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Novel Design for Door Handle—A Potential Technology to Reduce Hand Contamination in the COVID-19 Pandemic

Coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in Wuhan, China in late 2019 and has become a global pandemic.[1] Human-to-human transmission of SARS-CoV-2 is facilitated by droplets, contaminated hands, or surfaces of various materials.[2] Environmental contamination by patients with SARS-CoV-2 has been suggested as a likely medium of transmission.[3] One recent study demonstrated that SARS-CoV-2 may remain viable and infectious on surfaces for days, reminiscent of the nosocomial spread and fomite transmission of SARS-CoV-1.[4] Besides viruses, hospital environmental surfaces may easily be contaminated by multidrug-resistant organisms.[5] Therefore, environmental surfaces in hospital settings may act as vectors for the transmission of viruses and multidrug-resistant organisms responsible for nosocomial infections.[5] Both health care providers and the work environment may serve as vectors for disease transmission by viruses and multidrug-resistant organisms among patients.[5]

Door handles in hospital wards are surfaces that are frequently touched by health care providers and ancillary personnel. A previous study suggested that surface bioburden was associated with the frequency of hand contact by health care staff and visitors.[6] Reducing bacterial transmission via hands and the frequently touched door handles may reduce the risk of health care-associated infections.[6] The use of automatic doors may be a solution to decrease the spread of microorganisms acquired from door handles, but it is not feasible in most hospitals. A recent study attempting to address this issue focused on improving the design of door handles.[7] Here, we present a novel device to augment existing door handles with the goal to avoid direct contact by hand, reducing the spread of microorganisms via health care workers.

Our device to avoid disease transmission is a simple accessory to the standard door handles at our hospital (Figure). It creates an extension that allows passersby to pull the door open with their forearms instead of their hands. We chose to design a door extension so the door can be operated by a person's forearm based on 3 considerations. First, people usually use their hands to grab the door handles, so we wanted a device that can be operated by a body part as close to the hand as possible. Second, people rarely use their forearms to touch their mouths, noses, and eyes, so the forearm is an excellent body part to operate doors without posing additional disease-transmitting risks. Third, it is safe for users to use this device.

The production of this device was a multidisciplinary team effort. Surgeons provided their direct insights based on their infection control strategies in the operating room. Engineers at the 3D Printing and Design Center of our hospital supported the technical aspects of materializing the design concept. The product was designed by using SolidWorks (Waltham, MA) and Autodesk® Fusion 360™ (San Rafael, CA). Prior to putting the design into production, fine element analysis was completed to ensure that the structure could sustain mechanical forces from repeated use. The computer-aided design files were then saved in the stereolithography (.stl) format for additive manufacturing (D-force, Kaohsiung, Taiwan). Additive manufacturing technology not only allows our team to produce prototypes rapidly and accelerates design iteration, but it also enables small-volume manufacturing in a short period of time at a low cost. As for the material, polylactic acid was chosen for its low cost, readily available supply, and durability.

At our hospital, enhanced infection control measures were implemented in January 2020 soon after reports of COVID-19 transmission emerged in China. We evaluated residual contaminant levels on the door handle in a medical ward 5 minutes and 3 hours after routine cleaning by using

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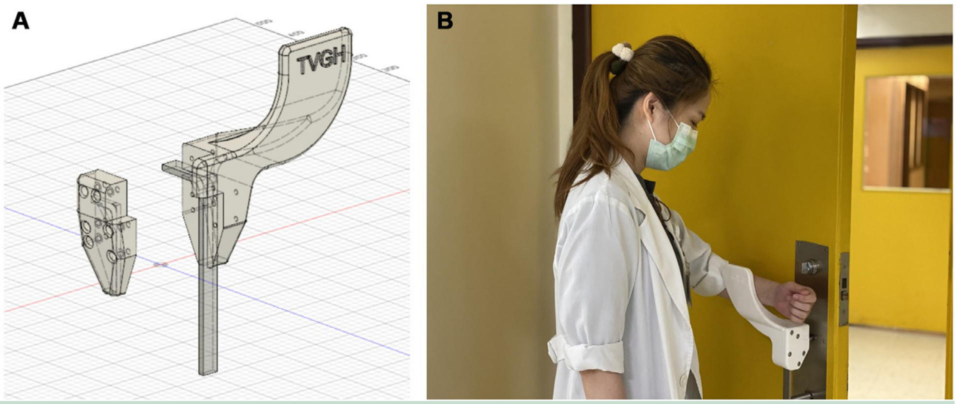

Figure **(A)** The design of this novel device. **(B)** An image demonstrating how to operate the door by using the door extension device.

the adenosine triphosphate (ATP) bioluminescence test. An ATP bioluminescence value <150 was defined as clean. We found a significant increase in ATP readings on the door handle 3 hours after routine cleaning, compared with readings obtained 5 minutes after cleaning (18.3 ± 8.4 vs 1188.3 ± 72.6, *P* = .001). Aerobic colony counts in sheep blood agar plate from the hands of health care workers (n = 10) also increased significantly after touching the door handles (18.9 ± 24.0 prior to touching, vs 28.6 ± 37.9 after touching, *P* = .018). After installing the novel extension device on the door handles, we found similar ATP readings on the surface of the extension device 5 minutes and 3 hours after routine cleaning. Consistently, aerobic colony counts from hands of health care workers (n = 10) were similar prior to and after operating the door.

In conclusion, the novel door handle extension device reported here is a feasible approach to reduce hand contact with environmental surfaces and disease transmission in hospital settings, which is critically important during the COVID-19 pandemic.

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