

Limiting potential COVID-19 contagion in squatting public toilets

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Abstract

Background: Since the outbreak of the SARS-CoV-2 virus in December 2019, the COVID-19 pandemic continues to threaten global stability. Transmission of SARS-CoV-2 is mostly by respiratory droplets and direct contact but viral RNA fragments have also been detected in the faecal waste of patients with COVID-19. Cleanliness and effective sanitation of public toilets is a concern, as flushing the toilet is potentially an aerosol generating procedure. When the toilets are of the squatting type and without a cover, there exists a risk of viral contamination through the splashing of toilet water and aerosol generation.

Methods: This study reports an online survey of 134 people in China to determine whether the cleanliness of public toilets was a concern to the general population during the COVID-19 pandemic, and whether a squatting toilet was preferred to a seated design.

Results: The survey showed that 91% of participants preferred squatting toilets, but that 72% were apprehensive of personal contamination when using public toilets. Over 63% of the respondents had encountered an incidence of water splash and would prefer public toilets to be covered during flushing and 83% of these respondents preferred a foot-controlled device.

Conclusions: This survey suggests that consideration should be given to the installation of a simple foot-controlled device to cover public squatting toilets to help restrict potential COVID-19 contamination and to meet hygienic expectations of the public.

1. Background

The COVID-19 pandemic demanded an urgent response from healthcare systems worldwide, challenging the management of patients with this novel disease and the adequacy of health service provision. In the early phase of the outbreak, strategies which limited the spread of the virus were fundamental considerations, together with the logistical provision of personal protective equipment, diagnostic kits and mechanical ventilators [1]. SARS-CoV-2 is the virus responsible for COVID-19, and the main routes of transmission of this virus are through infected respiratory droplets and close contact with an infected individual [2]. About 2 to 10% of patients with confirmed COVID-19 presented with diarrhoea [3-5] and COVID-19 viral RNA fragments were detected in faecal waste from patients with COVID-19 [6,7]. Appropriate management of excreta and wastewater disposal in sewerage systems is considered essential to public health policy [8]. Squatting toilets are common in Asian countries, and a squatting posture has been shown to widen the anorectal angle and facilitate defaecation [9]. However, use of a squatting toilet may be a concern if the toilet is left uncovered. Up to 145,000 droplets can be generated per flush [10] and microorganisms can be entrained into 'droplet nuclei toilet plume aerosols' and remain viable for extended periods while airborne [11]. The toilet flush is an 'aerosol generating procedure' and without a cover there is a potential risk of viral contamination of the user.

All health professions have a role in promulgating disease prevention strategies to the general public. To engage physical therapy students with an awareness of their role in public health education, program directors of physical therapy programs in China initiated a student-innovative project competition entitled "Stop viral contamination-cover the toilet". This campaign invited physical therapy students to design a toilet-lid that could be installed at low cost in public toilets. Students were required to produce a concept design that considered practicality, cost, maintenance and method of sanitisation, supported by a business proposal aimed at persuading leaders in

education and healthcare to upgrade public toilet facilities. Understanding a consumer's perspective is an important consideration for every successful business. In healthcare, understanding public concerns influences public adherence to advice and practice of public health care principles. One of the toilet cover proposals included a survey of community observations of public toilet facilities. Information gathered from this survey may contribute to future design perspectives for squatting public toilets. This article describes the findings of this survey of public toilet use in China.

2. Method

Ethics approval was sought prior to the launch of an online survey on views of the general public on their use of public toilet facilities in China. As this was an online survey, replies from participants were voluntary and implied consent to participate in the survey. Formal ethics application was waived by the ethics committee of the Shanghai University of Sport.

