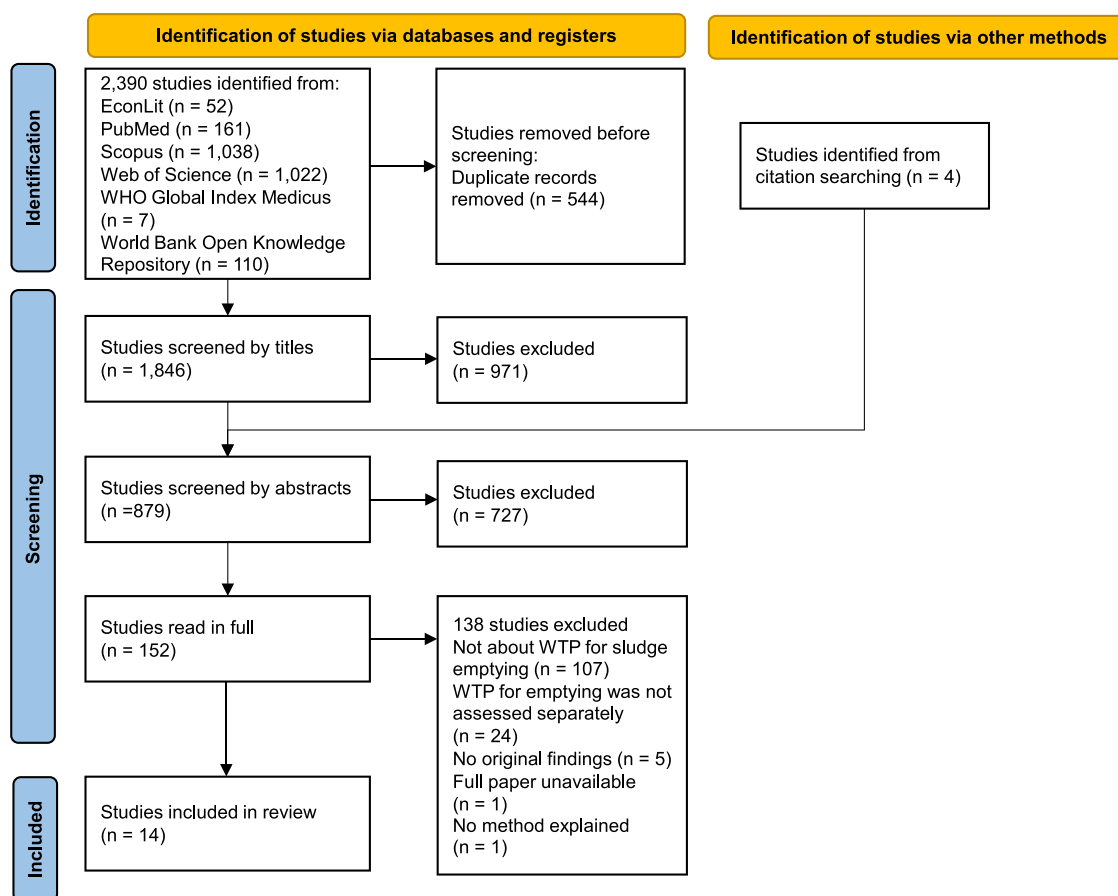


Figure 1. PRISMA 2020 flow diagram: an overview of search results.⁴⁰



Figure 2. Countries where included studies were conducted.

assessment was intended to identify steps that are often missed during planning, implementation, analysis, and reporting phases of studies and thereby improve future research.

Inflation and Currency Adjustment. Since WTP data were obtained from different years and reported in different currencies, the reported values were adjusted for inflation and expressed in 2022 US dollars (USD).³⁶ First, the original value (USD) was converted to local currency using the exchange rate at the time of data collection.³⁷ Second, the converted value was adjusted for inflation from the original year to 2022 using the local inflation rate.³⁸ These steps were necessary to account for differences in local inflation rates and the US inflation rate.³⁶ Finally, the value was converted back to USD using the 2022 exchange rate. The exchange rate for Tanzania Shilling was not available in the World Bank database. Instead, we used data from the Exchange Rates UK web site.³⁹

RESULTS

Search Results. A total of 2390 records were identified through electronic searches of six databases. Four additional records were identified during the manual reference list search. After removing duplicates, 1846 records were screened by title and abstract, with 152 records eligible for full-text screening. Fourteen studies are included in the review. The study selection process is shown in the PRISMA flowchart (Figure 1).

