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# Hand Hygiene Practices in Public Restrooms: Effects and Proposed Solutions

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## Abstract

Human safety is a popular ongoing research area in personal hygiene. Researchers are mostly apprehensive about how to protect humans from different hazards in the environment. Thus, guidelines developed for good hand wash practices in the public restrooms have showed little or no impact on human behavior. This research examined hand wash acts in the public restrooms and proposed possible solutions to improve the practice. There are 427 people who participated in the study. Participant age ranged from 18 years old and upward: statistically, female, 63%; male, 35%; and unidentified, 2%. Descriptive statistics revealed 99.5% respondents approved restroom redesign for appropriate hand hygiene practice, while 49% suggested restroom device automation. Inferential statistics results on redesign with a Welsh t-test were statistically significant ( $t=1.967$ ,  $df=300$ ,  $p<0.0001$ ;  $t=1.990$ ,  $df=80$ ,  $p<0.0001$ ;  $t=1.9746$ ,  $df=163$ ,  $p<0.0001$ ). Findings showed that hand hygiene guidelines and recommendations are insufficient to ensure proper promotion of hand wash practices in restrooms. This study concluded that good hand wash practices in public restrooms could be ergonomically redesigned to include a visual and auditory alert that reminds users to wash their hands after restroom usage and to include hand wash practice in school curriculum. The findings from this study could be applicable in restaurants, schools, and bars, to manage and control transmission of disease through direct hands contacted with infectious diseases in the restrooms.

**Keywords:** hygiene, human health, restroom, handwashing, ergonomics

## 1. Introduction

Human hygiene is considered as one of the most effective ways of preventing diseases, and germs. Center for diseases control and prevention (CDC) associated many diseases and sicknesses to poor body hygiene [1, 2]. One key body part that requires constant and continuous hygiene to prevent human infection from germs and diseases is hands. In 2004, one of the US FDA studies revealed that food establishments were frequently out of compliance with the food code requirements for proper and adequate handwashing. In the study, the percentage of food

establishments observed to be out of compliance with handwashing requirements ranged from 34% in hospitals to 73% in full-service establishments [3]. Our world today faces alarming rates of diseases related to hygiene and the quick spread of germs via contact of improper hand hygiene. According to the CDC [4], it is established that keeping hands clean is one of the most important steps to avoid sickness and spreading of germs and diseases to others. Hand hygiene is the most effective measure for interrupting the transmission of microorganisms, which cause infection both in the community and in the healthcare setting. Therefore, using epidemiology model, transmission of diseases and germs through poor hand hygiene practices could be reduced in the society. The use of restrooms and other everyday activities regularly expose a human to germs; therefore, the need to explore other factors surrounding handwashing for hygiene purposes is essential.

The knowledge of handwashing as a measure of hand and personal hygiene is not new, as it has been successfully transferred from generations to generations. Handwashing has been linked to culture and religion, see Staub [5]. The United States of America officially recommended that healthcare workers (HCWs) should wash their hands with soap for 1–2 min before and after patient contact, see Coppage [6]. In 1975, CDC released handwashing guidelines and practice in the healthcare (hospitals) and later modified the original version in 1985 [7, 8]. Research has revealed that the revised CDC handwashing guideline has been expanded for better practice in all organizations [9–11].

While we can say training people on the handwashing routine is important and it has helped improving hand hygiene practice, the attention to hand hygiene in health and safety should go beyond educating people commonly known in the healthcare industry. According to Jang et al. [12], healthcare workers' workload, other job interruptions, and overly conservative guidelines make it difficult to adhere to hand hygiene. The same authors concluded that it is imperative to study other factors on proper handwashing practice to make handwashing hygiene a lifestyle other than a routine. The process of hand hygiene could be regarded as cumbersome and demanding for many people due to workload and other conditions like availability of toiletries, environmental and structural conditions. It is no doubt that many people know that hand hygiene what is the most effective measure to prevent microbial pathogen cross-transmission and other healthcare-associated infections but wasn't enough to get people to do it and practice the routine that leads to good handwashing practice. World Health Organization (WHO) reported that several continuous evaluations and good team methodologies have helped compliance but are yet to sustain in specific critical communities and healthcare areas [13]. The study further shows that mentoring aside other handwashing routines could be an excellent way to make hand hygiene a lifestyle.