Design of the questionnaire

A 16-question questionnaire was designed by the investigators (PL, CSL, GYS, DYX, WXD) to determine whether the potential to spread COVID-19 in public squatting toilets was of concern to the general public. The preference for squatting or sitting type of toilet, hand-controlled or foot-controlled toilet cover, and flushing mechanism were sought. The questions were posted on the 'WeChat' contact groups of the investigators. The WeChat platform is a mobile communication APP extensively used in China. Friends and relatives of the investigators were invited by phone messages to complete the survey on the WeChat platform. Return of a completed questionnaire implied consent to participate in the survey. Descriptive data from completed questionnaires were analysed.

3. Results

A total of 134 participants (39 males and 95 females) completed the online questionnaire from 16 provinces and 3 municipalities (similar administrative status as provinces). The majority of the participants (95%) were in the age group 18-45 years (yr.), 4 aged between 45-65 and 3 over 65 yr. Results showed that 91% of the participants preferred a squatting toilet, and that 72% of the participants worried about personal contamination by water splash during toilet use. Sixty-three percent reported encountered a splashing incidence during toilet use and a similar percentage preferred the toilet to have a cover. Ninety-three percent of participants would like flushing conditions in public toilets improved, and over 83% preferred a foot-controlled device to cover the toilet or minimise water extrusion. Responses to the 16 questions are displayed in the Table.

4. Discussion

This is the first survey which explores the general view of toilet use in China and a preference for a squatting or seated arrangement, and whether there was any apprehension of contamination via splashing of toilet water. This report addresses an important public health concern, particularly during the COVID-19 pandemic. SARS-CoV-2, a virus responsible for COVID-19 and is transmitted via infected respiratory droplets [2] but also may be transmitted via faecal-oral route [5]. The majority of public toilets in China are of the uncovered squatting type.

Toilet flushing is potentially an 'aerosol generating procedure'. Johnson and colleagues reported about 145,000 droplets per flush in high-energy flushometer toilets, and 95% of droplets were <2 m in diameter and [10]. SARS-CoV-2 aerosol droplets found in hospitals in Wuhan were reported as 0.25-1 m in diameter [12]. The toilets used in Johnson et al's study were seated and quite possibly the water flow was higher than that in squatting toilets in China. However, over 63% of the participants in our survey encountered an incidence of splashing during toilet flushing. Clearly, flushing an uncovered toilet poses a risk of viral spread to the user. This survey showed while a third of the participants considered the hygienic condition of public toilets satisfactory, many would prefer the flushing conditions to be improved. While only about half of the participants considered they were worried public toilet hygiene during the COVID-19 pandemic, 72% of them admitted they were worried about personal contamination and all participants were willing to spend extra waiting time for any necessary sanitization procedure. If an improved sanitizing procedure were in place which required extra time for the cleaning process, the majority of our survey participants expressed a willingness to spend an extra 30 seconds, and some even more than 5 minutes waiting for the sanitizing process.

Upgrading public toilets in China is a considerable task because almost all public hospitals, schools, universities and the majority of commercial buildings have squatting public toilets without covers. In 2019, there are 147,466 independent and movable public toilets [13], these figures do not include public toilets in hospitals, schools, universities, or commercial malls. In 2019, the Chinese government allocated 7 billion RMB in upgrading rural toilet facilities [14]. The Chinese government actively supported the concept of a 'Toilet Revolution' originally proposed by UNICEF in 1997 [15]. China is a major industrialised country and most probably has the largest squatting toilet market in the world [15]. Squatting toilets with covers are available in some commercial malls in major cities, however most of these covers are hand controlled (Figure A1) and cleaning and disinfection procedures need further refining. Figure A2 shows an integrated toilet with a foot-controlled lid, but currently only available for domestic use. Designing covers for a large number of public toilets must obviously take into consideration production costs. Rather than a sophisticated device, simple step-to-open and step-to-close mechanisms might be considered. Factors that affect the ease of cleaning and disinfection are also essential considerations and must be carefully contemplated in a pandemic. Investment in effective public health disease prevention strategies in a pandemic is easily offset by a reduced healthcare spending treating people infected by COVID-19. The risk of splashing must be eliminated, and the manoeuvre for operation of the cover should be foot-controlled, to avoid direct physical contact of the toilet.

