Heliyon 9 (2023) e21209

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Exploration of appropriate media to influence sustainable on-site sanitation choices in Sri Lanka– visualization with still images or a video

Chika Tokunaga [a], Yurina Otaki [b,*], Hidehito Honda [c], Masahiro Otaki [d]

[a] Department of Human Life and Environmental Science, Ochanomizu University, 2-1-1 Otsuka, Bunkyo, Tokyo, 112-8610, Japan
[b] Graduate School of Social Sciences, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo, 186-8601, Japan
[c] Faculty of Psychology, Otemon Gakuen University, 2-1-15 Nishiai, Ibaraki, Osaka, 567-8502, Japan
[d] Faculty of Core Research, Natural Science Division, Ochanomizu University, 2-1-1 Otsuka, Bunkyo, Tokyo, 112-8610, Japan

ARTICLE INFO

Keywords:
Sustainable sanitation
On-site sanitation
Pit latrine
Septic tank
Still image
Video

ABSTRACT

Pit latrines are the most common form of improved sanitation in many rapidly developing countries. However, they cause the highest amount of groundwater pollution among on-site sanitation (OSS) facilities. Many households in developing countries use groundwater as their main or sub-source, and pit latrines are not a sustainable solution. Thus, the conversion from pit latrines to septic tanks is required.

We created two types of media, still images and a video, to illustrate the differences in functions and hygiene risks between pit latrines and septic tanks. Moreover, a survey was conducted in Sri Lanka to determine the media choice that would increase the people's preference for septic tanks as their next OSS, even weeks after the information is presented. The choice of the next OSS participants selected before they were presented with the images was the same as that currently in use, reflecting the belief that the problem of pit latrines was not currently apparent and need not be changed. However, a video presentation of the information made it possible for a larger group of people to choose the usage of septic tanks in the future, especially in suburban areas where the problems were likely to occur.

1. Introduction

In many of the rapidly developing countries, millions of toilets, primarily pit latrines have been constructed using on-site sanitation (OSS) to eliminate open defecation and improve sanitation [1,2]. Pit latrines are the most basic form of improved sanitation introduced in many countries and regions to achieve the Millennium Development Goals [3], targeting half the population without sustainable access to improved sanitation by 2015 [4]. Because pit latrines are used to separate excreta from humans, direct fecal infections can be prevented. However, pathogens and nutrients are easily transported to the soil beneath the pit and into groundwater, as it only temporally accumulates excreta and is not specifically designed to reduce pathogenic concentration [5]. Therefore, pit latrines cause the highest amount of groundwater pollution among the OSS. In developing countries, tap water supply is available only in a few urban areas. The majority of households use groundwater as their main or sub-source owing to insufficient funding and inefficiencies caused

* Corresponding author.
E-mail address: yurina.otaki@r.hit-u.ac.jp (Y. Otaki).

https://doi.org/10.1016/j.heliyon.2023.e21209
Received 16 May 2023; Received in revised form 12 October 2023; Accepted 18 October 2023
Available online 20 October 2023
2405-8440/© 2023 Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

by less densely populated areas. Thus, pit latrines that contaminate groundwater are not a sustainable solution.

As of 2016, approximately 80 % of the households in Sri Lanka used flush toilets and pit latrines [6]. Pit latrines are designed to collect human excreta without flushing large volumes of water [7], and their use along with flush toilets causes groundwater contamination [8]. The National Water Supply and Drainage Board (NWSDB), which is responsible for water supply and wastewater treatment in Sri Lanka, recommends avoiding pit latrine usage and constructing septic tanks with proper designs [9]. However, the conversion from pit latrines to septic tanks has not yet progressed. In Sri Lanka, although tap water supply is widespread in urban areas, groundwater is the main water source in the suburbs and rural areas. As for domestic wastewater, very few areas have sewage systems, and the majority use the OSS, mainly pit latrines. Therefore, there is an increased risk of contamination from OSS, particularly in the suburbs.

Regarding the transition of the sanitation method, research has been conducted on Water, Sanitation and Hygiene (WASH) interventions that improve elementary hygiene behaviors, such as encouraging handwash and discouraging open defecation [10–12]. However, to the best of the authors' knowledge, more advanced stage studies attempting to convert pit latrines into septic tanks have not been conducted. In addition, as the conversion from a pit latrine to a septic tank is aimed at improving the sanitation of the local population, direct application of WASH discoveries attempting to improve the sanitation of each individual is difficult.

Understanding the need to switch from pit latrines to septic tanks for sustainable sanitation requires specialized knowledge of microbial contamination. Currently, the general population lacks an understanding of this issue; therefore, clear communication and explanation are required. In general, people make different judgments depending on how they visualize it, whereas a verbal description of a product might lack realism. The use of visual aids, such as a video, improves the respondents' understanding of information and increases the reliability of the results, as visual information serves as a "common language" for all the stakeholders [13–15]. However, Lalley and Miller (2007) stated that no particular method is always better than another and that effective methods vary depending on the context [16]. Therefore, as a case study, we examined whether still images or a video would be more appropriate to help the people of Sri Lanka understand the mechanism that will ultimately encourage them to switch to septic tanks and continue it in the future.

2. Materials and methods

Here, we propose a method to enhance the general public's understanding of the difference between the functions and sanitation risks associated with the use of pit latrines and septic tanks; this approach will also emphasize on promoting the public with selecting an appropriate septic tank. This study is rooted in the concept of boosting in behavioral sciences, which has recently been garnering a lot of attention [17,18]. Boosting is an approach gearing toward increasing people's competence for understanding information correctly, so that they are empowered to independently make contextually optimal decisions. Continuity is one of the most important factors for improving competence. Specifically, competencies taught with an application of principles underlying boosting tend to be sustained for prolonged periods, pointing to the continuous nature of their effects [19]. In this study, we verified the effectiveness of the proposed boosting-linked method by measuring people's understanding of the targeted information before and after the proposed intervention, as well as after a certain period had elapsed.

