Does a Water Flow Timer Improve Food Handler Hand Washing Practices in Food Service Establishments? The Effects of Passive and Indirect Interventions

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Abstract **Proper hand washing practices in food service establishments are important for the adequate reduction of microorganisms on hands. To address practical barriers associated with active and direct interventions, this study employed passive and indirect interventions to examine whether the simple use of a water flow timer and an informational poster could influence food handler hand washing practices. A within-group, multiple-intervention experiment including baseline, single intervention, multiple intervention, and withdrawal phases was conducted at a student-operated, full-service restaurant over 4 weeks. We recorded a total of 839 hand washing practices over 112 hr of observation using a motion-detecting camera. Findings showed that the presence of a water flow timer increased the duration of hand washing and the compliance rate to proper scrubbing duration. The effects were robust in the weeks when establishments were busy with high-customer volume. The findings provide useful data regarding the use of passive and indirect interventions to change food handler hand washing practices.**

Introduction

Numerous studies have reported the critical importance of proper hand washing in food service establishments to prevent foodborne disease outbreaks (Food and Drug Administration [FDA], 2017; Green et al., 2006, 2007; Todd, Greig, Bartleson, & Michaels, 2008). For example, poor personal hygiene was included as one of five risk factors that significantly contributes to foodborne illness in food service and retail food stores (FDA, 2010). Properly washing hands following the correct sequence and required duration is particularly important for reducing the number of microorganisms on hands (Centers for Disease Control and Prevention [CDC], 2018). Unfortunately, observations reveal that proper hand washing compliance is still problematic (e.g., only 24% compliance in full-service restaurants and 48% in delis) (FDA, 2010).

Food handler education is pivotal to improving hand washing but mounting evidence suggests that classical strategies of mere knowledge transfer through lectures and text-loaded materials are not sufficient to drive targeted behavior change (Evans & McCormack, 2008; Schroeder et al., 2016). Pellegrino and coauthors (2015) questioned why hand washing compliance is still minimal after decades of food service employee training and emphasized the role of motivational interventions in changing long-term behaviors. Similarly, Yu and coauthors (2018) argued that knowledge-based training itself could lead to inadequate results and showed the effectiveness of behavior-based training, including active weekly feedback and monetary reinforcement, in improving the hand washing practice of food handlers.

While interest is growing in active and direct types of intervention (i.e., behavioral based training that actively and directly educates managers or employees) (Viator, Blitstein, Brophy, & Fraser, 2015), it often requires intense efforts and operational resources and, consequently, might be impeded by barriers of cost, time, and labor. In other words, it might be costly for managers to monitor each food handler's hand washing practices in order to provide regular feedback and consistently reinforce it in day-to-day operations. Considering an extremely high food service workforce turnover rate that exceeds 70% and the dominance of part-time entry-level employees (National Restaurant Association, 2017), active training and reinforcement becomes more problematic because it must be repeated almost constantly for new employees.

Other methods employ relatively passive and indirect intervention strategies that change the environment or system to

increase access to proper hand washing (Pellegrino, Crandall, O'Bryan, & Seo, 2015; Viator et al., 2015). This approach targets more implicit and habitual behavior changes through supportive environments, such as increased accessibility to facilities and knowledge. For instance, the Food and Drug Administration (2010) recommends that "hand wash facilities [are] conveniently located and accessible for employees" and "hand wash facilities [are] supplied with hand cleaner/sanitary towels/hand drying devices" (p. 47). In support of passive and indirect intervention strategies, Green and coauthors (2007) found hand washing occurred significantly more often in restaurants with multiple hand sinks and when the sinks were in employee sight.

Purpose of the Study

The current study addressed whether passive and indirect interventions using a system change could improve food handler hand washing practices. The proper duration of hand washing is essential (CDC, 2018), so we used a water flow timer that can be attached to a faucet and displays the duration of water flow throughout the hand washing process. Further, based on the idea of the facilitating effect of multicomponent intervention strategies (Pellegrino et al., 2015; Viator et al., 2015), an informational poster emphasizing proper hand washing procedures and duration was added to see whether multiple passive and indirect interventions would lead to a synergistic effect. Thus, the presence of a timing device on a faucet and the poster attached above the faucet represented the passive and indirect interventions in this study. Lastly, literature showed that food handlers tend to pay less attention to proper hand washing during periods of high-customer volume (Green et al., 2007; Yu, Neal, Dawson, & Madera, 2018), so we also monitored the impact of customer volume on food handler hand washing practices.