Experts have proven that hand hygiene is the most effective measure for interrupting the transmission of microorganisms, which cause infection both in the community and in the healthcare setting. Using hand hygiene as a training measure of reducing disease is unlikely to be successful when other factors in infection control, such as environmental hygiene, crowding, staffing levels, and education, are inadequate. Therefore, the way people use restrooms and regularly exposed to germs in everyday activities makes it essential to explore other factors surrounding handwashing that could encourage hand and body hygiene in general.

The lack of appropriate infrastructure, religious beliefs, and workplace conditions were the major influencers on the low compliance to handwashing hygiene among the health professionals [14–16]. It is about time to start focusing on the influencers on low complaint rates.

## 1.1 Children hand hygiene

About 1.8 million children under the age of 5 die due to diarrhea and pneumonia every year [17]. Diarrhea and pneumonia are the top two killers among children all over the world [17]. The same study showed how handwashing is the most effective way to prevent people in the world from dying through diseases and much other life-threatening conditions from hand contamination. Handwashing with soap has a strong capability to protect and shield about one out of every three young children who get sick with diarrhea [18, 19], and practically one out of five young children with respiratory infections like pneumonia [19]. Another research shows handwashing in educational institutions and access to water and soap in schools could improve student health [20, 21]. Children's exposure to proper handwashing from early life might help to improve their development in some settings [22]. If hand washing could affect children around the world this much, then, proper handwashing should be included in all organization culture.

If hand hygiene can be included in daily human behavior, it automatically becomes a lifestyle and not just a routine, because humans can tire of routine with time, but a lifestyle is part of human behavior that cannot be easily broken. In 2005, Jumaa highlighted areas needed for further research on proper handwashing, which include environmental conditions, people acts etc. and further concluded that cultural and behavioral issues also contributed to the poor practice of hand hygiene. This study investigated other factors influencing public's poor handwashing habits, suggested better restroom designs, and provided recommendations for improvement.

### Objectives of the study

- Develop a questionnaire that captures public opinion on the use of public restrooms or school restrooms.
- Propose a better design structure based on survey feedback and design of prototype.
- Evaluate prototype from user perception.

## 2. Working methods

This study was conducted in a university environment. The university is in Hammond and Westville, Northwest Indiana US. Data were collected through survey. The survey was a self-developed questionnaire adapted from a standardized resource online. Survey was reviewed by three experts, two health practitioners, and one safety specialist to validate the contents for the purpose of the research. The questions were presented in the form of Likert scale options. The IRB office of the university where the study was conducted approved the protocol before survey distribution. The survey was distributed via email to all students, faculty, and all the university employees. Four hundred and twenty-seven (427) participants, including 246 students, 109 university employees, and 72 faculty, participated in the study. Participants include 147 males, 270 females, and 9 people who preferred not to indicate their gender. All the participants took the same survey with the same preferences given to all. The research was divided into three parts. The first part is the questionnaire, research on appropriate solutions and redesign for appropriateness. The survey questions focused on the toilet's settings, design, user habit, and toiletries availability.

3. Data analysis and results

3.1 Data analysis

Data compilation was done with the use of Excel® version 365 ProPlus. The use, cleanliness, structure, and factors that affect handwashing practices were evaluated using simple descriptive statistics and inferential statistics (Welch T-tests). Descriptive statistics was used to assess the differences in the proportions of participants reporting specific handwashing practices by gender. At the beginning of the analysis, the data were checked for normality. As expected, the percentage who had used the college restrooms one time or more was found to be 100% (out of which 35% were male, 64% female, and 2% preferred not to say). **Table 1** details the frequency distribution of the participants in percentage. Analysis shows that the percentage of those who used the restrooms always was the highest with 71% compared with those who sometimes or rarely used the restroom, that is, 14%.

The percentage of those who are comfortable using the school restroom was 44% based on different levels of comfortability while the percentage of those who are rarely or not comfortable is 34%. About 88% of the participants reported to always wash their hands after the use of restrooms. Approximately 99% agreed to have seen someone at some point walking out of the restroom without washing their hands, 85% strongly agreed that hand and body hygiene is paramount after the use of public and private restrooms. Furthermore, 72% strongly agreed that proper handwashing will prevent one from many diseases and sicknesses, 22% agreed to some degree while only 3% somewhat disagreed. In another question, participants were asked if they have received any form of hand hygiene training in the last 3 years. The responses show that 50% had received different forms of training in the last 3 years. The use of alcohol-based hand rub for hand hygiene also shows about 67% at different level of agreement.

