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Major Article

An observational study of handwashing compliance in a child care facility

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Background: Handwashing (HW) compliance, although an effective means of limiting childhood illness, remains low among personnel in early childhood centers (ECCs). Our study determined HW compliance and efficacy of ECC personnel.

Methods: Surveillance cameras were used to determine HW opportunities, compliance, occurrences, and effectiveness based on child-care oriented criteria.

Results: We observed 349 HW triggering events, with 14 events per hour; a median of 2 personnel (caregivers, paraprofessional aides, or parents) were present at any given time period. Compliance was 30% (caregivers), 11% (paraprofessional aides), and 4% (parents), with an overall compliance of 22%. Between-room and between-age groups of children being cared for and compliance of caregivers and paraprofessional aides were not found to be significantly different ($P < .05$). For all personnel between the 10 different rooms, the median compliance was 20.2% (95% confidence interval, 8%-35%). Only 7% of personnel taking care of 2- to 3-year-old children washed their hands, the lowest compliance per age group. Of all steps in HW, paper towel usage had the highest compliance, with a 97% adherence, whereas turning off the faucet with a paper towel was the lowest at 17%.

Conclusions: Methods and strategies need to be developed to increase compliance. Current technology provides an effective means of gathering data for determining HW compliance in ECCs.

Out-of-home child care services play an important role in ensuring the well-being of >32 million children annually across the United States.[1] Caregivers of these children are responsible for providing care and education to this younger population in the absence of their parents or guardians. Keeping children healthy is a huge responsibility made even more difficult because children <5 years old have only partially developed immune systems, increasing their susceptibility to communicable diseases.[2] Bacterial infections, such as those caused by methicillin-resistant *Staphylococcus aureus*, are sometimes acquired by children through community child care settings.[3] The risk of infection is 2-3 times greater for children cared for at an early childhood center (ECC) than those cared for only in a home,[4] with respiratory and gastrointestinal infections posing the highest risks.[5] A key component in reducing the risks to this vulnerable population involves minimizing microbial cross-contamination through proper handwashing (HW) among child care professionals and teachers. Proper HW is crucial to removing the causative organisms responsible for the spread of infections.[6]

Children, especially those ≤5 years old, are highly susceptible to rotavirus, a diarrheal disease commonly transmitted in child care facilities because of poor hygiene.[7] Annual costs, including medical treatment and work missed by parents for child care, have been estimated at $1 billion.[7] Several studies and interventions have shown the positive effects of increasing HW compliance in ECCs, including alleviating the burdens of childhood illness.[8-11] The cost of a successful HW intervention has been estimated to be a mere 1% of the cost of infection treatment.[12] In a review investigating 9 HW interventions, the authors determined that proper HW education in ECCs and school settings has the potential to prevent or reduce diarrhea cases by approximately one-third.[13] Soto et al[8] conducted HW education in ECCs and observed a 72% decrease in cases of diarrhea and a 54% decrease in cases of colds among the children. Researchers in Georgia implemented HW interventions in 2 ECCs,

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with 2 others serving as controls.[11] After 35 weeks, the diarrhea rates of the control group were double that of the intervention group. A review encompassing infection interventions in ECCs highlighted 6 studies that included HW training as leading to decreases in the rates of upper respiratory infections and diarrhea,[9] and one in particular saw a 17% drop in upper respiratory infections.[14] The benefits of HW extend to the adults as well, especially given the ability for pathogens, such as respiratory syncytial virus, to spread from infants to child care personnel.[15]

The Centers for Disease Control and Prevention (CDC) recommend that all volunteers, teachers, and children within the ECCs comply with HW guidelines. The National Association for Education of Young Children also requires that accredited programs stipulate that "children and adults wash their hands on arrival (in their room) for the day" in addition to other key points in the schedule. This is why many programs, including the program where we made observations extend identical HW requirements to parents. It is postulated that because parents touch potentially contaminated surfaces and sometimes interact with children within the care environment, they too may carry bacteria to children. Such a requirement also serves an educational purpose. Standard 2.4.3.2 of the CDC regulations recommends that the centers serve as an educational hub for parenting information, including the importance of HW.