Overview of Included Studies. All 14 included studies were conducted in LMICs. Studies were conducted in five countries in sub-Saharan Africa (Tanzania, Sierra Leone, Rwanda, Kenya, and Ghana), four countries in Southeast Asia (Philippines, Myanmar, Bangladesh, and Cambodia), and two countries in Central America (Nicaragua and Haiti) (Figure 2). All included studies were published since 2013,

reflecting an increase in research on household WTP for sludge collection and transport in the past decade (Figure 3). Eleven

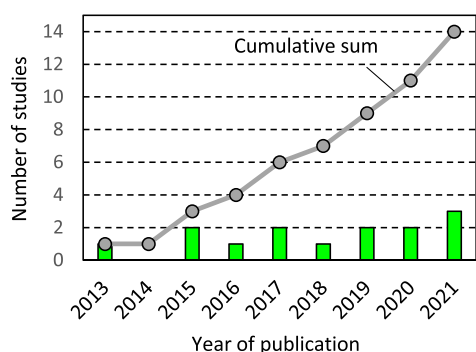


Figure 3. Number of included studies published each year.

studies were conducted in urban or periurban areas and three in rural areas. Reported average monthly incomes per household ranged from USD 115 to 196 (adjusted for local inflation and expressed in 2022 USD).³⁶

Quality Assessment. One study (Harper et al.) was considered to have good quality, while other included studies had one or more points to improve on in the study designs (Supporting Information 6).⁴¹ Although Harper et al. minimized bias by testing research instruments and training enumerators, they reported that WTP was likely overestimated since their discrete choice experiment (DCE) may have caused survey fatigue, primacy effect, and hypothetical bias.⁴¹ Six of the 14 included studies reported no rationale for the sample size. In addition, two studies did not report a bias mitigation strategy for starting point bias or price distribution. Regarding survey preparation, five studies did not report any measures to improve the validity of the research instruments via pretest or focus group discussion. For survey implementation, two studies were prone to nonresponse bias as a large proportion of respondents (30 and 42%) did not answer their WTP,^{42,43} two did not specify enumerator training or quality control, and six did not report implementation. For WTP elicitation, five studies did not report the econometric model used to elicit mean WTP. Finally, three studies did not assess the validity of the WTP results against income and price levels.

Study Methods. Eleven studies employed contingent valuation (CV) methods, and three employed DCE methods (Table 1). Among the studies using the CV methods, six used open-ended questions, while six used single- or double-bound dichotomous choice approaches. Two studies combined the double-bound dichotomous choice approach with open-ended questions by first asking two dichotomous questions and subsequently asking open-ended questions. Two studies also estimated revealed WTP using real-money voucher trials. These trials involved distributing vouchers to households that offered various levels of discounts for desludging services. Revealed WTP was estimated based on the number of voucher redemptions at different price points.^{10,44}

Emptying Services. The emptying services investigated for WTP in this review were classified into three groups: (i) manual emptying (with and without a manual desludging pump), (ii) mechanical emptying (i.e., vacuum pump), and (iii) container-based sanitation (CBS). CBS is a type of sanitation service that leases toilets with a sealable and removable container and collects excreta stored in the

container.⁴⁵ Users subscribe to the CBS service to get their containers collected daily or every two to three days. Sludge containment facilities used at the study sites include dry or pour-flush latrines connected to a pit (lined/unlined, tire, and drum), septic tanks, and container-based facilities. Nine out of the 14 included studies did not report the number of people sharing one sanitation facility and 10 studies did not report emptying frequency (Supporting Information 7).

Five studies reported specific payment methods for emptying services (Table 1). Of these, two investigated the WTP scenarios where respondents paid the emptying fee via a water bill, two examined WTP via a monthly payment to service providers, one employed mobile money (M-Pesa), and one examined volumetric pricing.^{10,44,46–48}

Gap between WTP and Market Price. The service scenarios varied across the included studies. Heterogeneity in service scenarios was caused by factors such as the facility type, the number of households sharing one latrine, and emptying frequency. As these metadata were not standardized or reported among the included studies, we did not compare WTP for service scenarios. Instead, we compared WTP for a given service as a proportion of the market price or cost of the service (Table 2). We identified 34 WTP scenarios across the 14 included studies. Nine scenarios (26%) were for manual emptying services, 10 (29%) for mechanical pump or vacuum truck services, and four (12%) for CBS. The remaining studies (32%, $n = 11$) did not specify an emptying method. Only one study (Ross and Pinfold) explicitly investigated WTP for informal emptying services.⁴⁹ Among the 26 scenarios that reported both mean (or median) WTP and market price (or cost), 20 scenarios (77%) reported that the mean or median WTP was lower than the market price or cost. Notably, 18 scenarios (69%) reported that WTP was lower than half of the market price. While WTP for one manual emptying and two mechanical emptying scenarios exceeded the market prices, none of the mean WTP for CBS reached the market prices (16% of the price in Haiti, 22–27% in Kenya, and 66% in Ghana).^{45,51}

Determinants of WTP. In total, there are 20 statistically significant ($p < 0.05$) determinants of WTP among the included studies (Table 3). The determinants were classified into five groups: economic situation, urgency, service characteristics, service accessibility, and knowledge. Other factors, such as education, gender, age, and province, were also considered.