2.1. Study design

The overall flow of the study is illustrated in Fig. 1. In the 1st questionnaire, we determined the participants' knowledge and thoughts on OSS prior to the intervention. Immediately after the 1st questionnaire, the intervention was implemented using two types of media, namely, still images and a video. These media were used to illustrate the differences in functional and hygienic risks between pit latrines and septic tanks. Participants were divided into two groups and each group was provided with either a still image or a video (hereafter, still group and video group, respectively). This was immediately followed by the 2nd questionnaire that asked them to determine their level of understanding and which OSS they would prefer to use at home. Approximately 2–3 weeks after the intervention, the 3rd questionnaire which was same as 2nd one, was administered to the same participants to determine the persistence of their understanding and the decision to choose the OSS. Memories generally fade rapidly after approximately 1 week [20]; therefore, we set 2–3 weeks as the longer period. We then analyzed whether there were differences in comprehension, choice of OSS, and continuity, depending on whether the participants viewed still images or a video.

Prior to the survey, we explained the methodology, confirmed their intent to participate, and obtained informed consent via e-mail and SNS tools. Subsequently, the survey was conducted virtually using Zoom, as travel was not possible within Sri Lanka owing to economic collapse and gasoline shortages in 2022. After accessing the online meeting, the participants were shown the URL containing

Fig. 1. Overall flow of survey.

the intervention and a questionnaire. After completion, a brief interview was conducted. This procedure prevented a 100 % trivial or incomplete response. Moreover, a Sri Lankan who understood the objectives of the survey was asked to participate in each Zoom survey to assist in communicating with the subjects. The survey was conducted from the end of July 2022 until November 2022.

The study was approved by Hitotsubashi University ethical committee (D019).

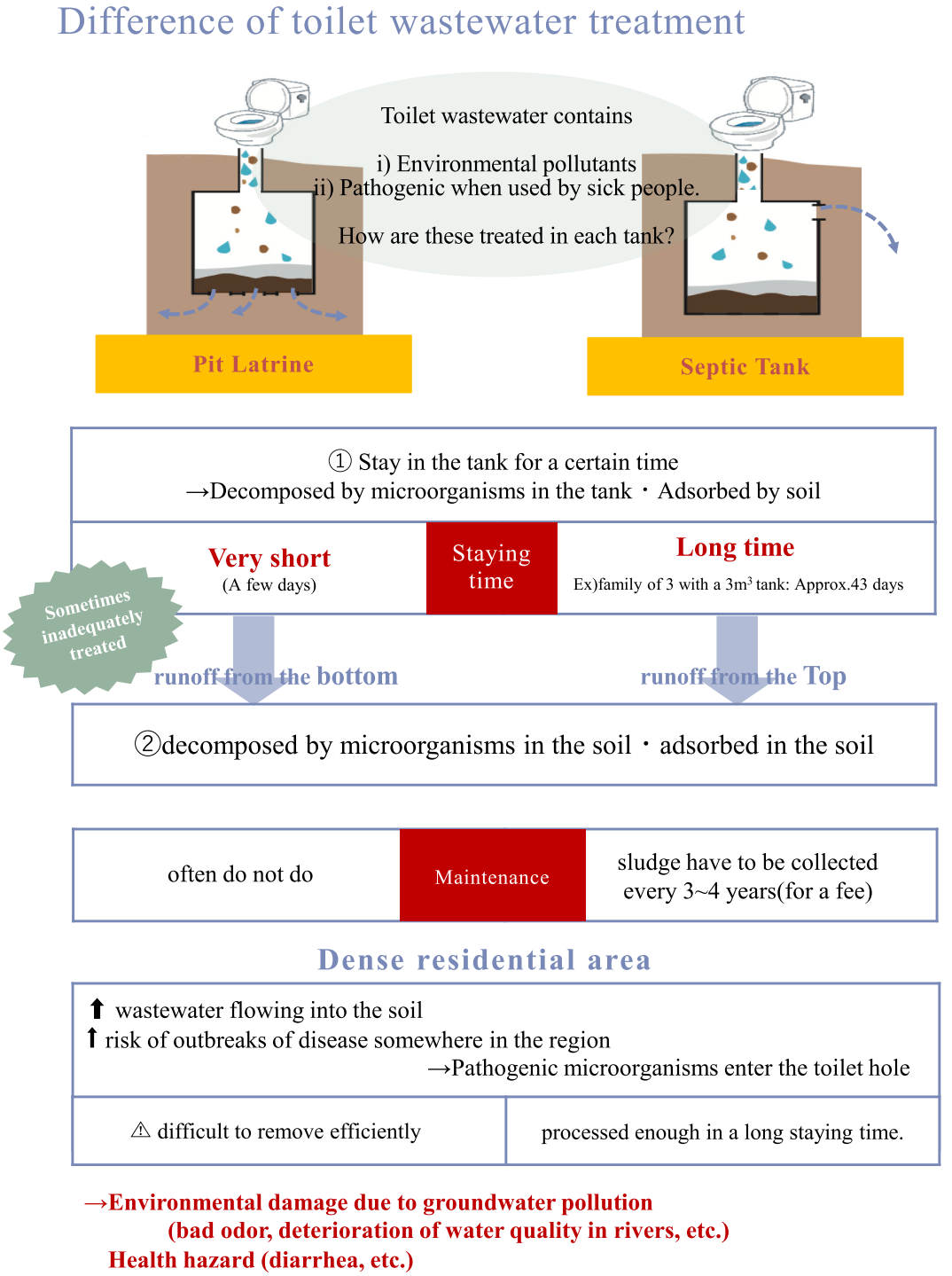

Fig. 2. Excerpts of the explanatory still images. Note: Translated from Sinhara to English.