This survey reveals that 91% of the participants prefer a squatting toilet compared to a sitting one. Although a sitting toilet may be more convenient, a squatting toilet has some advantages over a seated toilet. Firstly, no physical contact with a squatting toilet is necessary. Secondly, the squatting position facilitates relaxation of the muscles around the anal canal and widens the anorectal angle to allow a straighter passage for defaecation [9]. This theory led to the use of a 'Defecation Posture Modification Device' (DPMD) with the seating type of toilet. The DPMD brings the hips and knees in a pseudo-squatting position thus facilitates relaxation of the pelvic floor muscles during defecation [16]. It was also reported that the squatting action during use of squatting toilets improved blood flow velocity in the lower extremities [17], and the user is subjected to squatting, as a form of exercise for strengthening of the quadriceps muscles. Quadriceps strength is associated with a lower cardiovascular mortality in patients with coronary artery disease [18]. However, not everyone can squat [19, 20], especially those with restricted lower limb joint mobility and older people with poor balance and muscle weakness.

Irrespective of the type of toilet, limiting toilet flush water splash may reduce oral-faecal contamination and save on sanitation costs. The current COVID-19 pandemic provides opportunities for strengthening public health

systems globally, and it is time to consider long term optimal environmental plans beyond disaster response [21].

There are several limitations in this survey. Our questionnaire did not explore why our participants favored squatting toilets. It is therefore not clear whether squatting toilets were preferred on a cultural or a zero physical contact hygienic basis. Further, while we inquired about an improved sanitizing process, we did not explore whether our participants were willing to pay for a higher level of sanitization. Understanding the level of commitment of the general public help with the planning and future design of public toilets. Lastly, our sample size was relatively small and not randomised, nonetheless the results provide useful information for improvement of public toilets in China.

5. Conclusions

This survey showed that the general public cohort questioned in China preferred a squatting to seated type of public toilet. The majority of people had encountered splashing of toilet flush water and many were worried about personal contamination through this process. The majority of the participants hoped for improved public toilet cleanliness and were willing to spend more time to trade for an improved toilet sanitizing process associated with use of the public toilet. This survey suggests that consideration should be given to the installation of a simple foot-controlled device to cover public squatting toilets to help restrict potential COVID-19 contamination.

Declarations

Ethics approval and consent to participate:

Not applicable.

Consent for publication:

Not applicable.

Availability of data and materials:

All data generated or analysed during this study are included in this published article and its supplementary information files.

Competing interests:

All authors read and approved the final manuscript.

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Authors' contributions:

All authors have read and approved the manuscript. The specific contribution of each author is as follows: AYMJ, JH, LP, SLC, YSG, YXD, XDW conceptualize the study question and design. AYMJ, JH, LP designed the questionnaire. LP, SLC, YSG, YXD, XDW, AYMJ participated data collection, data analysis, data interpretation, and preparing the first draft of the manuscript. AYMJ, JH reviewed and advised on analyses and interpretation of data. JH, LP edited successive versions of the article.