Altogether, the research questions grounding this study were:

- Does the presence of a water flow timer improve food handler hand washing behavior?
- Does the presence of a water flow timer in conjunction with an informational poster improve food handler hand washing behavior?
- Does customer volume affect the impact of the interventions?

Methods

Site Selection and Sample

The experiment was conducted in an à la carte restaurant located at a large Midwestern university in the U.S. The restaurant serves as an open-to-the-public class designed to train hospitality management students in a real-world setting. Accordingly, subjects included approximately 70 sophomore and senior students and 9 nonstudent employees who included chefs, service instructors, and managers. The lunch hours were from 11:00 a.m.–1:00 p.m. Tuesday through Friday in order to serve university populations, local customers, and campus visitors. The hand sink used for the intervention was centrally located within the restaurant's kitchen and was the most frequently used of the six hand washing sinks. The sink was located near the dishwashing machine; therefore, it was frequently used by servers after clearing soiled dishes.

Design, Instruments, and Data Collection

A within-group, multiple-intervention experiment was conducted over the course of 4 weeks, from September 12–October 6, and included: 1) baseline phase, 2) single intervention phase using a water flow timer, 3) multiple intervention phase using a water flow timer and an informational poster, and 4) withdrawal phase. Food handlers work from 7:30 a.m.–2:30 p.m., so we collected the data within that time frame.

Data collection involved recording hand washing behaviors using a motion-detecting video camera (AUKEY DR-01 Dash Cam) that included a date and time stamp for recordings. The camera was installed above the sink with the lens directed at the faucet for all 4 weeks from the baseline week through the withdrawal week. Thus, the camera captured hand washing instances without person-identifiable information, such as the faces of food handlers (Figure 1). Although the camera was located above the sink, it was visible to individuals. In order to reduce potential Hawthorne effects (i.e., changes in behavior that occur as a result of the observation) from the installation of the camera (Clayton & Griffith, 2004), a short note was also posted close to the sink stating that the monitoring process was for a study on water usage and no personally identifiable data were being collected. Thus, in the baseline and withdrawal weeks, nothing else was added to the study sink other than the camera and the note about why the camera was installed.

FIGURE **1**

Sample Screenshot From Video Recording

For the first week, we collected baseline data documenting food handler hand washing practices without any intervention. During the second week, a water flow timer (SaniTimer) was installed on the faucet and data were collected. The device had a digital display face approximately 2 in. in diameter and enabled food handlers to observe a 30-s countdown on a display that begins when the water starts flowing and continues for a duration of 30 s. Thus, the water flow timer provided immediate, continuous, real-time, and individualized feedback to each food handler in terms of the length of time spent on hand washing.

For the third week, in addition to the water flow timer, we posted a poster in proximity to the sink and subsequent data were collected. The poster was designed to fit with the study intervention and 1) documented the proper 5-step hand washing procedure lasting 20–30 s in duration based on the ServSafe hand washing guidelines (National Restaurant Association Educational Foundation [NRAEF], 2017) and 2) encouraged individuals to use the timer to track the hand washing duration (Figure 2). For the final week, we removed the water flow timer and the poster, and data were collected to assess whether there was a residual effect from the interventions. Finally, we collected information on daily customer volumes based on cash register entries during the 4 weeks of the experiment.

Hand Washing Behavioral Measures

The video recordings were downloaded and coded for two quantitative and three qualitative measures. Quantitative measures were 1) hand washing frequencies per day and 2) duration per each hand washing instance. Qualitative measures included whether workers 1) scrubbed hands with soap for at least 10 s, 2) performed the 5-step hand washing sequence correctly, and 3) met both the required scrubbing duration and the 5-step sequence.

Quantitative measures: We documented the frequency of hand washing instances per day. Duration was measured in seconds beginning from when the food handler engaged in a hand washing step (such as wetting hands under running water or applying soap, whichever was performed first) until when the food handler turned off the faucet.

Qualitative measures: Based on the required duration of scrubbing behavior in ServSafe (10–15 s; NRAEF, 2017), we recorded hand washing instances as either 0 (scrubbing duration <10 s; incorrect scrubbing duration) or 1 (scrubbing duration ≥10 s; correct scrubbing duration). Similarly, based on the required 5-step sequence of hand washing in ServSafe: wetting under running water, applying soap, scrubbing, rinsing under running water, and drying (NRAEF, 2017), hand washing instances were recorded as 0 (incorrect sequence) or 1 (correct sequence). Lastly, using both criteria of proper scrubbing duration and proper sequence, hand washing instances that failed to meet one or both criteria were coded as 0 (incorrect hand washing), while hand washing instances meeting both were coded as 1 (correct hand washing).