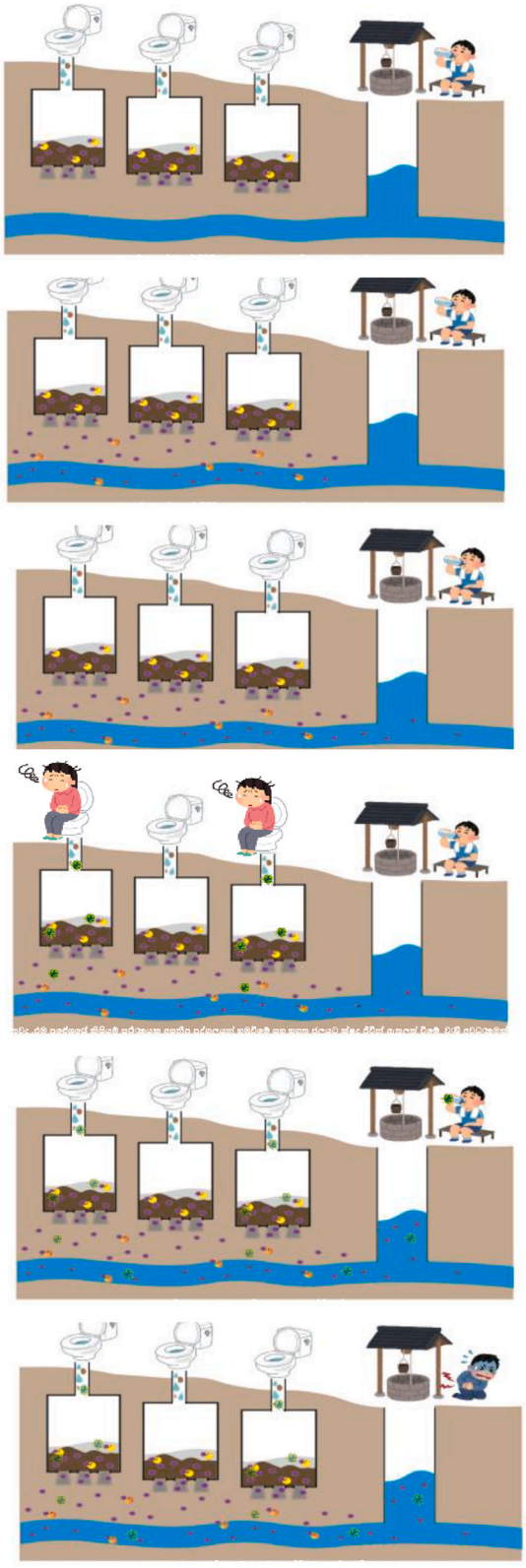

Fig. 3. Screenshots from the video.

2.2. Participants

We used the G*Power version 3.1.9.7 [21] to calculate the minimum required sample to conduct an independent two-group *t*-test with $d = 0.5$ (medium effect), $\alpha = 0.05$, and power = .8. The minimum sample size was 64 participants per group. Prior to the survey being administered, we confirmed that participants used OSS for the treatment of human waste. In Sri Lanka, OSS are usually constructed in the yard of residents' houses or apartments, and it is common for people to independently choose the kind of OSS they prefer.

A total of 128 Sri Lankan residents older than 17 years of age were selected through snowball sampling and randomly placed into two groups of equal halves. The two groups corresponded to the two interventions described below: the still and video groups.

2.3. Interventions

Explanation media describing the same content were available, one with a still image and the other with a video. The participants could view it repeatedly; however, they had to watch it for a certain amount of time. For the still group, they could not proceed to the next page until 30 s had passed, whereas the video group had to watch the video entirely before they could proceed to the next page.

The explanatory media indicated the following: 1) the toilet wastewater contains substances that cause environmental pollution and also contain pathogenic microorganisms owing to contamination from people with illnesses; 2) there are environmental and health risks associated with pit latrines; 3) pit latrines and septic tanks have different mechanisms of treatment, maintenance, and environmental and health risks. Some of the still images and screenshots from the video are shown in Figs. 2 and 3, and all are shown in Appendix.

2.4. Questionnaire design

The 1st questionnaire, intervention, and the 2nd questionnaire were conducted on the same day, and the entire process was complete in approximately 30 min. In the 1st questionnaire, the participants were asked for demographic data (i.e., age, sex, education, and residential area), their current OSS at home, and the new OSS they would build in future. Regarding their current OSS, the participants were asked to i) clarify the type of OSS (pit latrine or septic tank); ii) identify the degree of problem with their current OSS in terms of maintenance effort, cost, and odor on a 5-point scale (1 [problematic] to 5 [not problematic]); and iii) evaluate their current OSS in terms of environmental and health impacts. In addition, a 5-point scale was used to assess the preference of new OSS, which they were to build, regarding pit latrines or septic tanks (1 [pit latrine] to 5 [septic tank]) and how important they would consider the environmental impact, health impact, maintenance effort, and cost (1 ([important] to 5 [not important]).

In the 2nd questionnaire, which was conducted immediately after the intervention, participants evaluated themselves on how well they understood the explanation material on a 5-point scale (1 [not understood] to 5 [understood]). Subsequently, they were assigned quizzes to objectively measure their understanding of the intervention materials (Table 1). In addition, questions similar to those used in the 1st questionnaire were replicated.

Then, the 3rd questionnaire was conducted 2–3 weeks. The same quizzes as 2nd questionnaire were assigned to determine whether the participants remembered the explanatory material. In addition, questions similar to those used in the 1st questionnaire were replicated. This process required approximately 5 min to complete.

3. Results

3.1. Participants

The distributions of age, sex, education, and residential area are presented in Table 2. Residential areas were classified into three categories according to their population size: urban (50,000 or more), suburban (5000–50,000), and rural (5000 or less). There were no significant differences between the groups (Fisher's exact test for age: $p = .640$; sex: $p = .655$; education: $p = .949$, and chi-square test for residential area: $\chi^2(2) = 2.33$, $p = .312$).