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References

1. Coronavirus disease 2019 strategy and planning. Geneva: World Health Organization; 2020. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/strategies-and-plans>. Accessed 1 July 2020.
2. Coronavirus disease (COVID-19) advice for the public. Geneva: World Health Organization; 2020. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public>. Accessed 1 July 2020.
3. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*. 2020;395:497–506. doi: 10.1016/S0140-6736(20)30183-5.
4. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, et al. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*. 2020;395:507–13. doi: 10.1016/S0140-6736(20)30211-7.
5. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus-infected pneumonia in Wuhan, China. *JAMA*. 2020. Feb 7. doi: 10.1001/jama.2020.1585.
6. Xiao E, Tang M, Zheng Y, Li C, He J, Hong H, et al. Evidence for gastrointestinal infection of SARS-CoV. *medRxiv*. doi: 10.1101/2020.02.17.20023721.
7. Holshue ML, DeBolt C, Lindquist S, Lofy KH, Wiesman J, Bruce H et al. for the Washington State 2019-nCoV Case Investigation Team. First case of 2019 novel coronavirus in the United States. *N Engl J Med*. 2020. Jan 31. doi: 10.1056/NEJMoa2001191.
8. Coronavirus disease (COVID-19) Technical guidance publications. Geneva: World Health Organization; 2020. Water, sanitation, hygiene and waste management for the COVID-19 virus. Technical brief. 2020. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/infection-prevention-and-control>. Accessed 1 July 2020.
9. Sakakibara R, Tsunoyama K, Hosoi H, et al. Influence of body position on defecation in humans. *Low Urin Tract Symptoms*. 2010; 2:16-21. doi: 10.1111/j.1757-5672.2009.00057.x
10. Johnson D, Lynch R, Marshall C, Mead K, Hirst D. Aerosol generation by modern flush toilets. *Aerosol Sci Technol*. 2013; 47(9):1047-1057. doi: 10.1080/02786826.2013.814911

11. Barker J, and Jones MV. The potential spread of infection caused by aerosol contamination of surfaces after flushing a domestic toilet. *J. Appl. Microbiol.* 2005; 99:339-347. doi: 10.1111/j.1365-2672.2005.02610.x
12. Liu Y, Ning Z, Chen Y, Guo M, Liu Y, Gali NK, Sun L, Duan Y, Cai J, Westerdahl D et al. Aerodynamic analysis of SARS-CoV-2 in two Wuhan hospitals. *Nature.* 2020; 582(7813): 557-561. doi: 10.1038/s41586-020-2271-3.
13. National Bureau of Statistics of the People's Republic of China. *China Statistical Yearbook*[M]. Beijing: China Statistics Press, 2019.
14. The state council of the People's Republic of China. China to hold contest for technology innovation amid toilet revolution. *English.Gov.CN.* 2019.
http://english.www.gov.cn/statecouncil/ministries/201908/15/content_WS5d556392c6d0c6695ff7ec35.html. Accessed on 22 July 2020.
15. Cheng S, Li Z, Udden SMN, Mang HP, Zhou X, Zhang J, Zheng L, Zhang L. Toilet revolution in China. *J Environ Manage.* 2018;216:347-356. doi: 10.1016/j.jenvman.2017.09.043.
16. Modi RM, Hiton A, Pinkhas D, Groce R, Meyer MM, Balasubramanian G, Levin E, Stanich PP. Implementation of a defecation posture modification device: Impact on bowel movement patterns in healthy subjects. *J Clin Gastroenterol.* 2019. 53(3):216-219. doi: 10.1097/MCG.0000000000001143.
17. Eom JH, Chung SH, Shim JH. The effects of squat exercises in postures for toilet use on blood flow velocity of the leg vein. *J Phys Ther Sci.* 2014; 26; 1485-1487. doi: 10.1589/jpts.26.1485
18. Kamiya K, Masuda T, Tanaka S, Hamazaki N, Matsue Y, Mezzani A, Matsuzawa R, Nozaki K, Maekawa E, Noda C, et al. Quadriceps strength as a predictor of mortality in coronary artery disease. *Am J Med.* 2015; 128(11):1212-1219. doi: 10.1016/j.amjmed.2015.06.035
19. Kasuyama T, Sakamoto M, Nakazawa R. Ankle joint dorsiflexion measurement using the deep squatting posture. *J Phys Ther Sci.* 2009; 21:195-199.
20. Zelle J, Barink M, Loeffen R, De Waal Malefijt M, Verdonchot N. Thigh-calf contact force measurements in deep knee flexion. *Clin Biomech (Bristol, Avon).* 2007;22(7):821-826. doi: 10.1016/j.clinbiomech.2007.03.009
21. Corburn J, Vlahov D, Mberu B, et al. Slum Health: Arresting COVID-19 and Improving Well-Being in Urban Informal Settlements. *J Urban Health.* 2020;97(3):348-357. doi: 10.1007/s11524-020-00438-6