Regarding the economic situation category, higher income was associated with higher WTP (i.e., income elasticity), while emptying cost and a flat fee payment structure were associated with lower WTP.²⁰ Flat fee is a payment structure that allows customers to pay a fixed fee for an emptying event, regardless of the amount of sludge removed. A study conducted in low-income settlements in Kigali, Rwanda, reported lower WTP for flat fee pricing because respondents preferred volumetric pricing.⁴⁴

With respect to the urgency category, households had higher WTP if they required frequent or immediate emptying and lower WTP for longer wait times. Household size and latrine sharing with other households were associated with higher WTP for emptying services, as the greater number of users per latrine leads to a higher sludge accumulation rate. Conversely, households had lower WTP if there was a long wait time for the requested emptying service. Timely emptying services are

Table 1. Overview of Included Studies and WTP Elicitation Methods

authors	study country	setting	study design	type of WTP	service for which WTP was investigated	payment method
Harder et al. ⁴⁶	Philippines	urban	CV: single-bound dichotomous choice	stated	septic tank emptying	water bill
Russel et al. ⁴⁵	Haiti	urban	CV: single-bound dichotomous choice	stated	CBS	not specified
Jenkins et al. ⁷	Tanzania	urban	CV: single-bound dichotomous choice	stated	manual desludging pump	not specified
Parikh et al. ⁴²	Sierra Leone	urban	CV open-ended question	stated	improved pit emptying	not specified
Balasubramanya et al. ¹¹	Bangladesh	rural	CV: double-bound dichotomous choice	stated	pit emptying that transports sludge away	not specified
Ross and Pinfold ⁴⁹	Rwanda	urban	CV: bidding game	stated	manual/mechanical emptying with treatment	not specified
Vásquez and Alicea-Planas ⁴⁷	Nicaragua	urban	DCE	stated	excreta disposal	water bill
World Bank ⁵⁰	Cambodia	rural	CV: open-ended questions (price sensitivity measurement)	stated	vacuum truck emptying	not specified
Burt et al. ⁴⁴	Rwanda	urban	DCE, real-money voucher trial	stated and revealed	vacuum truck/manual emptying with group discount	not specified and volumetric/flat pricing
Peletz et al. ¹⁰	Kenya	urban	CV: double-bound dichotomous choice + open-ended question, real-money voucher trial	stated and revealed	manual, vacuum truck emptying	not specified and subscription/rent premium/M-Pesa
Naing et al. ⁴³	Myanmar	urban	CV: open-ended question	stated	vacuum truck emptying ^a	not specified
Harper et al. ⁴¹	Cambodia	rural	DCE	stated	improved pit emptying	not specified
Delaire et al. ⁵¹	Bangladesh, Ghana, Kenya	urban and peri-urban	CV: double-bound dichotomous choice + open-ended question	stated	CBS, vacuum truck, manual	not specified
Singh et al. ⁴⁸	Bangladesh	urban	CV: open-ended question	stated	emptying services	monthly payment

^aWTP for additional service fees to request emptying services through a phone call rather than visiting the administrative office.

