CONCISE COMMUNICATION

The Precision of Human-Generated Hand-Hygiene Observations: A Comparison of Human Observation with an Automated Monitoring System

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We compared the observations of nearly 1,400 hand-hygiene-related events recorded by an automated system and by human observers. Observation details differed for 38% of these events. Two likely explanations for these inconsistencies were the distance between the observer and the event and the busyness of the clinic.

Infect Control Hosp Epidemiol 2012;33(12):1259-1261

Hand-hygiene adherence is measured almost exclusively via direct human observation. Although it is considered to be the gold standard,[1] direct observation is susceptible to observer biases[1,2] and its reliability is affected by sporadic or inconsistent sampling.[1] Several emerging technologies[3-9] to measure hand-hygiene adherence offer alternatives to human observation. Until these become widely adopted, however, hand-hygiene adherence will likely continue to be measured by human observers. Thus, a better understanding of the limitations of human observation is needed. This article demonstrates how the accuracy of human observation is affected by activity in the observed area and the distance between the observer and the hand-hygiene events being observed.

METHODS

The experiment was conducted on 3 consecutive Tuesdays in a single hallway in an outpatient clinic. Hand-hygiene dispensers mounted outside the doors of each examination room were replaced with dispensers containing a mechanism designed to broadcast a radio transmission each time the dispenser is used. Each doorway was outfitted with an instrument that records the time when an infrared beam is interrupted, as an indicator that someone has crossed the threshold. This instrument also received and recorded radio broadcasts from the dispensers. The dispensing mechanism and infrared-beam instruments were custom built and equipped with a microprocessor, materials for wireless communication, and flash memory.

A human observer sat unobtrusively at the end of the clinic hallway. One observer worked each morning and another worked each afternoon. The observers recorded each threshold event, defined as each instance of a person entering or exiting a room. The observers also recorded whether the person in each threshold event used a hand-sanitizer dispenser when entering or exiting the room. Observations were coded as (a) no wash in, (b) no wash out, (c) wash in, (d) wash out, or (e) wash in the hallway without entering or exiting a room. On the first observation day, each observer collected this information for every event over a shift of approximately 4 hours. On the second Tuesday, each observer recorded the same information, but this time for only 1 hour during the 4-hour span. On the third observation day, the clinic was active only during the morning, and only 3 rooms were being used. On this day, the observer was positioned closer to the active rooms and recorded the same information indicated above, for only those 3 rooms.

We compared the human observations from the first and second days with the machine records from the same time periods. The records from the infrared receivers were synchronized with the data from the human observations. A time line of the automated record was then produced and compared with a time line of the human observations for each threshold-crossing and hand-sanitizing event. Inconsistencies between the records were coded as (1) a missed hand-hygiene event, (2) a missed threshold event, (3) a false hand-hygiene event, (4) a false threshold event, and (5) an incorrect room event. A missed hand-hygiene event or a missed threshold event occurred when the written record did not include an event perceived by the electronic system. A false hand-hygiene event or a false threshold event occurred when a hand-hygiene event or threshold crossing appeared in the written record but not in the electronic record. An incorrect room event occurred when the room number in the written record corresponded most closely to a threshold event with a different room number in the electronic record.

Each inconsistency was then coded with 4 factors that we believed might affect the reliability of human observations. These 4 factors were observer identification, number of minutes spent observing (to control for observer fatigue), distance between the observer and the room where the inconsistency occurred (to control for range of view), and clinic activity (to control for degree of hallway traffic). Next, we used logistic regression to determine which factors were associated with the occurrence of an inconsistency. A similar analysis was applied to data about hand-hygiene adherence, starting on the third day of the experiment (excluding observer identification). Finally, 3 types of errors (incorrect room, hand-hygiene events, and threshold events) were again modeled using logistic regression. All statistical analyses were performed using R, version 2.12.2 (R Foundation).

RESULTS

Nearly 1,400 unique threshold events were recorded by both the human observers and the equipment. Approximately 62% of these events were consistent between the two systems. Table

TABLE 1. Inconsistencies in Observations Recorded by Human Observers and by an Automated Monitoring System

Error type	Day 1	Day 2	Day 3	Total
False threshold event	23 (2.39)	13 (4.51)	10 (6.80)	46 (3.29)
False hand-hygiene event	5 (0.52)	2 (0.69)	0 (0.00)	7 (0.50)
Missed threshold event	284 (29.52)	41 (14.24)	21 (14.29)	346 (24.77)
Missed hand-hygiene event	39 (4.05)	1 (0.35)	4 (2.72)	44 (3.15)
Incorrect room	66 (6.86)	14 (4.86)	2 (1.36)	82 (5.87)
No error	545 (56.65)	217 (75.35)	110 (74.83)	872 (62.42)
Total	962 (100.0)	288 (100.00)	147 (100.00)	1,397 (100.00)

NOTE. Data are no. (%).