FIGURE **2**

Informational Poster Used in the Intervention

Results

The 4-week period yielded 112 hr of observation during which 839 hand washing instances were observed (Table 1). Food handlers washed their hands an average of 52.4 times per day with an average duration of 13.8 s. Out of 839 hand washing instances, 9.3% met the criteria for proper scrubbing duration, 44.2% complied with the proper sequence of hand washing steps, and 7.4% correctly followed both criteria. The average daily customer volume was 46.3.

Quantitative Measures

Frequency of hand washing: Despite the variations in the frequencies of hand washing across intervention weeks (Table 1), results of a one-way analysis of variance (ANOVA) showed that the daily frequencies did not significantly differ across weeks ($F(3, 12) = 0.48$, $p = .70$).

Duration of hand washing: On the other hand, one-way ANOVA results showed that the duration of hand washing was significantly affected by the intervention ($F(3, 835) = 7.59$, $p < .001$) (Table 1, Figure 3). More specifically, pairwise comparison results with a Bonferroni adjustment method showed that after installing the water flow timer, the duration significantly increased compared with that of the baseline week (difference = 3.32, $SE = 0.92$, $p = .002$). While the duration further increased after adding the informational poster, the difference was not found to be significant (difference = 0.71, $SE = 0.95$, $p > .99$).

After removing both the timer and the poster, the duration significantly dropped (difference = -2.83, $SE = 0.97$, $p = .02$). In fact, the reduced duration of the withdrawal week was comparable to that of the baseline week (i.e., not significantly different from each other; difference = 1.20, $SE = 0.94$, $p > .99$), implying a reversion to baseline hand washing behavior.

Qualitative Measures

Compliance to proper scrubbing duration: Logistic regression results showed that, on average, the differences in the compliance rates involving proper scrubbing duration across the 4 weeks approached significance (Wald $\chi^2(3) = 6.38$, $p = .095$). In general, the compliance rates were greater when the timer was present and the poster was added than during the baseline or withdrawal weeks (Table 1).

Compliance to proper sequence: Overall, logistic regression results showed that the intervention across the 4 weeks did not significantly affect the compliance to proper sequence (Wald $\chi^2(3) = 5.09$, $p = .17$) (Table 1). The results also showed that, in comparison to the baseline week, however, the odds of compliance to the proper sequence after installing the water flow timer were 1.41 times greater with a marginal significance (Wald $\chi^2(1) = 3.14$, $p = .076$).

Compliance to proper scrubbing duration and sequence: Logistic regression results showed that the differences in compliance rates that include both proper scrubbing duration and proper sequence across the 4 weeks of the intervention trend-

TABLE **1**

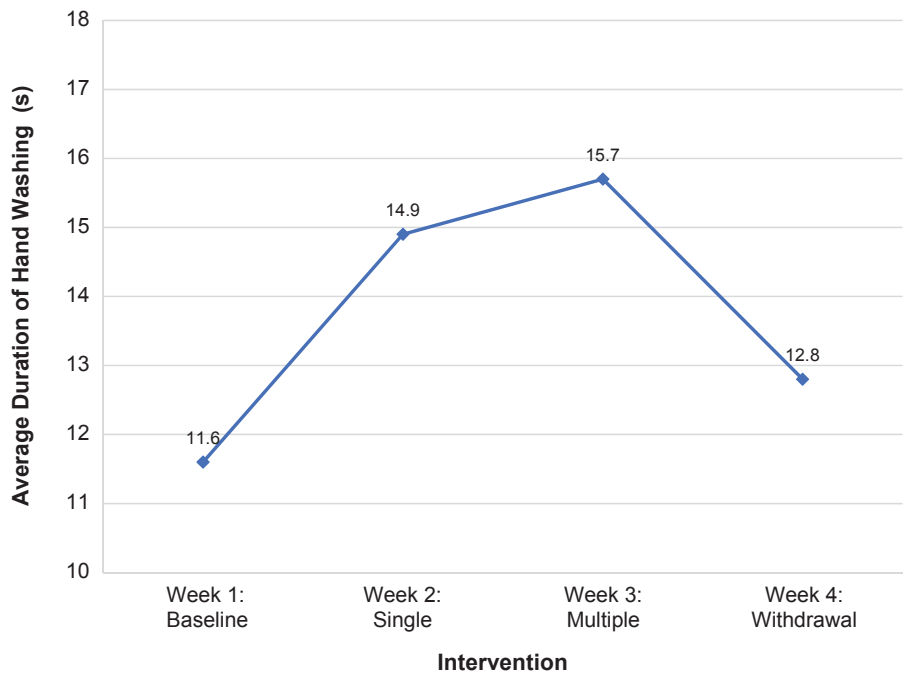
Descriptive Statistics of Hand Washing Behavioral Measures Across Intervention Weeks and Customer Volume