Despite the various benefits, several studies have shown low HW compliance in the child care setting.[16-18] Out of 572 observed instances in which food service workers at an ECC should have washed their hands, only 200 HWs occurred, a rate slightly <35%.[17] Zomer et al[16] observed a 29% compliance rate for caregivers before eating, a 25% compliance rate after touching bodily fluids, and an overall compliance rate of 42% for >2,000 HW opportunities. A survey given to parents whose children attended a child care center discovered only one-third of the respondents regularly washed their hands after wiping their child's nose.[18]

To our knowledge, to date, no study has been conducted using cameras as a means of determining HW compliance at an ECC, despite the advantages this form of data collection offers. Research on HW conducted by Judah et al[19] suggests observations minimizing researcher-subject contact aid in developing intervention strategies. Furthermore, it has been shown that human monitoring alone can contribute to altered behaviors and outcome.[20,21] Video observations have been used in a variety of settings, including hospitals,[22,23] a veterinary clinic,[24] and an elementary school,[25] to determine HW compliance, frequency, and efficacy based on adherence to guidelines. Shah et al[22] measured the quality of HW events as defined by the World Health Organization (WHO) using motion-sensing cameras placed directly over the HW area in a neonatal intensive care unit. Over 1 week they were able to capture >1,000 handwashes from doctors, nurses, and parents. Despite the fact that all persons who entered the neonatal intensive care unit washed their hands at least once, 14.5% of all handwashes were considered unacceptable (omitted at least 3 of the 6 WHO steps deemed important and when washing time failed to be >20 seconds), with the unacceptability rate being >34% for parents.

The purpose of our study was to collect baseline data using video observations to determine the quality and frequency of HW practices in an ECC in the Northwest Arkansas region caring for infants and children up to 5 years of age.

MATERIALS AND METHODS

To properly determine the number of HW opportunities and to assess the quality of HW occurrences, wide-range, robotic surveillance cameras (ClearVIEW HD-19; Vaddio, Minnetonka, MN) were used. Two cameras were placed in each of the 10 classrooms in the early childhood facility. The cameras, secured to the walls and connected to the facility's video capture system, allowed for clear views of the sinks used for adult HW. The 2 cameras were placed on opposite sides of the room and were situated approximately 2 m above the ground on shelving or cabinets and were used simultaneously to assess behavior. Both cameras captured recordings that were then automatically displayed side by side when viewed for researcher's coding purposes. In the event that a caregiver moved from one side of the room to the other, the use of 2 cameras made their transition seamless; the opposite camera picked up the behavior right when personnel exited the frame of view from the initial camera. Key room features captured by the cameras included 1 handwashing sink per room located at the entrance to each room and a sink located proximal to child feeding areas. There were 4 rooms responsible for care of infants in the age range of 2-22 months that were equipped with an additional handwashing sink adjacent to a diaper changing station (Fig 1). The cameras were able to film most of the space of the room, and handwashing opportunities were assessed based only on visible footage.