Only 215 participants responded to the open-ended question, the responses showed 48.8% strongly suggested restroom redesign to improve hand hygiene and reduce germs transmission. Approximately 14% believe that automated hand-sanitizer machines should be installed in the restrooms. Further, only 3% of the participants responded that the inclusion of handwashing training as part of the school curriculum and regular cleaning of the university community restrooms would improve hygiene practices.

|          | Level               | Responses |
|----------|---------------------|-----------|
| Gender   | Male                | 35%       |
|          | Female              | 63%       |
|          | Prefer not to say   | 2%        |
| Category | Student             | 58%       |
|          | Faculty             | 17%       |
|          | University employee | 25%       |
| Age      | 18–25               | 40%       |
|          | 25–30               | 8%        |
|          | 30+                 | 52%       |

**Table 1.**  
*Participants percentage distribution.*



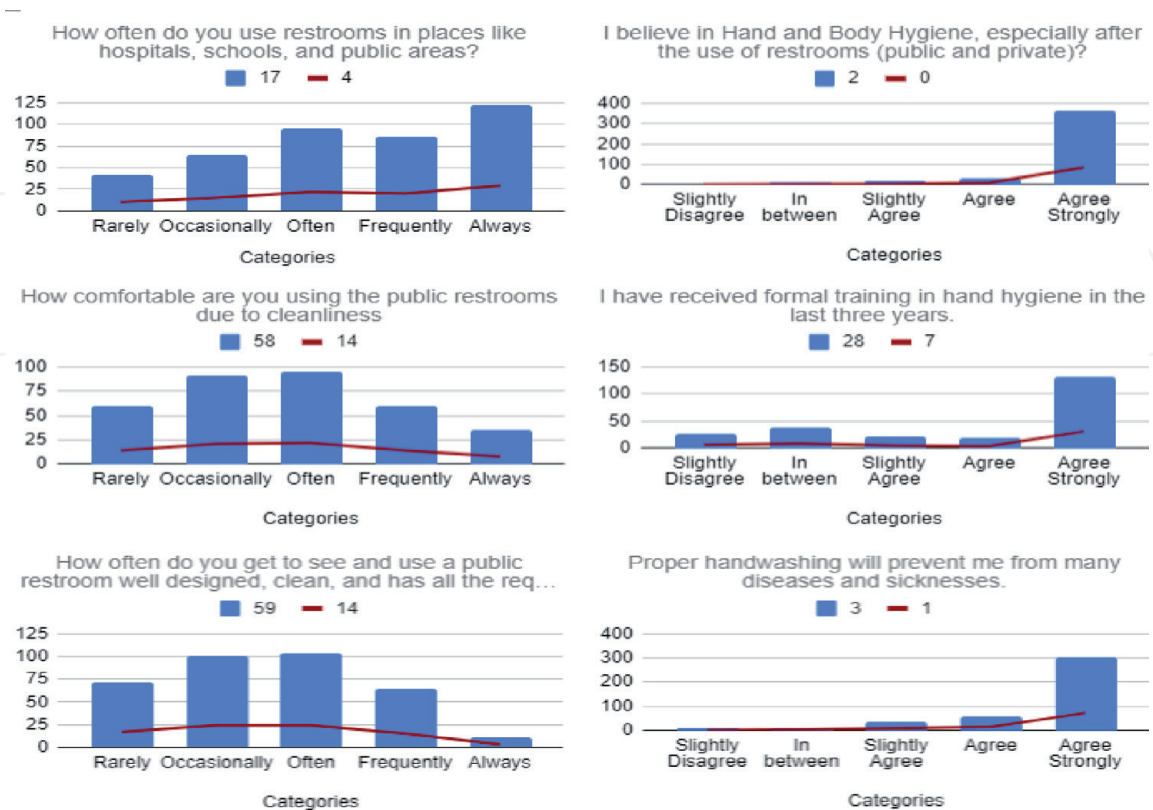
3.2 Results

Survey questions were divided into two categories, the first part focused on individual hand hygiene and the second part focused on restroom restructure or redesign for health safety purposes of the community. **Figure 1** is the graphical representation that shows the significances of some major factors that could potentially affect college restrooms and handwashing hygiene among college students:

The purpose of this study is to investigate factors influencing poor handwashing practices in the community, especially among the younger generation. These days, poor handwashing practices and inadequate body hygiene have been attributed to different illnesses around the world and have increasingly expanded the spreading of the present pandemic case called COVID-19. Therefore, the results of this study could be instrumental to promote good handwashing practices. Promotion of good handwashing will prevent viral infection and reduce exponential chances of spreading any illness outbreak. Handwashing hygiene should be taken beyond restrooms, but also to prevent viral infections, especially those that spread through droplets from coughs and sneezes. In this situation, proper handwashing is the first line of measure.

Four survey questions that specifically addressed restroom redesign and restructure were separately analyzed using descriptive and inferential statistics (Welch T-test). Participants' responses on the question "Do you think public restrooms should be structured and well designed for Heath safety?" were analyzed. The participants that neither agreed nor disagreed (in-between) were eliminated in order to define the significance of those that agreed or disagreed. The number of people in this category was found to be 10, constituting 2% of the total participants. Group 1 was considered people who disagreed and group 2 as people who agreed with restroom redesign.

**Table 2** shows that only two participants disagreed to the opinion that public restrooms on campus should be restructured and well redesigned for health safety



**Figure 1.**  
Graphical representations of survey responses.

of the users, while 416 agreed to the opinion that university community restrooms should be restructured and redesigned for health safety (**Table 3**).

Based on the descriptive analysis of the user’s opinion, it is concluded that restrooms should be redesigned for health safety. **Figure 2** reveals the relationship between the participants that agreed and disagreed that restrooms’ redesign would improve the health safety of the users.

Questions 3, 6, and 12 were analyzed using Welch t-test to further determine the significance of redesigning and restructuring university community restrooms for health safety. As shown in **Table 4**, participants’ response to question 3 reveals ( $t = 1.967903$ ,  $df = 300$ ;  $p < 0.0001$ ) to question 6 ( $t = 1.99006$ ,  $df = 80$ ;  $p < 0.0001$ ) and to question 12 ( $t = 1.97462$ ,  $df = 163$ ;  $p < 0.0001$ ).

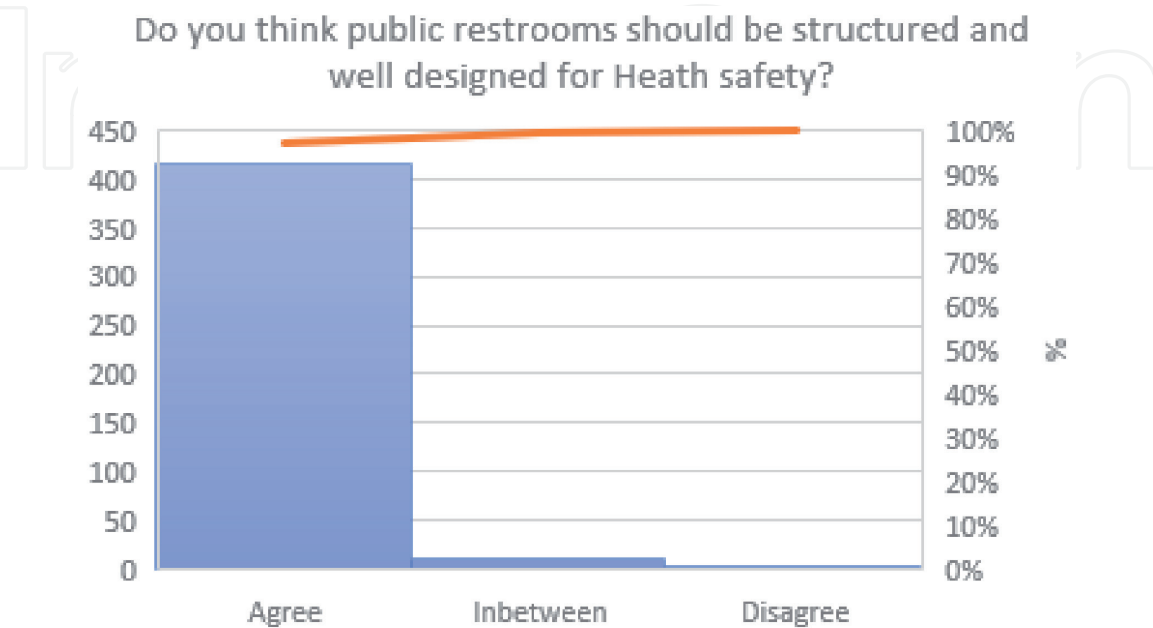
| Categories  | Participants’ answer |
|-------------|----------------------|
| Disagree    | 2                    |
| Neither nor | 9                    |
| Agree       | 416                  |
| Total       | 427                  |