		Hand Washing Behavioral Measures					
Week	**Intervention**	**Frequency of Hand Washing (per day)**	**Mean Duration of Hand Washing in Seconds (*SD*)[a]**	**Frequency of Proper Scrubbing Duration (%)[b]**	**Frequency of Proper Sequence (%)**	**Frequency of Proper Scrubbing Duration and Sequence (%)[b]**	**Customer Volume (per day)**
1	Baseline	204 (51.0)	11.6 (8.7)	17 (8.3)	83 (40.7)	13 (6.4)	152 (38.0)
2	Single	234 (58.5)	14.9 (10.1)	28 (12.0)	115 (49.1)	25 (10.7)	244 (61.0)[c]
3	Multiple	186 (46.5)	15.7 (10.6)	21 (11.3)	74 (39.8)	15 (8.1)	187 (46.8)
4	Withdrawal	215 (53.8)	12.8 (9.1)	12 (5.6)	99 (46.0)	9 (4.2)	158 (39.5)

Note. Single = water flow timer; multiple = water flow timer and informational poster.
[a]$p < .001$.
[b]$p < .1$.
[c]One day of week 2 included a special banquet for 100 consumers. Without this day, the average daily volume of this week was 48.0.

FIGURE **3**

Effect of the Intervention on the Average Duration of Hand Washing Across 4 Weeks



ed towards significance (Wald $\chi^2(3) = 7.04$, p = .071). The compliance rate demonstrated the greatest increase after the water flow timer was installed, slightly dropped after adding the poster (still greater than that of the baseline week), then finally dropping to the lowest level in the withdrawal week (Table 1).

Relationships Between Hand Washing Duration and Compliance Measures

In order to further explore the relationships between hand washing duration and compliance with proper scrubbing duration, proper sequence, and both proper scrubbing duration and sequence, point-biserial correlation tests were conducted (Table 2). The results showed that hand washing duration and scrubbing hands for at least 10 s ($r_{pb} = .51$, $p < .001$), performing five hand washing steps in a correct order ($r_{pb} = .41$, $p < .001$), and performing the right sequence of five steps with scrubbing for at least 10 s at the same time ($r_{pb} = .45$, $p < .001$) were all significantly, positively, and strongly correlated.

The Impact of Customer Volume on Hand Washing Behavioral Measures

Customer volume fluctuated across the 4 weeks of the intervention (Table 1). During baseline and withdrawal weeks, the average daily volumes were lower than those in the single (i.e., water flow timer) and multiple intervention weeks (i.e., water flow timer and poster). Although one day in the single intervention week had a banquet with 100 customers (a number greater than the typical number of guests), the mean daily volume of the week after removing the banquet day from averaging was still the highest among all weeks.

Despite the highest customer volume, overall hand washing practices in terms of frequency, mean duration, compliance with

proper scrubbing duration, proper sequence, and both proper scrubbing duration and sequence criteria improved after installing the water flow timer compared with the baseline week (Table 1). Conversely, in the multiple intervention week, which saw the second-highest customer volume, a slight drop in the frequency of hand washing and compliance rates related to the proper scrubbing duration, the correct sequence, and following both requirements was observed. Still, the compliance rates for following the proper scrubbing duration as well as both requirements (proper scrubbing duration and sequence) during this week were higher than those of baseline and withdrawal weeks, which had the lowest customer volumes (Table 1), demonstrating a degree of robustness of the intervention effects against the high customer volume.

TABLE **2**

Point-Biserial Correlations Between Hand Washing Duration and Compliance Measures

	Compliance to Proper Scrubbing Duration	Compliance to Proper Sequence	Compliance to Proper Scrubbing Duration and Sequence
Hand washing duration	.51*	.41*	.45*

*$p < .001$.

Discussion and Conclusion

A water flow timer and an informational poster were used to assess the effect of a passive and indirect intervention on food handler hand washing practices. Findings provide several useful implications.