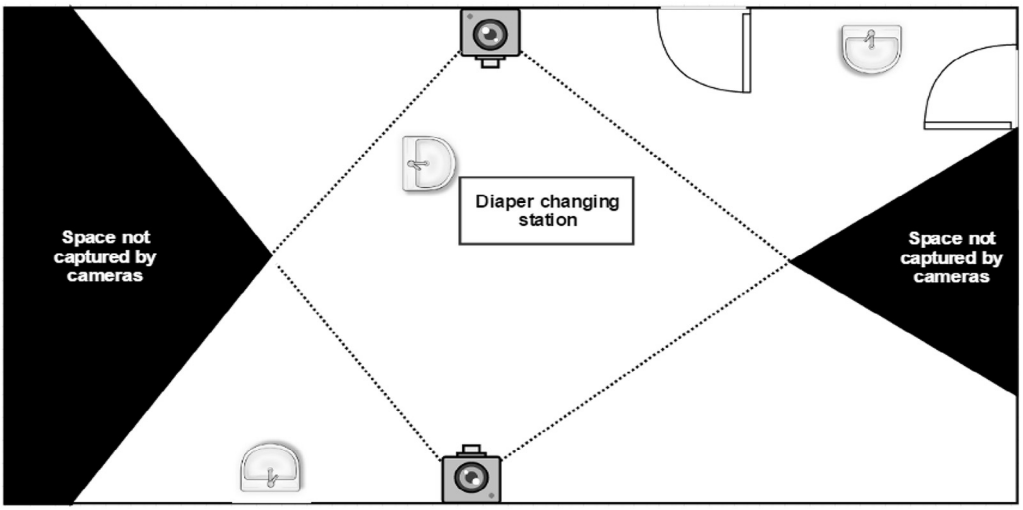

Fig 1. Room layout used for collecting handwashing compliance and efficacy data for children 2-22 months old. White space indicates areas in the room cameras were able to record. Dotted lines emanating from cameras define field of vision.

Table 1
Handwashing opportunities coded for based on early childhood center quality indicators and "Caring for Our Children" guidelines

After	Before and after
Entering the classroom	Food and drink preparation and handling
Handling a cell phone	Eating
Contact with bodily fluids	Diapering
Taking out or touching garbage	
Cleaning	
Touching sand	

Table 2
Compliance characteristics of early childhood center personnel in relation to the different rooms footage was taken and the activities that prompted handwashing opportunities

Personnel	Between rooms, % (n =10)	Between activities, % (n = 12)	Between rooms, % (n =10)	Between activities, % (n = 12)
Caregivers*	27.5	21.2	30 (16-44)	24 (12-36)
Overall†	20.2	7	22 (8-35)	22 (16-28)

Values are median compliance or compliance (95% confidence interval).
*Paraprofessional aide and parent values too low to warrant individual analysis.
†Includes caregivers, paraprofessional aides, and parents.

The study was found to be exempt from further review by the Institutional Review Board of the University of Arkansas on the premise of maintaining individual anonymity of the personnel observed. Ten hours of video footage (a full operational day in the ECC) of caregivers, paraprofessional aides (PAs), and parents were obtained from each of 10 different classrooms on 10 separate days over the course of a month. The ages of the children in the 10 rooms varied from <1 year old to 5 years old. A random, 2.5-hour time slot was selected from each of the 10 rooms for a total of 25 hours of footage, which was later coded for HW by a researcher and assistant; these randomly selected time slots encompassed all hours of the 10-hour work day. HW opportunities and events were based on guidelines for early child care established by the American Academy of Pediatrics et al.[26] Briefly, use warm water, moisten hands with water, apply soap to hands, rub hands together vigorously out of the water until a soapy lather appears, continue for at least 20 seconds, rinse hands under running water, leave the water running while drying hands with a paper towel, and turn taps off with paper towel.

The percentage of HW compliance for this article, as defined by Zomer et al,[16] is defined as the number of times a person washes their hands divided by the number of handwashing opportunities. The percentage of compliance was also figured for each of the recommended components of HW recommended by the CDC.[27] The researchers carefully observed each of these components to determine which steps in the sequence were most often omitted or slighted. R Version 3.2.5 (The R Foundation for Statistical Computing, Vienna, Austria) was used to calculate compliance, medians, and 95% confidence intervals (CIs).

