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# Evaluation of a smart toilet in an emergency camp

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ABSTRACT

An experimental prototype of the eSOS (emergency Sanitation Operation System) Smart Toilet® was evaluated in an emergency settlement in the Philippines. The toilet was equipped with sensors and information communication technologies (ICT) for an efficient operation in an emergency setting. The field testing aimed at evaluating the toilet's service capacity related to the user frequency/intensity obtaining insight on the usage patterns in an actual post emergency situation. In addition, the novel features and functionality of the toilet were assessed. Operational performance of the toilet was assessed based on data collected from nearly 700 users within a 7-weeks period. The eSOS Smart Toilet has been properly operating during the evaluation period. A methodology to distinguish defecation and urination activities was developed based on determining discharges to faeces and urine tank. The toilet achieved up to 97% savings on water consumption compared to conventional toilets. The application of sensors and ICT features, combined with manually obtained data informed comprehensive usages data e.g. 62% of identified users were female users, 40% children, and 60% of the visits were for urination and 40% and for defecation. The accumulation of urine, faeces and grey water was measured to allow for a responsive maintenance resulting in optimized operation and increased interest to use the toilet. The field evaluation generated ideas for further improvements in terms of cost savings, services, and an overall vision for sustainability.

## 1. Introduction

People living in refugee camps are susceptible to displacement-associated diseases such as diarrhoea causing high morbidity and mortality rates [1–3]. Diarrheal diseases are transmitted predominantly through the faecal-oral route. Safe excreta handling, sufficient clean water supply, and proper hygiene practices are measures that need to be provided to intercept the transmission routes. Moreover, the sanitation provision at the emergency camps, being mostly on-site systems, needs to deal with the entire sanitation service chain including containment/collection (i.e. toilet/latrine facilities), conveyance (sewerage and desludging/transportation devices for non-sewered areas), treatment, and final disposal or reuse [4].

Servicing and maintaining onsite sanitation infrastructure is challenging, even for non-emergency situations, due to technical difficulties and under investments [5]. Digging toilet pits in an emergency camp can be difficult or practically impossible due to rocky soil and risk of flooding. Limited technical options suitable for the proper provision of sanitation under such challenging conditions call for innovations [6–8]. An example of such an innovation is the raised latrine using chemical or container toilets [6,9]. These raised latrines are usually waterless with different servicing and maintenance requirements compared to water-based toilets that use septic-tanks for storage of faecal sludge.

Several innovative container-based sanitation (CBS) toilets have been recently evaluated such as the MobiSan® and Uniloo® toilets [10–13]. These evaluations lead to a conclusion that more information on the usage pattern of these toilets is needed to make the required servicing frequency more effective and efficient, as the limited storage capacity of the containers demands a continued provision of emptying services. An improved operation and maintenance would likely lead to an increased number of users and revenues, and will reduce environmental, public health and social issues. Programs aiming at increasing sanitation coverage through the provision of latrines usually report on the number of facilities constructed; however, they fail to evaluate the usage and performance of the provided sanitation alternative with a proper accuracy and sensitivity [14,15]. Often, newly installed latrines

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