Table 2. WTP Amount and the Gap between the Market Price^a

authors	service for which WTP was investigated	study site	elicitation method	study population and context	mean/median WTP (adjusted for inflation and converted into USD)	ratio of WTP to price or cost (%)
Jenkins et al. ⁷	manual emptying using a Gulper pump	Tanzania, Dar Es Salaam	CV: single-bound dichotomous choice	property owner (88%) or head of the longest tenant household (12%) from unplanned low-income areas	USD 31/300L (median)	153% (median)
Ross and Pinfold ⁴⁹	manual emptying	Rwanda, Kigali	CV: bidding game	households in two unplanned settlements	USD 95 (median)	NA
Peletz et al. ¹⁰	formal manual emptying (Gasia Poa) ^b	Kenya, Kisumu	CV: double-bound dichotomous choice + open-ended question	live-in landlords, homeowners and tenants in low-income areas	USD 31 (median) USD 35 (mean)	25–43% (median)
Peletz et al. ¹⁰	formal manual emptying (Gasia Poa) ^b by subscription/premium payment	Kenya, Kisumu	same as above	same as above	ranging from 44% of households willing to pay USD 3 to 12% of willing to pay USD 7 per month	NA
Delaire et al. ⁵¹	formal manual emptying using a long-handled bucket ^c	Kenya, Kisumu	CV: double-bound dichotomous choice + open-ended question	(i) homeowners or landlords living on the premises and without adequate sanitation for themselves or all of their tenants or (ii) tenants without access to adequate sanitation in low-income areas	USD 29 (median) USD 34 (mean)	27% (median) 32% (mean)
Delaire et al. ⁵¹	formal manual emptying using a Gulper pump ^c	Kenya, Nakuru	same as above	same as above	USD 44 (median)	31% (median)
Delaire et al. ⁵¹	formal manual emptying using a diesel pump ^c	Kenya, Malindi	same as above	same as above	USD 49 (mean)	35% (mean)
Delaire et al. ⁵¹	formal manual emptying using a long-handled bucket ^c	Ghana, Kumasi	same as above	same as above	USD 49 (median)	40% (median)
Delaire et al. ⁵¹	formal manual emptying using a long-handled bucket ^c	Bangladesh, Rangpur	same as above	same as above	USD 60 (mean)	49% (mean)
Ross and Pinfold ⁴⁹	mechanical emptying with treatment	Rwanda, Kigali	CV: bidding game	households in two unplanned settlements across six cells in Nyarugenge district	USD 39 (median) USD 54 (mean)	31% (median) 44% (mean)
World Bank ⁵⁰	vacuum truck	Cambodia, Siem Reap and Kratie	CV: open-ended question	households in rural provinces	USD 12 (median) USD 18 (mean)	13% (median) 20% (mean)
Burt et al. ⁴⁴	vacuum truck	Rwanda, Kigali	real-money voucher trial	landlords and households in dense informal settlements	~USD 109 (median) USD 14–19	fully covered (>100%) 39–55%
Peletz et al. ¹⁰	vacuum truck	Kenya, Kisumu	CV: double-bound dichotomous choice + open-ended question	live-in landlords, homeowners and tenants in low-income areas	USD 88 (revealed WTP)	152% (95% CI: 120–208%, mean)
Peletz et al. ¹⁰	vacuum truck	Kenya, Kisumu	same as above	same as above	ranged from 52% of households willing to pay USD 2 to 6% willing to pay USD 5 per month	33–50% (median)
Peletz et al. ¹⁰	vacuum truck	Kenya, Kisumu	real-money voucher trial	same as above	USD 21 (median) USD 22 (mean) USD 15 (mean, revealed WTP)	33–50% (median) 27–40% (mean)
Delaire et al. ⁵¹	vacuum truck	Kenya, Kisumu	CV: double-bound dichotomous choice + open-ended question	(i) homeowners or landlords living on the premises and without adequate sanitation for themselves or all of their tenants or (ii) tenants without access to adequate sanitation in low-income areas	USD 20 (median) USD 21 (mean)	34% (median) 36% (mean)
Delaire et al. ⁵¹	vacuum truck	Kenya, Nakuru	same as above	same as above	USD 29 (median)	33% (median)
Delaire et al. ⁵¹	vacuum truck	Kenya, Malindi	same as above	same as above	USD 32 (mean)	36% (mean)
Delaire et al. ⁵¹	vacuum truck	Ghana, Kumasi	same as above	same as above	USD 25 (median)	18% (median)
Delaire et al. ⁵¹	vacuum truck	Ghana, Kumasi	same as above	same as above	USD 33 (mean) USD 39 (median) USD 38 (mean)	21% (mean) 42% (median) 40% (mean)