Coding criteria were based on ECC quality indicators in the Environmental Rating Scales[28] and were adapted from the "Caring for Our Children" guidelines[26] (Table 1), and were adapted from the coding scheme in Green et al.[29] Minor modifications were made to this criteria, including the addition of cell phone handling as a HW opportunity because of the present body of research highlighting the role of cell phones as fomites for disease.[28]

Because of the continuous nature of the recorded footage, it was inevitable that multiple HW opportunities could be attached to 1 HW event, such as if a caregiver were to enter the classroom, wash their hands, and then immediately prepare food. To account for this, such a circumstance would have been coded as 2 HW opportunities and 2 corresponding HW events, despite only 1 actual HW taking place. Therefore, we distinguished between corresponding and actual HW events. In calculating HW compliance, we divided the number of corresponding HW events over the number of HW opportunities.

Establishing satisfactory interrater reliability (IRR) is a critical component of conducting a HW compliance study because it assures the integrity of the observations and HW criteria when limited time and resources may necessitate multiple coders to individually examine a large sample of data. Although some studies have relied on percentage agreement between users,[29] this method fails to account for chance in contributing to agreement, leading to an overestimation of consensus.[30] Cohen κ has been used previously in determining IRR for hand hygiene observations,[31] but it offers less flexibility in the event of missing data.[30] Krippendorf α[32] was selected as the test statistic of choice because it has been shown to account for the shortcomings of percentage agreement and Cohen κ while being more suited for the unstructured observations[33] characteristic of our study. IRR was established between the researcher and assistant using extraneous footage not part of the 25 hours selected for data collection. An IRR score of 92%, considered well above average for reliability tests,[33] was obtained using SPSS Statistics version 23 (IBM, Armonk, NY) and Krippendorf α[33] as the test statistic before the 25 hours of footage were coded.

RESULTS

There were a total of 349 HW opportunities in the random 25 hours selected to code from between the 10 classrooms, equating to roughly 14 HW opportunities per hour. The median number of caregivers in a classroom at any given time was 2, with a range of 2-6. For students, the median number in the room was 1, with a range of 0-5. Seventy-eight corresponding HW events took place, and overall compliance was 22%. Compliance, defined as the number of corresponding HW events over the number of HW opportunities, was highest among caregivers because they handwashed 30% of the time; PA compliance was 11%, and parent compliance was 4%. Because each room was frequented by a predominantly different group of caregivers, PAs, children, and parents, calculating the median compliance gave us an indication of how compliance rates varied among the caregivers and personnel overall (Table 2). Median compliance of caregivers between the 10 rooms was 27.5% and 21.2% for between the 14 activities. After comparing between-room compliance of teachers and PAs, no significant difference ($P < .05$) was found between the 2 groups of personnel. The 95% CI of compliance for caregivers between rooms was 30% (16%-44%), and between activities it was 24% (12%-36%). Although compliance rates from PAs and parents were informative, the number of HW opportunities for these groups was low and therefore not appropriate for individual statistical analysis for interquartile differences and 95% CIs. As such, we used PA and parent compliance rates, along with caregiver compliance rates, to determine overall interquartile differences and 95% CIs.

Caregivers were responsible for 64% of all HW opportunities, followed by PAs (23%), and parents (13%). For caregivers, "before child food, drink preparation, handling" was the most frequently occurring activity that warranted HW, with "after touching/playing with sand" and "after taking out or touching items in the garbage" comprising the least. The most frequent HW opportunity for PAs was "after entering the classroom," with "after taking out or touching items in the garbage" the least. Of the 12 categories of HW opportunities measured, "after diapering" had the highest compliance rate for caregivers (67%) and "after entering the classroom" had the highest compliance rate for PAs (47%). "After eating," "after taking out or touching items in garbage," and "after touching or playing

Table 3
Overall number of occurrences of key components of HW steps and percent total for caregivers, paraprofessional aides, and parents

	Overall	
HW event attributes	n	%
Length of HW (s)		
1-5	20	32
6-10	22	36
11-14	11	17
15-19	6	10
≥20	4	6
HW criteria		
Used soap	59	94
Wetted hands prior to soap addition	18	33
Lathered with soap outside of running water	11	25
Dried hands with paper towel	61	97
Turned off faucet with paper towel	10	17