1. The findings showed that simply by installing a water flow timer, the duration of food handler hand washing practices significantly increased and successfully remained higher over the 2 weeks of greatest customer volume. These findings are particularly notable in that the intervention did not involve any active and direct training efforts that could be operationally difficult on a day-to-day basis. That is, food handler hand washing practices improved in the absence of direction, education, or training from managers pertaining to the installation, function, instruction, or benefits of the water flow timer in relation to hand washing practices—and thus showed practical advantages in this regard.

   Furthermore, considering the strong and positive correlations between the hand washing duration and the compliance to both proper scrubbing duration and sequence, these study results suggest that compliance to scrubbing duration or hand washing sequence are more likely to co-occur with the timer in place. On the other hand, the effects occurred only while the water flow timer was in place; hand washing behaviors reverted to baseline levels once the timer was removed. Therefore, the current passive and indirect intervention was found effective in improving hand washing practices, but only while the environmental change remained in place.
2. In terms of hand washing frequency, although the intervention did not significantly affect the overall frequencies across weeks, anecdotal evidence suggested that the installation of a water flow timer was interesting to the food handlers. During the video coding, it was observed that food handlers showed a curiosity about the water flow timer, frequently standing around, touching, watching, operating, and playing with the device. In fact, though not significant, the frequency of hand washing increased during the single intervention week when the water flow timer was installed in comparison with the baseline. As food handlers have been shown to be less likely to properly wash their hands during a busy serving period (Green et al., 2007; Yu et al., 2018), and the highest customer traffic occurred during the single intervention week, it is possible that the presence of a water flow timer could result in an increase in hand washing frequency in other contexts.
3. The effects of the passive and indirect intervention on hand washing compliance rates regarding proper scrubbing duration and proper sequence were found marginal. This result showed that, at least in this study, the effects of a water flow timer and the addition of an informational poster were largely limited to the increased hand washing duration. Also, it could be that some compliance behaviors, such as following the correct 5-step sequence, are more readily affected by an active and direct intervention. Future research might wish to consider the potential effect of combining a passive and indirect intervention such as a water flow timer with a more active and direct intervention to trigger a greater degree of hand washing compliance. For example, during the introduction stage, managers could directly explain the necessity and appropriate use of a water flow timer and actively encourage food handlers to use the timer to meet hand washing requirements.
4. Between the single and multiple intervention weeks, the posting of an informational poster in addition to a water flow timer did not contribute to improved hand washing. This finding could be attributed to the 1) negative impact of high customer volume on the third week, 2) potential adaptation to the water flow timer, or 3) none-to-weak effect of the simple informational poster. For example, it might be that the food handlers did not pay attention to the poster because they thought they already knew the procedure. Future intervention studies might be able to identify the most plausible reason and extend the understanding in different types and combinations of intervention methods.
5. It is notable that most of the observed noncompliance behavior to the proper hand washing procedures occurred by skipping the hand-wetting step before applying soap and not meeting the hand washing and scrubbing durations, which is consistent with a recent study from the U.S. Department of Agriculture (2018). Also, employees seemed to be under time pressure from "work speed," which caused them to not follow entire procedures completely (Green et al., 2007). While the optimal effective hand washing durations were set based on research (CDC, 2018), the evidence supporting the importance of a hand-wetting

step is not clear. In this regard, future studies could examine if it makes a significant difference to exclude the hand-wetting step before applying foam-type soap. The findings will help government agencies make a more evidence-based decision on improving protocols for hand washing, balancing safety and practice needs.

This study is not free from limitations. Although the camera was needed to anonymously monitor hand washing, it is possible that the installation of the camera close to the sink during the 4-week experiment could have had an impact on food handler hand washing behaviors. In addition, during the third week, a poster was placed near the sink that described appropriate hand washing, with details on the proper length of time needed for adequate hand washing. Although the poster was intended to convey information that also affected water usage (length of time), it is possible that the poster could have created a different perception about the purpose of the study. Future studies might wish to hide or disguise the camera from view to minimize a possible Hawthorne effect.

Also, while we showed the behavior change within a 4-week period, future longitudinal studies with additional experiment weeks will help verify more long-term outcomes of the intervention. For example, the effect might last due to the development of habitual behaviors of employees in response to continued feedback, or the effect might disappear due to an adaptation to the intervention. Lastly, this study tested the effect of a water flow timer on a manual faucet. As the effects might differ based on the type of faucet (e.g., automated faucets and pedal sinks), researchers can extend the literature by investigating these differences.

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