Table 2. continued

authors	service for which WTP was investigated	study site	elicitation method	study population and context	mean/median WTP (adjusted for inflation and converted into 2022 USD)	ratio of WTP to price or cost (%)
Delaire et al. ⁵¹	vacuum truck	Bangladesh, Rangpur	same as above	same as above	USD 18 (median) USD 14 (mean) USD 4.5/month (mean)	20% (median) 24% (mean) 16%
Russel et al. ⁴⁵	CBS (twice-weekly collection)	Haiti, Cap-Haïtien	CV: single-bound dichotomous choice	households in an informal and formal settlement	USD 2.0 (median) USD 2.0 (mean)	22% (median, mean)
Delaire et al. ⁵¹	CBS (every few days collection)	Kenya, Kisumu	CV: double-bound dichotomous choice + open-ended question	(i) homeowners or landlords living on the premises and without adequate sanitation for themselves or all of their tenants or (ii) tenants without access to adequate sanitation in low-income areas	USD 2.0 (median) USD 2.4 (mean) USD 3.9 (median) USD 4.6 (mean) USD 1.8/month	23% (median) 27% (mean) 55% (median) 66% (mean) 128% ^d
Delaire et al. ⁵¹	CBS (every few days collection)	Kenya, Nakuru	same as above	same as above	USD 2.0 (median) USD 2.4 (mean) USD 3.9 (median) USD 4.6 (mean) USD 1.8/month	23% (median) 27% (mean) 55% (median) 66% (mean) 128% ^d
Delaire et al. ⁵¹	CBS (every few days collection)	Ghana, Kumasi	same as above	same as above	USD 2.0 (median) USD 2.4 (mean) USD 3.9 (median) USD 4.6 (mean) USD 1.8/month	23% (median) 27% (mean) 55% (median) 66% (mean) 128% ^d
Harder et al. ⁴⁶	septic tank emptying by water bill payment	Philippines, Dagupan	CV: single-bound dichotomous choice	households	USD 80 (mean)	116%
Parikh et al. ⁴²	improved pit emptying ^e	Sierra Leone, Freetown	CV: open-ended question	households in urban area where over 90% of households use on-site sanitation facilities	~USD 7.2	47%
Balasubramanya et al. ¹¹	pit emptying that transports sludge away	Bangladesh, Bhaluka	CV: double-bound dichotomous choice	male heads of the pit-latrines owner household in Bhaluka, where sludge management services are being piloted by the government	USD 3.9/month	NA
Vásquez and Alcega-Planas ⁴⁷	excreta disposal by water bill payment	Nicaragua, Ciudad Sandino	DCE	households in an urban settlement with high population density and no emptying service	USD 7–14 (median) ^f	NA
Naing et al. ⁴³	WTP for additional fee to request vacuum truck emptying through a phone call	Myanmar, Mandalay	CV: open-ended question	households in the five urban townships	USD 69	NA
Harper et al. ⁴¹	pit emptying that prevents contact with fecal sludge	Cambodia	DCE	households in rural provinces that owned a pour-flush latrine for more than 2 years and were present in a sales database	USD 29	NA
Harper et al. ⁴¹	pit emptying that produces fertilizer from fecal sludge	Cambodia	DCE	same as above	USD 16	NA
Harper et al. ⁴¹	pit emptying that reduces foul odor from high to moderate	Cambodia	DCE	same as above	USD 23	NA
Harper et al. ⁴¹	pit emptying that reduces foul odor from moderate to none	Cambodia	DCE	same as above	77% said USD 0.9–4.5/month	107–535% ^g
Singh et al. ⁴⁸	emptying services by monthly payment	Bangladesh, Khulna	CV: open-ended question	households in a ward that represents a mix of planned and unplanned development, slum areas, and community of manual sweepers		

^aMean or median WTP amounts are stated as WTP, unless otherwise noted as revealed WTP. ^bA trained service that worked with recognition of the local government and National Environment Management Authority (NEMA), had permission to dump waste at the city's treatment plant, and complied with public health regulations. ^cA service delivered by trained, licensed, and vaccinated workers wearing protective gear. The workers minimize going inside the pits. They collect the fecal sludge into barrels and transport them to a treatment plant with pick-up trucks. ^dCalculated by authors based on the most probable scenario (3 year desludging interval). ^eA service that is easy to contact with emptiers, is timely and fast, leaves less dirt, and takes sludge away and safely disposes of sludge. ^fDue to a lack of data on the inflation rate and currency exchange rate, the original WTP amount (in 2017) is shown here. ^gCalculated by authors based on the most probable scenario (3 year desludging interval and 1.96 m³ average pit volume).