HW, handwashing.

with sand" had the lowest compliance rates for caregivers, with "after eating" contributing to the most HW opportunities[16] from these 3 activities. For PAs, "before child food, drink preparation, handling" had the most opportunities[14] of the activities with 0% compliance, which was all but 3. Of the 46 HW opportunities for parents, only 2 corresponding HW events took place, and "after entering the classroom" comprised most, with a compliance rate of 6%. "After entering the classroom" had the highest overall compliance among caregivers, PAs, and parents at 32%. To clarify, based on the "Caring for Our Children" guidelines, this was considered a HW opportunity when personnel entered the classroom at the start of a work shift, after a break, or after switching child groups.

Overall compliance of personnel by age group are as follows: for the ≤1-year-old age group there was 21% compliance in 2 rooms, in the 1- to 2-year-old age group there was 29% compliance in 2 rooms, in the 2- to 3-year old age group there was 7% compliance in 2 rooms, and in the 3- to 5-year old age group there was 29% compliance in 4 rooms. There was an average of close to 35 triggering events per classroom. A comparison between age group compliance of teachers to PAs showed no significant difference ($P < .05$). Regarding the occurrence of HW opportunities, in some cases, there was no corresponding after to a before because of the adherence to a 2.5-hour video segment limit, therefore inhibiting the viewing of a potential subsequent event.

Of the 78 corresponding HW events, caregivers comprised approximately 85%, PAs comprised 13%, and parents comprised 3%. Of the actual HW events, there were 63 total between caregivers (50 events), PAs (11 events), and parents (2 events). Only 2% of the HW events by caregivers and 18% by PAs reached the minimum recommended HW time of ≥20 seconds (Table 3). Of the 5 designated time slots for HW time, 6-10 seconds comprised the most of the actual HW events for caregivers (38%), and 1-5 seconds (27%) and 6-10 seconds (27%) for PAs. One actual HW event of the parents was 1-5 seconds and the other was ≥20 seconds. The average HW duration was approximately 10 seconds overall and individually for caregivers and PAs.

Our HW event criteria was divided into 7 measurable steps, excluding such protocols as using 60°F-120°F (15°C-60°C) water and the efficacy of the personnel in removing visible dirt and soap. Every room was equipped with sufficient paper towels and soap, in part having an influence on the high paper towel and soap usage we observed by personnel. PAs used soap 91% of the time and never missed an opportunity to dry their hands with paper towels. Of the 2 corresponding HW opportunities in which gloves were worn by caregivers, they were removed both times before HW. Caregivers and PAs rarely turned off the faucet with a paper towel, complying with this step 27% and 0% of the time, respectively.

DISCUSSION

The average compliance rate we observed of 22% was lower than the rates in ECC studies mentioned previously of Zomer et al[16] with 42% and Strohbehn et al[17] at approximately 35%. However, our study was unique in using video surveillance compared with direct observation, which could in part explain the discrepancy. Furthermore, our population differed from Zomer's in that we included PAs and parents, both of whom had much lower compliance than the caregivers in our study and the Strohbehn study, which focused on food service workers in the ECC setting. We also used slightly different criteria as to what warranted HW and used different methodologies for recording HW opportunities. In the ECC of our study, beginning PAs are not authorized to engage in several behaviors that warrant HW, such as changing diapers and taking out trash; this could account for, in part, the disproportionate amount of HW opportunities observed for the children's actual caregivers compared with PAs. We were unable to make the distinction between beginning and more experienced PAs, and the calculated compliance rates reflect this. Therefore, this may further explain our lower compliance rates compared with prior studies. We were not surprised by the low level of compliance parents demonstrated toward the handwashing regulations even though several teachers posted HW reminders on the classroom doors. Parents are often rushed at drop-off and pickup times. Teachers, too, are rightfully more engaged with children than with policing the sink area at these times. Furthermore, teachers, many of whom are young, are often too intimidated to confront parents.