3.2. Current OSS at home

Approximately 70 % of the patients in both groups had pit latrines. There were no significant differences between groups in the type of OSS used at home ($\chi^2(1) = 0.15$, $p = .697$) (Table 3).

Table 1
Quiz to assess comprehension.

Questions	Answer choices
Which has a longer residence time?	Pit latrine/Septic Tank
Which one requires regular maintenance?	Pit latrine/Septic Tank
When the sludge is full, which OSS requires you to construct a new one?	Pit latrine/Septic Tank
After how many years is it necessary to remove the sludge from a septic tank?	One year/several years/ten years/no need

Table 2
Distribution of age, sex, education, and residential area Number of people.

	Still group	Video group
Age		
11–20	4	6
21–30	17	17
31–40	7	5
41–50	15	10
51–60	14	21
61–70	7	5
Sex		
Male	20	14
Female	43	50
Others	1	0
Education		
Primary	1	0
Secondary	4	3
High school	20	20
University	34	34
Others	5	7
Residential Area		
Urban	8	13
Suburb	37	38
Rural	19	13

3.3. Evaluation of current OSS

In both groups, approximately 80 % of the participants presumed that their OSS had no environmental or health problems prior to the intervention. However, immediately after the intervention, participants tended to think that there was a significant problem (Fisher's exact test: $p = .000$). After 2–3 weeks, they still presumed that there was a significant problem compared to that before the intervention, although the trend weakened (Fisher's exact test: $p = .000$) (Fig. 4).

3.4. Comprehension of information presented in the intervention

The participants were asked to self-assess their understanding of the intervention materials on a 5-point scale immediately after the intervention. More than 80 % of the participants presumed that they fully understood the intervention materials, reaching 100 % when combined with those who thought that they understood the materials to some extent. Thus, all the participants evaluated their understanding.

The analysis of the number of correct answers to the quiz showed no significant differences between the still and video groups immediately after the intervention. However, the video group tended to answer more questions correctly several weeks later than the still group (Fisher's exact test: $p = .080$) (Fig. 5). This indicates that videos may be a better medium for understanding and retaining OSS-related knowledge.

3.5. Preference of OSS in the future

Participants were asked to rate the type of OSS that they would choose in the future on a 5-point scale from "pit latrine (1) "to "septic tank (5)." In both groups, the information provided about OSS resulted in a significant increase in the number of people choosing septic tanks (Fisher's exact test: $p = .000$ for both groups) (Fig. 6). In the still group, immediately after the intervention, the number of people who chose the septic tank significantly increased, and those who chose the pit latrine significantly decreased; however, a few weeks later, those who chose the pit latrine increased again. In the video group, immediately after the intervention, the number of people who chose the septic tank significantly increased, and those who chose the pit latrine significantly decreased. However, after a few weeks, unlike in the still group, the number of people choosing pit latrines did not increase, and the tendency to choose septic tanks increased. It was found that videos were more likely to result in knowledge retention about OSS and thus

Table 3
Type of OSS. Number of people.

	Still group	Video group
Pit latrine	44	47
Septic tank	20	17

Approximately 80 % of the participants indicated that maintenance effort, cost, and odor were not problematic for them; therefore, they were satisfied with their current OSS to some extent. There were also no significant differences between the groups (Fisher's exact test: $p = .766$, .311, and 0.769, respectively).

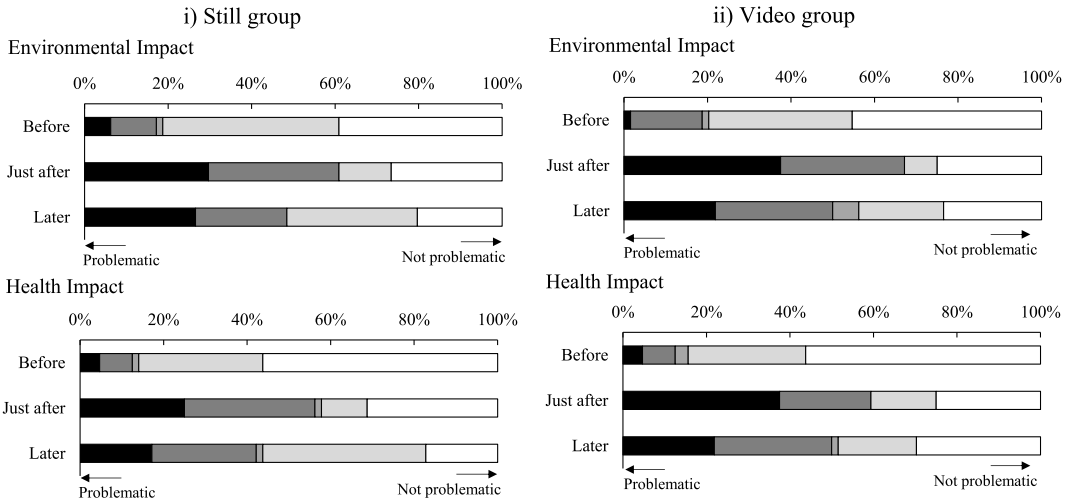

Fig. 4. Evaluation of current on-site sanitation (OSS).

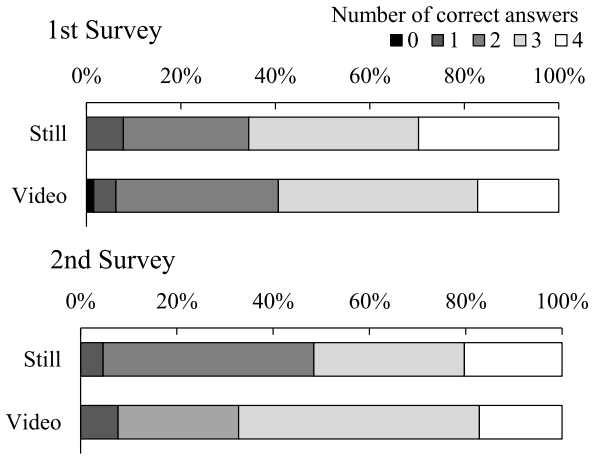

Fig. 5. Number of correct answers to the quiz.

participants continued to select the septic tank for their next OSS.