1 provides the number and percentage of each type of inconsistency. Clinic activity and distance were significant predictors of inconsistencies, whereas observer identification and minutes spent observing were not. Table 2 describes the resulting model fit.

When distance was held constant, the odds of an error occurring were 1.11 (95% confidence interval [CI], 1.02–1.21) times greater for each 5 additional events observed within a 3-minute period. Likewise, when clinic activity was held constant, the odds of an error occurring in the far rooms were 3.70 (95% CI, 2.86–4.80) times that of an error occurring in the closer rooms.

When specifically modeling threshold-event errors (errors related to room entry or exit), we found a significant association with distance (odds ratio [OR], 2.68 [95% CI, 2.06–3.50]). Distance was also found to be associated with errors related to hand-hygiene event (OR, 2.02 [95% CI, 1.12–3.62]). Errors related to wrong room assignment were found to be significantly associated with both the observer identification (OR, 3.58 [95% CI, 2.00–6.38]) and distance (OR, 3.20 [95% CI, 1.99–5.14]).

DISCUSSION

The frequency of inconsistencies between the human observations and observations by the automated system (38%) was surprising. After eliminating the possibility of systematic equipment errors, we found that the most likely explanations for the inconsistencies were the distance between the observer and the observed event and the activity level in the clinic.

Existing guidance for human observation of hand-hygiene compliance often recommends increasing the number of observations collected to improve data accuracy.[10] However, this assumes that observations are all equal with respect to their accuracy. Our results show that errors are dependent on the circumstances of the observations. The lower accuracy noted with high clinic traffic likely correlates with missed events because of near-simultaneous threshold crossings in multiple rooms.

Our study has several limitations. First, it was performed in a single medical center. Second, our statistical analysis treated all of the inconsistencies as equally important. Thus one type of error may have excessive influence on our results. For example, if we removed from our model missed machine threshold events, the busyness covariate is no longer significant ($P = .14$). However, distance was still strongly associated with all of the remaining types of error. Furthermore, the data did not allow for subject-level effects such as the individual nurses and doctors triggering the events. Finally, our results assume that the hardware we used was the gold standard and all of the errors were the fault of the human observers, which may be inaccurate. For example, if 2 people entered a room in rapid succession, an observer may have counted 2 entries while the equipment counted only 1.

Despite our limitations, we demonstrate that the accuracy of an observer may depend on when and where observers are asked to perform an audit. By increasing the number of observations through more frequent events or over a longer distance, accuracy may suffer. The degree to which our results apply to other settings warrants further investigation. When planning an observation, it may be beneficial to limit the number of observations during a specific time period and limit the distance between observers and the healthcare workers under observation.

TABLE 2. Values from the Logistic Regression Model

Coefficient	Estimate (SE)	OR (95% CI)	Z value	P value
Intercept	−1.197 (0.133)	3.310 (2.551–4.296)	−8.964	<.001
Clinic activity[a]	0.021 (0.009)	1.021 (1.003–1.039)	2.455	.014
Distance	1.309 (0.132)	3.702 (2.858–4.796)	9.880	<.001

NOTE. CI, confidence interval; OR, odds ratio; SE, standard error.
[a] Events occurring within the current and 3 preceding minutes.

ACKNOWLEDGMENTS

The door-minder equipment described in this article is not commercially available. The equipment described in this article was designed and built to support research studies for our group. We do not have plans to develop this door-minder device into a commercial hand-hygiene compliance system.

Financial support. This work was supported in part from a cooperative agreement from the Centers for Disease Control and Prevention and from the National Institutes of Health (research grants K01 AI75089 and R21-AI081164).

Potential conflicts of interest. All authors report no conflicts of interest relevant to this article. All authors submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and the conflicts that the editors consider relevant to this article are disclosed here.

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Received April 7, 2012; accepted July 15, 2012; electronically published October 25, 2012.

 0899-823X/2012/3312-0014$15.00. DOI: 10.1086/668426

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