Looking at just the caregivers, we compared compliance rates to what Zomer observed using the similar, applicable HW criteria. In some cases, multiple activities Zomer documented were analogous to just one activity we documented. The comparable HW activities followed by the percentage compliant were as follows: "before child food, or drink preparation, handling" (Clark study: 36%)/"before food handling" (Zomer study: 31%); "after diapering" (Clark study: 67%)/"after changing a diaper with feces" and "after changing a wet diaper when the child was lying down" (Zomer study: 61%); and "after contact with bodily fluids from child or self" (Clark study: 18%)/"after contact with body fluids" (Zomer study: 25%). Whether or not these differences in compliance observed are marginal or significant remains to be seen, but they could be a matter of slightly divergent interpretations as to what constitutes each HW opportunity and the variation in sample size.

We documented the fewest number of HW opportunities (349) in relation to the 2 other comparable studies for ECCs by Zomer (2,003) and Strohbehn (572). Questions continue as to what constitutes an adequate sample size for determining representative HW compliance, but the WHO suggests a minimum of 200 HW opportunities per specific setting and time period.[34] Our study fits these criteria in focusing on a single ECC and through randomly selected footage that encompassed all 10 hours of the day children were present. A successful intervention has been conducted with as few as 294 HW opportunities, which was divided between multiple time frames of baseline, postintervention, and follow-up periods.[35] We exceeded this amount of opportunities as part of a baseline period alone.

According to the "Caring for Our Children" guidelines used in our study, HW should last ≥20 seconds; our data indicate a 6% overall adherence rate to this recommendation. Hand sanitizing is an approved means of quickly and safely reducing bacterial loads on the hands when no visible dirt or soil is present. Arkansas regulations do not allow hand sanitizer usage to substitute for HW in childcare, and therefore it stands to reason that in the 25 hours of footage we reviewed, there was not a single instance in which hand sanitizer was used. However, given the low adherence to the duration

a HW should be and the overall low compliance rates of caregivers, PAs, and parents, the state regulation might benefit from a review that would allow use of hand sanitizer in certain instances.

We observed a greater portion of actual HW events that lasted ≥15 seconds compared with several other studies,[31,36] one of which, conducted by Drankiewicz,[37] showed only 1 in 50 HW events lasting ≥10 seconds. These differences could in part be attributed to the slight variance in criteria as to what defines a HW; Borchgrevink et al[31] considered the duration of a HW to be how long an individual's hands were in contact with water, whereas ours was from when an individual turned on the water to when they turned it off. Sample size and demographics could also play a role in our differing results. The average duration of an actual HW event we observed (approximately 10 seconds) is similar to what some studies have shown in hospitals[38,39] and about twice as long as what has been documented at the university setting.[40]

To our knowledge, this is the first study to use video surveillance to determine HW compliance in the ECC setting. Although the cameras were visible to personnel, knowledge of the intentions for this study remained anonymous. In such a way, the cameras functioned as covert observers, much like studies done previously in which the observer had a less authoritative role within the setting[41] or disguised their intentions.[16] Furthermore, prior to the start of this study, personnel were accustomed to being monitored, with security cameras (not used for this study) and 2-way mirrors already put in place by the ECC.

Our strategy of using cameras has been used previously in different settings[22-25] as a means of limiting the effects of observers on behavior,[21] which has been shown to inflate HW frequencies and impact behavior.[42,43] Commonly known as the Hawthorne effect, this refers to the potential for an experiment to alter behaviors[44] and is often associated with affecting the results of observational studies. Although some evidence suggests the Hawthorne effect to be minimal,[45] this has been shown to be only true if observations are limited to 15 minutes; such a time frame has obvious limitations by impeding the ability of the researcher to observe HW behavior throughout the course of a day.