Table 3. Determinants of WTP for Fecal Sludge Emptying Services, Which Were Statistically Significant (at 5% Level) in One or More Studies

determinant of WTP	WTP ^a	description	reported by
economic situation category			
income/expenditure	+	higher WTP for manual and mechanical emptying as customers' income or expenditure gets higher	Harder et al. ⁴⁶ Naing et al. ⁴³ Peletz et al. ¹⁰ Ross and Pinfeld ⁴⁹ Vásquez and Alicea-Planas ⁴⁷
price	−	lower WTP for vacuum/manual emptying as prices get higher	Burt et al. ⁴⁴ Harper et al. ⁴¹
flat fee	−	lower WTP for vacuum truck emptying if a flat fee is used	Burt et al. ⁴⁴
urgency category			
shared latrine	+	higher WTP for manual emptying if their latrine is shared	Peletz et al. ¹⁰
household size	+	higher WTP for excreta disposal as the household size gets larger	Vásquez and Alicea-Planas ⁴⁷
waiting time	−	lower WTP for longer waiting time	Naing et al. ⁴³ Harper et al. ⁴¹
service characteristics category			
branded service that provides workers with protection	+	higher WTP for branded vacuum truck emptying	Burt et al. ⁴⁴
smell prevention during work	+	higher WTP for manual emptying that prevents smell	Harper et al. ⁴¹ Jenkins et al. ⁷
sludge taken away	+	higher WTP for vacuum truck/manual emptying that takes sludge away to a remote place	Burt et al. ⁴⁴ Jenkins et al. ⁷
sludge treatment before disposal	+	higher WTP for vacuum truck emptying that treats sludge before disposal (removing smells and pathogens)	Burt et al. ⁴⁴
contact with sludge prevented	+	higher WTP for pit emptying that prevents workers from contacting with sludge	Harper et al. ⁴¹
fertilizer production	+	higher WTP for pit emptying that produces fertilizer from the sludge	Harper et al. ⁴¹
service accessibility category			
alternative hygienic method available	−	lower WTP for formal manual emptying if an alternative hygienic emptying method is locally available	Jenkins et al. ⁷
distance from a road	−	lower WTP for vacuum truck emptying if they have a toilet located >50 m from a road	Peletz et al. ¹⁰
knowledge category			
knowledge about another hygienic method	−	lower WTP for manual emptying if they know another hygienic emptying method	Jenkins et al. ⁷
knowledge about the only available option	+	higher WTP for manual emptying if they have emptied their latrine using the only available option before	Jenkins et al. ⁷
others			
education	+−	WTP for manual emptying can get higher or lower if they are more educated	Jenkins et al. ⁷ Peletz et al. ¹⁰ Harper et al. ⁴¹
age	−	lower WTP for manual/mechanical emptying as they get older	Peletz et al. ¹⁰
gender	male, +	higher WTP for manual/mechanical emptying if they are male	Peletz et al. ¹⁰
province	+−	WTP vary depending on province	Harper et al. ⁴¹

^aA plus sign (+) means that WTP increases as the determinant increases or the service/customer has the characteristic. A minus sign (−) means that WTP decreases as the determinant increases or the service/customer has the characteristic. Plus and minus signs (+−) mean that the determinant can either increase or decrease WTP.

particularly relevant in informal urban settlements where multiple households commonly share one latrine.^{7,51}

The service characteristics category included most determinants. Households had higher WTP for manual and mechanical emptying services if sludge was taken far away from the latrine and if emptiers were equipped with safety gear to avoid direct contact with fecal sludge. Households also had higher WTP for manual emptying if the service had minimal smell and the fecal waste was treated and processed as a fertilizer. Regarding mechanical emptying, households had higher WTP if sludge was treated before disposal.

The service accessibility category included factors concerning the physical availability of services. Households had lower

WTP for a formal emptying service if an alternative hygienic service was available in the community. They had higher WTP for mechanical emptying if they had a toilet less than 50 m from a road. The distance from a road is particularly critical in urban settlements as narrow roads and congested buildings often prevent vacuum trucks from accessing latrines.^{7,42,49}

The determinants in the knowledge category, such as awareness or experience about emptying services, can affect WTP regardless of whether the service is physically available or not in the area.

Education level was both positively and negatively associated with WTP.^{7,10,41} While higher education seems to increase valuation of sanitation,⁴¹ reasons for negative associations have

not been investigated.⁷ WTP was higher for male and for customers <35 years of age.

DISCUSSION

To our knowledge, this is the first scoping review on WTP for fecal sludge emptying services. This review summarizes WTP price gaps for three types of emptying services (manual emptying with and without a manual desludging pump, mechanical emptying with a vacuum pump, and CBS), methods for eliciting WTP, and determinants of WTP and identifies knowledge gaps.