**Table 2.**  
*Participants response to question 4.*

| Groups | Categories | Response | Percentage % |
|--------|------------|----------|--------------|
| G1     | Disagreed  | 2        | 0.5          |
| G2     | Agreed     | 416      | 99.5         |
| Total  |            | 418      |              |

*G1 = Group 1; G2 = Group 2.*

**Table 3.**  
*Participants’ response to question 4 in percentages.*



**Figure 2.**  
*Graphical representation of participants’ response to question 4.*

| Questions | Method | Variance | df  | t-value  | P(T<=t)  |
|-----------|--------|----------|-----|----------|----------|
| 3         | Welch  | Unequal  | 300 | 1.967903 | < 0.0001 |
| 6         | Welch  | Unequal  | 80  | 1.99006  | < 0.0001 |
| 12        | Welch  | Unequal  | 163 | 1.97462  | < 0.0001 |

**Table 4.**  
*Summary of the Welch unpaired T-test.*

#### 4. Findings

1. From the participant's opinions, visual and auditory alerts will be necessary for most of the public restrooms to enhance user's awareness of handwashing after use.
2. Redesign of most restrooms was another issue raised by the respondents if proper hygiene levels must be reached for safety purposes.
3. Automated handwashing devices like an automated sink with soap dispenser, auto sensor water, and hand sanitizer pump dispenser were also recommended to be made available.
4. A redesign of the restroom doors to be touchless (auto open and close) without touch or ergonomic design (i.e., pull to go in and push to exit) as the participants felt that touching might increase the chances of contacting germs.
5. A high percentage of the participants also believe that the current hand dryer is unhealthy, breeds germs, and is against proper hygiene and health safety.
6. Respondents also mention the inclusion of hygiene training into college's education curriculums in all levels of education.

Ergonomically redesign doors/restroom system was suggested in order to fit the operating process of the restroom to the users' capability. This could be perfect as stated in Fasanya and Shofoluwe's [23] finding that fitting job to worker capability improved worker performances.

##### 4.1 Redesigning option

After a careful review of the findings, it is decided that the inclusion of auditory and visual alert sensor in the **urinal bowl** area and **toilet compartment** will improve the handwashing practice.

###### 4.1.1 Operation process of sensor

The visual and auditory alerting signals will assist in reminding restroom users to wash their hands after use. Visual and auditory alerts have been known for being vital reminders of activity in different areas of life such as in traffic control (transportation industry). Visual and alert methods have also played important roles in many other situations relating to alerting and reminding users. It has been used in the airplane for almost everything possible, especially in alerting, reminding, and giving the passengers directions when needed. According Papastavrou and Lehto



[24], visual and auditory alerts help in the detection of anticipated stimuli. This study suggested for the design shown in **Figure 3** to ensure proper reliabilities and the alerts required for the safe use of the restrooms. The design is a computer-based script that senses restroom flush and gently nudges and reminds the users to wash their hands. The process involves the following.

4.1.2 Design processes

It involves designing a computer screen algorithm that will help to auto-sense sides. The machine design can be achieved by using C# combined with light and sound using sensor fusion with computer vision to sense flushing sound and press of restroom flushes. **Figure 3** also shows the sample of visual message that would be displayed on the screen.

This device is an auditory and visual alert device coded with C# and with a motion and sound sensor to sense either the motion or flush sound before displaying a message as shown in **Figure 3**.