Changes in the choice of future OSS before and weeks after the intervention are shown in Fig. 7. In both groups, those who had initially selected the septic tank continued to select the same after several weeks of intervention. In the still group, those who had initially selected pit latrines continued to do so; however, in the video group, the selection of pit latrines decreased and those who selected the septic tank increased several weeks after the intervention. Therefore, it can be said that the use of a video to communicate information reached the necessary target audience (those who had selected pit latrine).

Ordinal logistic regression analysis was conducted on the choice of future OSS before intervention and 2–3 weeks after intervention. The explanatory variables used were the type of intervention (video or not); percentage of correct answers to the quiz; current OSS type (septic tank or not); and aspects considered important for the next OSS—environmental impact, health impact, maintenance effort, and cost (1 [important] to 5 [not important]), and demographics (age and residential area). Variance inflation factors (VIF) between variables were calculated (Table 4). As all VIFs were smaller than 10, we judged that there was no multicollinearity between the variables.

Table 5 indicates the result of ordinal logistic regression analysis before intervention and 2–3 weeks after intervention. Before the intervention, under normal conditions, the current type of OSS tends to influence future OSS selection. However, 2–3 weeks after the intervention, a video presentation of scientific information about OSS led to a significant trend in the selection of a septic tank. In addition, the trend was more pronounced among the suburban residents, where problems are more likely to occur. Furthermore, there was a significant trend that the more the environmental impact was considered a problem, the more septic tanks were chosen.

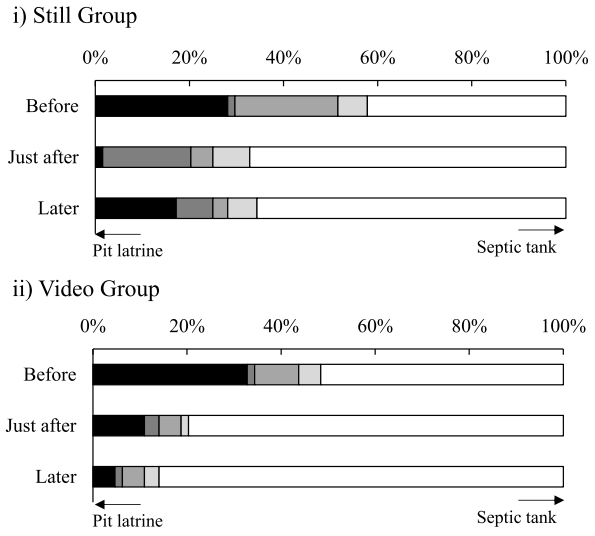

Fig. 6. Preference of the next on-site sanitation (OSS).

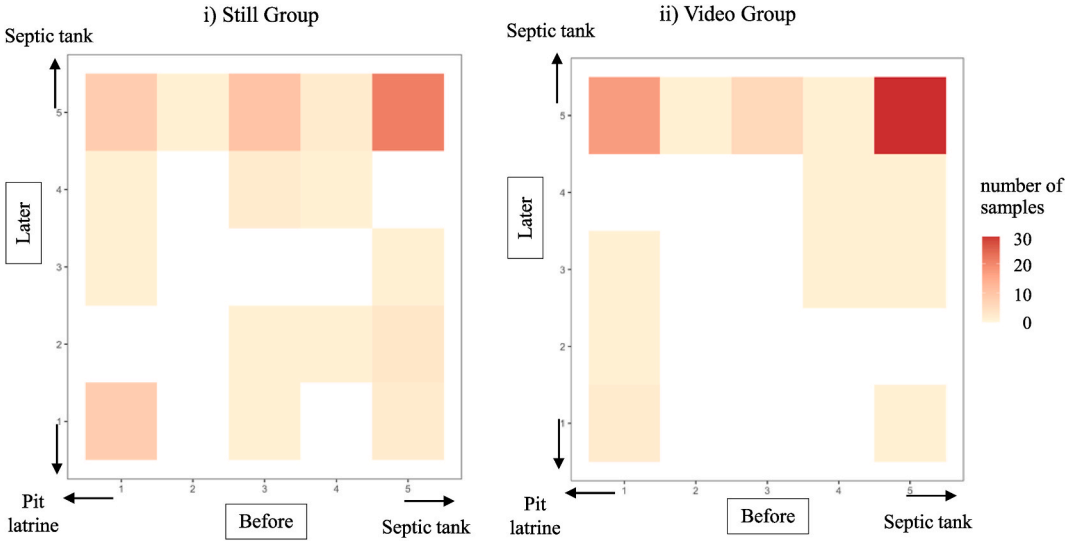

Fig. 7. Changes in the choice of future on-site sanitation (OSS) before and weeks after the intervention.

Table 4
VIF of explanatory variables.

	Before	Later date
Intervention	1.04	1.11
Quiz	–	0.96
Current OSS type	1.05	−4.91
Aspects to consider important for the next OSS		
Environmental impact	2.64	1.72
Health impact	2.59	1.77
Maintenance effort	1.64	1.81
Cost	1.38	1.76
Demographics		
Age	1.03	1.06
Residential area	1.06	1.05

Table 5
Result of ordinal logistic regression analysis.

	Before		Later date	
	estimate	*p*-value	estimate	*p*-value
Intervention	0.35	0.329	1.272	0.008***
Quiz	–	–	–	–
Current OSS type	1.64	0.000***	0.17	0.746
Aspects to consider important for the next OSS				
Environmental impact	−0.118	0.817	−0.188	0.082*
Health impact	−0.057	0.937	0.505	0.469
Maintenance effort	0.167	0.624	0.186	0.646
Cost	0.237	0.425	−0.214	0.678
Demographics				
Age	−0.011	0.343	0.009	0.583
Suburbs	0.502	0.304	1.546	0.010***
Rural	0.178	0.739	0.628	0.316

***$p < .01$, **$p < .05$, *$p < .1$.
Note: If the p value is less than the significance level, the effect of the explanatory variable is significant.