WTP Elicitation Methods. CV was the most common approach for eliciting WTP for FSM services among the included studies, while only three studies used DCE. Compared to CV, DCE provides an estimate of the marginal utility of service attributes.⁵² This helps identify the optimal combination of attribute levels, including price.⁵³ Therefore, it may be beneficial to use DCE instead of CV in instances where the objective is to design new emptying services. While CV is flexible and applicable to a variety of scenarios, respondents are subject to hypothetical bias.⁵² Stated WTP is usually overestimated compared to revealed WTP, since the respondents hypothetically state their willingness to pay without actual payment.⁵² For example, Peletz et al. reported that stated WTP was higher than revealed WTP.²⁰

Two included studies conducted market experiments using real-money vouchers to estimate revealed WTP. In the experiments, both studies had short redemption periods of 3 months. In addition, both studies mentioned the logistic complexity of real-money vouchers as a limitation for eliciting WTP.^{10,44}

None of the studies used the hedonic pricing method to investigate WTP for FSM. This method estimates revealed WTP for a certain service or a characteristic using rent or land prices and is commonly applied in the water and sanitation sector.^{53–55} Hedonic pricing may not have been applied in included studies, as homeowners or landlords may not pay for emptying services, even where they are responsible. Therefore, rent prices may not necessarily reflect the cost of emptying services.^{7,49,56}

Payment Method. Payment methods vary in terms of pain of paying (direct and immediate displeasure or pain from the act of making a payment), nature of the payment (voluntary or compulsory), and convenience^{57,58} and may therefore affect WTP. In general, the less pain of paying customers feel, or the more convenient the method is, the higher WTP customers show.⁵⁷ If the payment is voluntary, WTP can be lower than compulsory because concerns about free-riders affect their motivation.⁵⁸

Two studies investigated household WTP by including the emptying fee in the water bill, while two studies compared WTP for emptying services as a one-time payment versus monthly payments. Ten studies did not specify the payment method, so it was assumed to be a one-time cash payment. No studies considered taxes or surcharges as a payment method.

Two studies noted that monthly payments, instead of a one-time payment, would allow households to spread the emptying cost over time.^{7,11} The monthly payment methods can include water bills, earmarked savings accounts, and monthly subscriptions.^{50,59} One of two studies that investigated the impact of monthly payment reported that households preferred paying monthly to one time.⁴⁸ However, another study carried out in low-income areas of Kisumu, Kenya, reported that stated

WTP for subscription of emptying services with monthly payments was not significantly higher than WTP for one-time payments, although 61% of respondents preferred monthly payments.¹⁰ This implies that continuous payments for low-income households could be challenging even if each payment is small because they may have a weak guarantee of future income. Alternatively, flexible payment schemes that can accommodate household income at the time of service uptake such as volumetric pricing (pay as you go) might be more favorable.⁴⁴

Determinants of WTP. The set of determinants identified in this Review (Table 3) can be applied as a checklist when improving or introducing new emptying services. It is worth noting that some determinants are interlinked. First, when households require immediate emptying services, they may use a service that is more quickly accessible, thereby compromising on emptying quality. To capture this demand, short waiting times are favorable. Regarding urgency and economic situation, the more people that share a latrine, the lower the cost per person, but the faster sludge accumulates, which results in more frequent emptying. When investigating WTP for emptying services, future research should consider not only a household's WTP but also the number of households sharing one latrine. We should also note that there may be collective action challenges in shared sanitation situations.⁶⁰

Although the set of determinants is useful to improve customers' WTP, gaps between WTP and market price should be addressed from multiple angles. For instance, utilizing subsidies (including cross-subsidies) and reducing the price should also be considered to close the gaps.⁶¹ Furthermore, enabling conditions, such as regulations and incentives, can help establish competitive markets and, in turn, contribute to reducing prices and improving service quality.⁸

Implications of Study Findings and Research Gaps. To date, research has focused on understanding the current demand (WTP) for existing services compared to service supply (prices or costs).^{11,42} There has been little focus on WTP for emerging services, which adopt flexible pricing schemes. These involve payment approaches that allow users to spread payments over time as well as volumetric pricing. Our review identified four studies that investigated how different payment approaches (e.g., water bill, volumetric pricing, and monthly payment) could affect households' WTP compared with one-time cash payment. Only two studies examined whether the difference in WTP was statistically significant.^{10,44} Of these, one study reported no significant difference in WTP for monthly vs one-time payment, but the majority (61%) preferred monthly payment.¹⁰ Also, one survey conducted in Rwanda reported that flat fee pricing was significantly associated with low WTP, suggesting a preference for volumetric pricing.⁴⁴ Given the lack of studies, the effectiveness of those approaches needs further investigation.