The visual and auditory alert system design would be placed in two locations as shown in the **Figure 4**—the device with the “Message Area” caption here is a LED Message display board designed and computer coded for auditory and visual alert for the users at the sound of restroom flush. The device should be a computer coded



**Figure 3.**  
*Message display.*



**Figure 4.**  
*Restroom message display design.*

with the **passive infrared (PIR) sensor** to sense and detect body heat (**infrared energy**) and the most widely used motion sensor, at the sound of the flush. Pleasant messages are to be included in the alert to remind the users to wash their hands: messages like “Do you know handwashing hygiene increases health safety? Don’t forget to wash your hands? Washing Hands prevents from deadly diseases, etc.” The application that controls the device is suggested to be designed with C# and designed with LED message display board and passive infrared sensor. It is important for it to be both visual and auditory to accommodate visually or aurally challenged individuals.

## 4.2 Post analysis results

Findings from this study had led the university management to include in all restrooms hand soap dispensers and gradually work on how to restructure the rooms to be ergonomically fit for the users. From the management comments, less attention has been given to restroom designs of all things in the academic environment. Meanwhile, the outcome of this study has proved that less important things in management perspective might be a huge factor to promote health and safety of both students and the employees.

## 5. Discussions and conclusion

### 5.1 Discussions

Different studies have concluded that there are other factors affecting hand hygiene behavior. For example, Zimakoff et al. [25] concluded by identifying few other factors affecting hand hygiene such as skin irritation and dryness as the leading factors affecting handwashing in health care. The same authors affirmed that there are other possible factors not covered in the scope of the research. Likewise, in 1982, Larson and Killien concluded that it is imperative to identify factors that are the antecedents to whether the individual decides to wash one’s hands or not as they are critical in the prevention or intervention plans to improve handwashing practice. The same authors further ascertained that most emphases are placed on the importance of handwashing instead of other factors affecting people’s behavior toward handwashing compliance. The results of this study supported that there are other factors different from training people and showing people how to practice hygiene properly. Researchers are now focusing on the growing literature about the other factors affecting hand hygiene behavior.

Day by day, researchers are focusing on other factors that could affect hand hygiene behavior, none or few have looked into the structure and redesign of restrooms. This study investigated the people’s experience in the restroom, why handwashing compliance is low, and other factors, which could affect hand hygiene behavior. A significant proportion of the participants requested for restroom redesign for their health safety. A significant finding from this study is that about 83% of the participants suggested alert systems to remind restroom users to wash hands after use. The participants also reported the significance of other factors like an automated sink, soap dispenser, water dispenser, dryer devices as well as ergonomically designed doors. The participants unanimously believe that ergonomically designed door (pull and push type) would reduce touch and greatly enhance health safety. The above data results reflect restroom equipment, structure, cleanliness, and comfortability have significant effects on hand hygiene behavior. The results from this study supported other researchers who found that there are other factors

affecting hand hygiene behavior, rather than just training and those factors should be focused on in order to improve handwashing practices.

## 5.2 Conclusion

The handwashing procedure is a little monotonous, especially for healthcare professionals, and can be frustrating or become things of no interest when relevant factors are not available and very challenging in different ramifications. The low compliance of handwashing is a significant issue around the world as reported in several literatures. Appropriate handwashing practices can reduce the risk of foodborne illness and prevent transmission of viral infections, especially those that spread through droplets from coughs and sneezes. Besides, among many other hygiene practices, poor handwashing is the most common practice among the younger generation. The message and the information about handwashing or hand hygiene has been around for over 200 years, yet the level of compliance is low as revealed from this study. Thus, this study details another factor affecting handwashing hygiene after the use of public restrooms and suggests how hand hygiene could be improved in human daily behavior. The findings of this study revealed that restroom designs and structures have significant effects on hand hygiene behavior based on participant's opinions from the survey. Redesign to include visual and auditory alerts will be necessary for most of the public restrooms to enhance user's awareness for handwashing after use. Findings from this study suggest for a restroom redesign to include auto-sensor soap and water dispenser, dryers, and touchless doors. Findings further revealed that inclusion of hygiene training in all college's education curriculums at every level would encourage user's handwashing hygiene lifestyle and behavior. The findings from this study could help identify the design structures for ensuring more compliance with handwashing hygiene and health safety practice among the public. Further research is needed in this direction to investigate how other factors aside from the aforementioned could potentially discourage individuals from making hand hygiene a daily behavior.

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