4. Discussion

In Sri Lanka, although OSS is installed in every household, pit latrines are still mainstream. However, a pit latrine paradox is evident: it was chosen as the sanitation technology to safeguard human health, yet its use resulted in pollution and health risk hotspots [22,23]. As many suburban and rural households in Sri Lanka use groundwater as their primary source of water, it is necessary to shift to septic tanks; however, this shift has not progressed well. As most policies do not allow funding for individual OSS, the selection of OSS is the responsibility of the household owners [24]. Usually, residents have limited knowledge of the technical aspects of OSS, and they believe that the current situation is satisfactory, because there are currently no apparent problems. Therefore, they are unaware of the importance of sanitation facilities and their maintenance [25]. However, fecal-derived contamination is certainly spreading, albeit being invisible. To promote the transition to septic tanks, it is necessary to clearly communicate the risks of pit latrines to residents to raise their awareness and aid their understanding. For that purpose, this study prepared still images and a video explaining the environmental and health impacts of pit latrines, and investigated whether residents who viewed them would consider choosing pit latrines or septic tanks as their next OSS.

The next OSS to be selected before presenting the information was the same as that currently in use, reflecting the belief that the problem was not currently apparent to the participants. However, by presenting the information using a video, it was possible to increase the number of people who chose to use the septic tank for their next OSS, especially residents in the suburbs where problems are likely to occur. The higher percentage of correct answers to the quiz in the video group suggests that the understanding of information and its continuation increased when using a video, thereby increasing the selection of septic tanks. The power of video in promoting understanding has been noted in other areas. For example, video has been shown to be the most appropriate learning medium for teaching students in a formal setting [26,27]. In the context of the health science, the use of only writing- or audio-based information has been linked to limited comprehension [28]. Overall, the inclusion of video-based information has been shown to be of utmost importance for optimizing comprehension [29].

However, this study had some limitations. First, even though participants may have chosen a septic tank in this study, it does not imply that they will act upon it. Discrepancies between intentions and actions have been reported in previous studies in the context of the environment [30–32]. To translate intentions into actionable steps, not only the method or the specifics of the information being taught, but also the other elements, such as financial support and social mechanisms, should be considered. These obtained results are expected to provide insights to various stakeholders and policy makers that will allow them to move in this direction. Furthermore, for household equipment such as OSS, the investment is large, and the family's intention impacts the decision-making process. These different elements are supposed to be considered comprehensively. Second, we asked people to look at still images and a video; however, in the real world, it is difficult to direct people's attention to such information. Therefore, it is necessary to not only find ways to present information, but also to help people perceive the information. Since no method is universally applicable, it is important to find multiple effective methods and combine them to form a robust solution. Third, we surveyed OSS choices 2–3 weeks after the intervention. However, the actual OSS changes occur after a longer period; thus, it is uncertain what they will think at that time. In addition, during the transition from intention to actual action, long-term behavioral change is also needed to consider various elements comprehensively. Fourth, after a successful conversion to a septic tank, maintenance is required to pull out the sludge every few years, a process not required for a pit latrine. The tank condition and maintenance influence the effluent quality [33]. Currently, the maintenance of desludging many septic tanks is not through, making the septic tank a hot spot for contamination just like the pit latrine [34]. When providing information about the septic tank in this study, we explained the importance of desludging every few years. It is necessary to continue to encourage people to maintain the septic tank after the transition to decrease the environmental and health impacts. Fifth, since snowball sampling was used, representativeness is limited. In developing countries, where there have been no survey companies like developed countries, it is difficult to use the typical sampling methods. Past studies conducted in developing countries indicated that a certain degree of knowledge can be acquired [35–37].

Although there are certain limitations, similar situations occur in several parts of Asia besides Sri Lanka, and the findings of this study can be applied to such areas. In this study, we compared still images and a video; however, recent technologies, such as AR and VR, may also be effective. AR and VR can be used to visualize spatial dynamics [38], making them highly suitable for the visualization and communication of facts related to hygiene that are happening underground in an easy-to-understand manner. In addition, since AR and VR are attractive [39], they may be effective in capturing attention. Although it is possible that older people may not be familiar with advanced technologies, there has been an overall positive attitude toward the use of VR among the elderly [40], suggesting that there is no age-related resistance to the use of such technology. However, the use of this technology in such contexts still requires further investigation.

5. Conclusions

In this study, we propose a method to enhance the general public's understanding of functional and risk-related differences between pit latrines and septic tanks. In addition, we also aim to promoting the public with selecting an appropriate septic tank. We first verified the effectiveness of the still images and a video explaining the environmental and health impacts of pit latrines by measuring people's understanding of the targeted information before and after the proposed intervention, as well as after a certain period. We found that presenting the information in video form increased the number of people who chose to use the septic tank for their next OSS. The higher percentage of correct answers to the quiz in the video group suggests that the use of videos resulted in a sustained comprehension of the presented information; this outcome then; culminated in an increased selection of septic tanks by participants.

Data availability

The dataset is available in Supplementary Material and also in repository (DOI: 10.17632/2p448jrv5t.1).

CRediT authorship contribution statement

Chika Tokunaga: Data curation, Formal analysis, Investigation, Visualization, Writing – review & editing. **Yurina Otaki:** Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft. **Hidehito Honda:** Conceptualization, Methodology, Supervision, Validation, Writing – review & editing. **Masahiro Otaki:** Funding acquisition, Methodology, Supervision, Validation, Writing – review & editing.