Our methodology of using video observations provided several advantages, including that we could rewind and review our recordings if necessary. This allowed us to meticulously code the behaviors to give us an accurate indication of HW opportunities, compliance, and efficacy. Surveillance and observations conducted where the researcher is present have been shown to yield similar results for determining HW compliance,[25] therefore validating our method for data collection. In recording the audio of the classrooms, we were better able to pinpoint when HW began, based on aural cues. The sound provided insight into specific HW compliance strategies used by caregivers as aids directed toward the children, such as songs and frequent reminders. HW was a common practice enforced for children on entering the classroom, but based on a low overall compliance rate (32%) for caregivers, PAs, and parents for this activity, perhaps the HW strategies used should be geared toward both children and adults. This is further reinforced given the large difference in compliance rates for all activities between caregivers (30%), PAs (11%), and parents (4%).

With respect to the discrepancies in compliance rates between personnel groups, they could, in part, be caused by the large variance in amount of HW opportunities observed. The larger number of HW opportunities observed for caregivers potentially gave a slightly more accurate indication of HW practices. Varying levels of HW training exposed to by the personnel groups could also have contributed to the broad range of compliance. Regardless of the source of the discrepancy, this study reinforces the need to institute comprehensive, effective HW training for all persons involved with child care. Also, considering that there was no significant difference in compliance between teachers and PAs either between rooms or between age groups, the hypothesis that more training leads to increased HW compliance could be brought to bear on this question.

Apart from gleaning strategies for future HW interventions, our footage provided evidence of potential sources for cross-contamination, such as clipboards and pens used immediately after diaper changes but before HW. This information sheds light on the location of potential fomites and highlights the need for a thorough update and review of cleaning and sanitizing policies. Although HW frequency is important in mitigating the spread of disease, the order in which HW takes place compared with other tasks could also play a role, as suggested by our study.

The study did have some limitations, one of which was the use of cameras that were only able to capture a portion of the room. This had the potential to alter the compliance rates we observed because we were limited to behaviors viewed on screen. The positioning of the caregivers, PAs, and parents in relation to the HW sink inhibited our ability to properly assess HW procedures of certain actual HW events, such as lathering with soap. Furthermore, we were not able to observe HW behavior in relation to outdoor activity or when caregivers left the classroom to take children to play in the indoor play room; more HW opportunities could have occurred unknown to us.

A more thorough examination of the "Caring for Our Children" guidelines after data were collected and analyzed revealed another recommended scenario for HW, that of HW after assisting children HW. We were unable to include this event in our analysis, which, in doing so, could have affected the amount of HW opportunities observed and compliance rates calculated. Future coding will include this extra criterion.

We recognize our decision to base HW compliance from 12 criteria from the "Caring for Our Children" guidelines as being rather extensive and prone to overestimation of how often personnel needed to HW in light of respective risk of spreading contamination. Fraser et al[47] reached a similar conclusion in their evaluation of hand hygiene guidelines and expectations in the foodservice industry. Combining their methods of calculating total time required for a HW event and the number of HW opportunities we observed in our study, with an average of 14 events per hour, to achieve 100% compliance, personnel would have spent 12 minutes, or 20% of each hour, in HW. Much like the difficulty a line cook faces in the pressure of ensuring customer satisfaction with quick food production times versus HW at the prescribed frequency, ECC personnel have the same difficulty when prioritizing the care of a crying infant versus meeting HW compliance demands. Our study supports the need within child care and food service for a more risk-based approach to required HW events as posited by Fraser et al.[47]

Nevertheless, we calculated overall compliance using the 6 HW criteria recommended by the state's Division of Child Care and Early Childhood Education and local health department for ECCs,[46] which involved food preparation, eating, and diapering. Interestingly, overall compliance for these 6 categories was 22%, the same percentage we observed when all 12 criteria were included in our analysis.

CONCLUSIONS

HW is an important component of reducing illness transmission among children in ECCs, especially for the adults in charge of their care. Our study shows the need to adopt creative strategies to increase compliance and efficacy, to mitigate the potential for cross-contamination via fomites, and to consider usage of current technology in assessing behaviors.

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