Tables

Table. Questions and responses of the 134 participants. Data as number (%).

| | | 1 | 2 | 3 | 4 | 5 |
|----|--|--------------|--------------|--------------|------------|-----------|
| 1 | Are you worried about public toilet hygiene because of the recent COVID disease? 1= worried 2=not particularly 3=not worried | 72 (53.7) | 46 (34.3) | 16 (11.9) | | |
| 2 | During the COVID period, are you satisfied with the condition of public toilets in hospitals? 1=satisfied 2= not sure 3=not satisfied | 39 (29.1) | 81 (60.4) | 14 (10.4) | | |
| 3 | During the COVID period, are you satisfied with the condition of public toilets in commercial complexes and public entertainment areas? 1=satisfied 2= not sure 3=not satisfied | 41 (30.6) | 74 (55.2) | 19 (14.2) | | |
| 4 | Do you prefer squatting toilets or sit-down toilets in public places? 1= squatting toilet 2= no preference 3= sitting toilet | 122 (91) | 11 (8) | 1 (1) | | |
| 5 | Are you satisfied with the current hygienic condition of public 'squatting' toilets? 1=satisfied 2= not sure 3=not satisfied | 41 (30.6) | 57 (42.5) | 36 (26.9) | | |
| 6 | Are you satisfied with the convenience of use of current public squatting toilets? 1=satisfied 2= neutral 3=not satisfied | 61 (45.5) | 50 (37.3) | 23 (17.2) | | |
| 7 | During the use of public squatting toilets, did you encounter any incidence of water splashing? 1= Yes 2= do not remember 3=No | 85 (63.4) | 18 (13.4) | 31 (23.1) | | |
| 8 | When using public squatting toilets, were you worried about personal contamination by water splashing? 1= yes worried 2= not really 3= not worried | 97 (72) | 29 (22) | 8 (6) | | |
| 9 | Do you wish public toilets had some type of cover to improve the level of cleanliness? 1=yes 2=no strong view 3= no | 83 (62) | 31 (23) | 20 (15) | | |
| 10 | If more time is necessary for proper sanitization of public toilets, how long would you be prepared to wait? 1=<5sec 2= up to 10sec 3=up to 20 sec 4=up to 30 sec 5=others | 13 (10) | 27 (20) | 23 (17) | 59 (44) | 12 (9) |
| 11 | If a foot or hand-controlled device was installed to improve sanitization, would you be willing to use it? 1= yes 2= not sure 3= no | 117 (87) | 12 (9) | 5 (4) | | |
| 12 | Would you prefer the sanitization device be hand-controlled or foot-controlled? 1= foot controlled 2=either 3=hand-controlled | 107 (83) | 17 (13) | 5 (4) | | |

| | | | | | | |
|----|---|--------------|--------------|-------------|------------|------------|
| 13 | Do you wish the water flushing condition in public toilets can be improved? 1=yes 2=no sure 3=no | 125 (93) | 8 (6) | 1 (1) | | |
| 14 | If a foot or hand-controlled device was installed to reduce water splashing, would you be willing to use it? 1= yes 2= not sure 3= no | 120 (90) | 11 (8) | 3 (2) | | |
| 15 | Would you prefer this device to be foot-controlled or hand controlled? 1=foot-controlled 2= either 3=hand-controlled | 110 (83) | 16 (12) | 7 (5) | | |
| 16 | What is your first-choice mechanism for toilet flushing? automatic flushing foot-controlled flushing press- button turn button pull string | 73 (54.5) | 45 (33.6) | 13 (9.7) | 2 (1.5) | 1 (0.7) |

Figures



Figure 1

This Multigrid hand-controlled toilet cover to prevent objects dropping into the toilet when not in use



Figure 2

This Multigrid hand-controlled toilet cover to prevent objects dropping into the toilet when not in use

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Questionnaireontheuseofdifferenttypeoftoilets.docx](#)