Declaration of competing interest

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

Acknowledgements

This research was funded by the JSPS: Japan Society for the Promotion of Science, Grant-in-Aid for Scientific Research (b) (grant numbers JP20H04391). We would like to thank Ms. Rasangika Thathsarani and Ms. Liyanage Chamindi for their research support.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2023.e21209.

References

[1] N. Chandana, B. Rao, A critical review on sludge management from onsite sanitation systems: a knowledge to be revised in the current situation, Environ. Res. 203 (2022), 111812, https://doi.org/10.1016/j.envres.2021.111812.
[2] M.W. Jenkins, O. Cumming, S. Cairncross, Pit latrine emptying behavior and demand for sanitation services in Dar Es Salaam, Tanzania, Int. J. Environ. Res. Publ. Health 12 (2015) 2588–2611, https://doi.org/10.3390/ijerph120302588.
[3] J.P. Graham, M.L. Polizzotto, Pit latrines and their impacts on groundwater quality: a systematic review, Environ. Health Perspect. 121 (5) (2013) 521–530, https://doi.org/10.1289/ehp.1206028.
[4] WHO (World Health Organization)/UNICEF, Progress on Drinking Water and Sanitation: 2012 Update, 2012. https://apps.who.int/iris/handle/10665/44842. (Accessed 8 March 2023).
[5] E.A. Odey, B.O. Abo, A.S. Giwa, Z. Li, Fecal sludge management: insights from selected cities in Sub-Saharan Africa, Arch. Environ. Protect. 45 (2) (2019) 50–57, https://doi.org/10.24425/aep.2019.127984.
[6] Sri Lanka Demographic and Health Survey, 2016. http://www.statistics.gov.lk/Resource/en/Health/DemographicAndHealthSurveyReport-2016-Contents.pdf. (Accessed 8 March 2023).
[7] K. Orner, C. Naughton, T.A. Stenstrom, Global Water Pathogen Project Part Four. Management of Risk from Excreta and Wastewater, Pit Toilets (Latrines), 2018. https://www.waterpathogens.org/book/pit-toilets-latrines. (Accessed 8 March 2023).
[8] Y. Otaki, M. Otaki, T. Chaminda, Y. Kishimoto, Y. Nakazawa, K. Gimhana, Hygiene risk of waterborne pathogenic viruses in rural communities using onsite sanitation systems and shallow dug wells, Sci. Total Environ. 752 (2021), 141775, https://doi.org/10.1016/j.scitotenv.2020.141775.

[9] National Water Supply & Drainage Board, Handbook for Water Consumers, 2014. https://waterboard.lk/web/images/pdf/Con_Hnd_Book/Con_man_%20English.pdf. (Accessed 8 March 2023).

[10] E.D. Buck, H.V. Remoortel, K. Hannes, T. Govender, S. Naidoo, B. Avau, A.V. Veegaete, A. Musekiwa, V. Lutje, M. Cargo, H.J. Mosler, P. Vandekerckhove, T. Young, Approaches to promote handwashing and sanitation behaviour change in low- and middle-income countries: a mixed method systematic review, Campbell Systematic Reviews 13 (1) (2017) 1–447, https://doi.org/10.4073/csr.2017.7.

[11] J. Charnley, Sustaining Water, Sanitation and Hygiene (WASH) behavior change produced during schools-based interventions: perspectives from East New Delhi primary schools, Annual Review of Education, Communication, and Language Sciences, Special issue 18 (2021) 20–53.

[12] S. Ginja, S. Gallagher, M. Keenan, Water, sanitation and hygiene (WASH) behaviour change research: why an analysis of contingencies of reinforcement is needed, Int. J. Environ. Health Res. 31 (6) (2021) 715–728, https://doi.org/10.1080/09603123.2019.1682127.

[13] J. Dijkstra, J.V. Leeuwen, H. Timmermans, Evaluating design alternatives using conjoint experiments in virtual reality, Environ. Plann. Plann. Des. 30 (2013) 357–367, https://doi.org/10.1068/b12932.

[14] W. Rid, W. Haider, A. Ryffel, B. Beardmore, Visualisations in choice experiments: comparing 3D film-sequences and still-images to analyse housing development alternatives, Ecol. Econ. 146 (2018) 203–217, https://doi.org/10.1016/j.ecolecon.2017.10.019.

[15] A.N. Ryffel, W. Rid, A. Grêt-Regamey, Land use trade-offs for flood protection: a choice experiment with visualizations, Ecosyst. Serv. 10 (2014) 111–123, https://doi.org/10.1016/j.ecoser.2014.09.008.

[16] J.P. Lalley, R.H. Miller, The learning pyramid: does it point teachers in the right direction? Education 128 (2007) 64–79.

[17] T. Grüne-Yanoff, R. Hertwig, Nudge versus Boost: how coherent are policy and theory? Minds Mach. 26 (1) (2016) 149–183, https://doi.org/10.1007/s11023-015-9367-9.

[18] R. Hertwig, T. Grüne-Yanoff, Nudging and boosting: steering or empowering good decisions, Perspect. Psychol. Sci. 12 (6) (2017) 973–986, https://doi.org/10.1177/1745691617702496.

[19] P. Sedlmeier, G. Gigerenzer, Teaching Bayesian reasoning in less than two hours, J. Exp. Psychol. Gen. 130 (3) (2001) 380–400, https://doi.org/10.1037/0096-3445.130.3.380.

[20] H. Ebbinghaus, Memory: A Contribution to Experimental Psychology, Teachers College, Columbia University, New York, 1913.

[21] F. Faul, E. Erdfelder, A.G. Lang, A. Buchner, G* Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences, Behav. Res. Methods 39 (2007) 175–191, https://doi.org/10.3758/BF03193146.

[22] W. Gwenzi, J. Marumure, Z. Makuvara, T.T. Simbanegavi, E.L. Njomou-Ngounou, E.L. Nya, K. Kaetzl, C. Noubactep, P. Rzymski, The pit latrine paradox in low-income settings: a sanitation technology of choice or a pollution hotspot? Sci. Total Environ. 879 (2023), 163179 https://doi.org/10.1016/j.scitotenv.2023.163179.