Services that improve supply side efficiency to reduce prices have not been fully investigated, as well. For instance, approaches such as group emptying and scheduled emptying have recently been proposed to reduce service prices by aggregating the demand of multiple households for efficient operation.^{44,48} However, there are concerns that these approaches do not always provide services at the household's preferred timing. It is worth examining whether households want to use the approaches despite its drawback, which could reduce WTP. In addition, services that employ geographic information systems (GIS) could reduce transport costs for

vacuum trucks by optimizing service logistics and therefore contribute to identifying areas where service accessibility is low.⁶² Also, some services use sales of sludge-derived products for cost recovery.⁶³ These services could gain higher WTP from households for their added value and brand images.⁴¹

Only one study employed mobile money as a payment method.¹⁰ According to the International Monetary Fund, mobile money is “a form of mobile payment service typically offered by a mobile network operator (MNO) or another entity in partnership with an MNO using mobile money accounts”.⁶⁴ Mobile money allows users to safely store transfer money.⁶⁴ Although the influence of mobile money payment on WTP is a relatively new research topic, it has been reported that mobile money could increase WTP due to its convenience and widespread use in certain context.⁵⁷ Mobile money services are already prevalent in many LMICs where people have limited access to traditional financial services.^{65–67} One or more mobile money services are available in the 11 countries where the included studies were conducted.⁶⁷ For instance, in Kenyan informal settlements, the vast majority (97%) of respondents to a recent WTP survey had the local mobile money service M-Pesa.¹⁰ Unlike cash, mobile payment can be easily combined with other information technology such as geographic information system (GIS) or behavioral science techniques such as “nudging”.^{59,62}

Limitations. This review highlights key points related to WTP to consider when improving or launching new emptying services. However, this review has several limitations. First, although there was no restriction on the language, the search was conducted in English. The literature published in other languages may have been excluded. Second, as this review only included studies with methodologies for WTP elicitation, some peer-reviewed and gray literature with WTP data was excluded. In addition, studies that do not meet all eligibility criteria might have reported relevant information for this scoping review. For example, one study conducted in Malawi was not identified in our search and did not meet eligibility criteria (i.e., no WTP amount reported), but it reported determinants of revealed WTP.⁶⁸ Therefore, depending on the objectives of studies, future researchers should consider broadening search terms more than those used in this review. Third, since the included studies used different methods to elicit WTP and investigated scenarios were heterogeneous, it was not possible to compare WTP amounts between studies. This heterogeneity is also a limitation to our comparison of WTP as a proportion of the market price. As more studies are conducted in the future, it will be possible to compare WTP amounts in similar settings, which could help improve emptying services.

Recommendations for Future Research. This review highlights that market prices exceeded WTP in most (77%) included studies, with WTP only covering 13, 16, and 18% of the prices for manual emptying, vacuum emptying, and CBS, respectively, in worst cases. This reaffirms that the provision of emptying services by the private sector in free markets is not affordable for all and that interventions to close the WTP–market price gaps in emptying services by the public sector are needed. Given the upward trends in the users of on-site sanitation and urban population, emptying and transport will become more important in the FSM value chain. Future research needs to address the knowledge gaps: researchers, together with stakeholders, need to validate whether interventions (e.g., establishing improved services or subsidies) that attempt to make services more affordable are effective in

closing the WTP–market price gaps. Researchers can improve study designs by using a methodological overview and the quality assessment in this review. In areas where mobile money is prevalent, future research can explore the impacts of mobile payment as well as its application in conjunction with other information technologies or marketing techniques. It is also worth examining how disadvantages of group emptying and scheduled emptying, such as waiting times for service delivery, affect WTP. To ensure universal access to safe sanitation by 2030, it is essential that affordable services are available for all, enabling users to safely operate and maintain on-site sanitation systems. Researchers and the private and public sectors must work together based on robust evidence, including this review.

■ ASSOCIATED CONTENT

SI Supporting Information

The Supporting Information is available free of charge at <https://pubs.acs.org/doi/10.1021/acs.est.3c06628>.

Willingness to pay and elicitation methods; Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist; example search strategy; list of codes used in the screening process; components of the data extraction sheet; results of quality assessment; characteristics of sanitation management behavior (PDF)

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Author Contributions

This paper was conceived by H.T. The screening and data extracting processes were conducted by H.T. and C.M. Analysis was performed by H.T. The first draft of the manuscript was prepared by H.T. All authors contributed to subsequent drafts. All authors have given approval to the final version of the manuscript.

Notes

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ABBREVIATIONS

CBS, container-based sanitation; CV, contingent valuation; DCE, discrete choice experiment; FSM, fecal sludge management; LMICs, low- and middle-income countries; MNO, mobile network operator; USD, United States dollar; WTP, willingness to pay

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