[23] A.T. Ndoziya, Z. Hoko, W. Gumindoga, Assessment of the impact of pit latrines on groundwater contamination in Hopley Settlement, Harare, Zimbabwe, J. Water, Sanit. Hyg. Dev. 9 (3) (2019) 464–476, https://doi.org/10.2166/washdev.2019.179.

[24] A. Nakagiri, C.B. Niwagaba, P.M. Nyenje, R.N. Kulabako, J.B. Tumuhairwe, F. Kansiime, Are pit latrines in urban areas of Sub-Saharan Africa performing? A review of usage, filling, insects and odour nuisances, BMC Publ. Health 16 (2016) 120, https://doi.org/10.1186/s12889-016-2772-z.

[25] F.O. Gudda, W.N. Moturi, S.O. Omondi, E.W. Muchiri, E.J. Ensink, Pit latrine fecal sludge accumulation: assessment of trends and determinants in low-income settlements, Nakuru, Kenya, in: Proceedings of the 41st WEDC International Conference, Nakuru, Kenya, 2018, pp. 9–13.

[26] S. Sulihin, A. Asbar, E. Elihami, Developing of instructional video media to improve learning quality and student motivation, Edumaspul: Jurnal Pendidikan 4 (2) (2020) 51–55, https://doi.org/10.33487/edumaspul.v4i2.692.

[27] C. Widahyu, The Effectiveness of Using Video as a Learning Media Online Learning to Improve Students' Learning Motivation and Creative Thinking at Home during the COVID-19 Pandemic, 2021. https://www.researchgate.net/profile/Cindy-Widahyu/publication/348296038_THE_EFFECTIVENESS_OF_USING_VIDEO_AS_A_LEARNING_MEDIA_ONLINE_LEARNING_TO_IMPROVE_STUDENTS_'LEARNING_MOTIVATION_AND_CREATIVE_THINKING_AT_HOME_DURING_THE_COVID-19_PANDEMIC/links/5ff6ab10a6fdccdcb8374ba3/THE-EFFECTIVENESS-OF-USING-VIDEO-AS-A-LEARNING-MEDIA-ONLINE-LEARNING-TO-IMPROVE-STUDENTS-LEARNING-MOTIVATION-AND-CREATIVE-THINKING-AT-HOME-DURING-THE-COVID-19-PANDEMIC.pdf. (Accessed 31 August 2023).

[28] D.H. Howard, J. Gazmararian, R.M. Parker, The impact of low health literacy on the medical costs of Medicare managed care enrollees, Am. J. Med. 118 (4) (2005) 371–377, https://doi.org/10.1016/j.amjmed.2005.01.010.

[29] K. Pearce, Undergraduate creators of video, animations and blended media: the students' perspective, Proceedings of The Australian Conference on Science and Mathematics Education (2014) 152–162.

[30] G. ElHaffar, F. Durif, L. Dube, Towards Closing the Attitude-Intention-Behavior Gap in Green Consumption: A Narrative Review of the Literature and an Overview of Future Research Directions, 2020.

[31] B. Zhang, K. Lai, B. Wanga, Z. Wang, From intention to action: how do personal attitudes, facilities accessibility, and government stimulus matter for household waste sorting? J. Environ. Manag. 233 (2019) 447–458, https://doi.org/10.1016/j.jenvman.2018.12.059.

[32] S. Zhang, Z. Xia, C. Zhang, X. Tian, J. Xie, Green illusions in self-reporting? Reassessing the intention-behavior gap in waste recycling behaviors, Waste Management 166 (2023) 171–180, https://doi.org/10.1016/j.wasman.2023.04.036.

[33] S. Richards, E. Paterson, P.J.A. Withers, M. Stutter, Septic tank discharges as multi-pollutant hotspots in catchments, Sci. Total Environ. 542 (2016) 854–863, https://doi.org/10.1016/j.scitotenv.2015.10.160.

[34] K. Conaway, S. Lebu, K. Heilferty, A. Salzberg, M. Manga, On-site sanitation system emptying practices and influential factors in Asian low- and middle-income countries: a systematic review, Hygiene and Environmental Health Advances 6 (2023), 100050, https://doi.org/10.1016/j.heha.2023.100050.

[35] D. Arli, F. Tjiptono, R. Porto, The impact of moral equity, relativism and attitude on individuals' digital piracy behaviour in a developing country, Market. Intell. Plann. 33 (3m) (2015) 348–365, https://doi.org/10.1108/MIP-09-2013-0149.

[36] F.P. Oyawole, D. Akerele, A.O. Dipeolu, Factors influencing willingness to pay for organic vegetables among civil servants in a developing country, Int. J. Veg. Sci. 22 (2) (2016) 121–128, https://doi.org/10.1080/19315260.2014.942763.

[37] D. Youssef, J. Youssef, L. Abou-Abbas, M. Kawtharani, H. Hassan, Prevalence and correlates of burnout among physicians in a developing country facing multi-layered crises: a cross-sectional study, Sci. Rep. 12 (1) (2019), 12615, https://doi.org/10.1038/s41598-022-16095-5.

[38] Y. Ma, J. Wright, S. Gopal, N. Phillips, Seeing the invisible: from imagined to virtual urban landscapes, Cities 98 (2020), 102559, https://doi.org/10.1016/j.cities.2019.102559.

[39] H. Ardiny, E. Khanmirza, The role of AR and VR technologies in education developments: opportunities and challenges, Proceedings of the 6th RSI International Conference on Robotics and Mechatronics (2018) 482–487, https://doi.org/10.1109/ICRoM.2018.8657615.

[40] M.C. tom Diek, T. Jung, E. Michopoulou, Experiencing virtual reality in heritage attractions: perceptions of elderly users, in: Augmented Reality and Virtual Reality, vols. 89–98, Springer, Cham, 2019.