CONCISE COMMUNICATION

Optimum Outlier Model for Potential Improvement of Environmental Cleaning and Disinfection

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The effectiveness and efficiency of 17 housekeepers in terminal cleaning 292 hospital rooms was evaluated through adenosine triphosphate detection. A subgroup of housekeepers was identified who were significantly more effective and efficient than their coworkers. These optimum outliers may be used in performance improvement to optimize environmental cleaning.

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The patient care environment has been linked to the transmission of pathogens responsible for healthcare-associated infections (HAI).[1,2] Methods to monitor the thoroughness of environmental cleaning through the use of ultraviolet-tagged marking gel or adenosine triphosphate (ATP) detection are available,[3-5] but means to improve environmental cleaning without a major commitment of resources are needed. Recently, we noted that the time spent by environmental services (EVS) personnel to clean hospital rooms did not correlate with objective measures of cleanliness, giving rise to the premise that a positive deviance or "optimum outlier" model for improving cleaning might be possible.[6] This project was conducted to ascertain whether a subgroup of housekeepers could be identified as role models in an optimum outlier improvement model.

METHODS

The study was conducted in 3 patient care units (a 7-bed burn unit, a 32-bed telemetry unit, and a 40-bed medical surgical unit) from April 2011 to August 2011 at a 689-bed academic medical center. The University of Nebraska Medical Center (Omaha, Nebraska) institutional review board (IRB) approved this study.

Following routine terminal cleaning by EVS personnel, a convenience sample of rooms was assessed during regular work hours by measuring ATP levels (3M Clean Trace Surface ATP System) on 18 designated surfaces (exterior door handle, bed rail [2 sites], nurse call button, bedside table [2 sites], toilet flush handle, bathroom door handle, toilet seat, bedside chair [2 sites], light switch, mattress, sink light switch, sink faucet handle, stethoscope, soap dispenser, and telephone). A consistent surface area was sampled for each surface. As previously described, a composite cleanliness score was calculated on the basis of the percentage of surfaces that were below a cutoff point of 250 relative light units.[5]

The amount of housekeeper time spent cleaning a room was documented through use of an automated system (teletracking technologies). The automated system required personnel to document by telephone when they arrived at the room and when room cleaning was complete. As required by the IRB, the anonymity of housekeepers was protected by assigning them a code for use in the activity log where housekeeper identity and time to clean a room were recorded.

Logistic regression was used to estimate the cleaning effectiveness rate (as measured by ATP detection) for each housekeeper. Pairwise comparisons were performed using odds ratios to compare the rate of effectiveness of each housekeeper to all other housekeepers. Analysis of variance was used to compare the efficiency of cleaning (mean time to clean a room) between housekeepers, and pairwise comparisons were performed with Tukey post hoc adjustment (α set at 0.10). The association between effectiveness and efficiency was analyzed by plotting the median time to clean hospital rooms versus the median percentage of surfaces graded as clean per housekeeper and use of the Spearman correlation test. P less than .05 was considered statistically significant.

RESULTS

Seventeen housekeepers (A–O) performed routine terminal cleaning of 292 hospital rooms at patient discharge. Housekeeper cleaning effectiveness ranged from 46% to 79% as estimated by logistic regression. Pairwise comparisons placed housekeepers into 3 groups. Housekeepers in group 1 (A–G) had similar rates of cleaning effectiveness compared with one another but were statistically less effective than the more effective housekeepers in group 3 (K–Q). Housekeepers in group 2 (H–J) were of intermediate effectiveness. The median time to clean a room for the 17 housekeepers ranged from 24 minutes to 47 minutes ($P < .0001$; Table 1). For each housekeeper, the median effectiveness of cleaning versus the median efficiency of cleaning was plotted (Figure 1). Based on the plot, housekeepers M, O, and Q cleaned rooms more effectively and efficiently than did their coworkers. Housekeeper A cleaned rooms quickly but was not effective. There was no correlation between the median effectiveness and median efficiency ($R = -0.16$; $P = .53$).

DISCUSSION

From the viewpoint of hospital administration, there are 2 major variables to be considered in managing the operations of EVS. First, cleaning must be effective; as much as possible, potential pathogens should be eradicated or removed. There are increasing data to link environmental contamination to HAI, and the first priority should be given to providing patients a safe environment.[1,2] Second, resources are limited,

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TABLE 1. Individual Housekeeper Efficiency

	Time required to clean room, minutes		
Housekeeper	Mean (±SD)	Minimum	Maximum
A	30.8 (18.3)	14	52
B	35.3 (4.4)	29	39
C	44.6 (4.5)	37	49
D	37.7 (3.5)	34	41
E	33.0 (6.0)	23	39
F	37.5 (5.5)	31	43
G	35.3 (10.1)	23	49
H	34.5 (8.2)	22	48
I	37.6 8.4)	26	50
J	42.4 (10.9)	22	75
K	33.2 (10.8)	18	54
L	46.7 (12.9)	10	95
M	36.7 (17.7)	25	57
N	39.5 (7.1)	27	55
O	27.6 (6.0)	23	36
P	36.7 (3.8)	34	41
Q	34.4 (10.4)	20	55

NOTE. SD, standard deviation.

and thus housekeepers must be encouraged to maximize efficiency. Our study yields valuable insight into optimization of EVS performance in terms of both effectiveness and efficiency.

Environmental cleanliness can be assessed by direct observation, surface cultures, detection of ATP, or use of fluorescent marking solution, and each monitoring technique has limitations.[3-5,7] In this study, using ATP detection with a cutoff of 250 relative light units to assess effectiveness of cleaning, we extended our previous observations, which used a fluorescent marking gel,[6] and again demonstrated that there is no correlation between the amount of time that a housekeeper spends cleaning a room and the cleanliness of the room. We also documented that an optimum outlier model of EVS performance improvement is a viable option. Optimum outlier models have been used previously in infection prevention to improve compliance with hand hygiene and prevent methicillin-resistant *Staphylococcus aureus* transmission.[8,9] Boyce et al[10] noted that, despite attempts to standardize training and cleaning techniques, there is great variation between housekeepers with regard to cleaning practices. In our study, we demonstrate that there is a subset of housekeepers who regularly clean hospital rooms more effectively and more efficiently than their coworkers. The next step is to learn from these optimum outliers and translate the knowledge into improved practice for all housekeepers.

Our study has several limitations. We did not attempt to evaluate the impact of cleaning on microbial contamination, but the association between ATP levels and microbial contamination has previously been noted.[3,5] Similarly, we did not seek to demonstrate an association between room cleanliness and HAI incidence. An automated system to monitor the amount of time that it took to clean a room was used, and direct observation was not conducted. We felt that direct observation of housekeepers to assess the amount of time that it took to clean a room would unduly affect their cleaning practices and create a strong Hawthorne effect. The physical variability between patient care units may have influenced the amount of time needed to clean a room, and patient-specific factors that were not accounted for may have impacted the amount of soiling of the room and thus the results of terminal cleaning. The study is subject to selection bias, because we assessed a convenience sample of rooms during normal work hours. Because there was concern from regu-

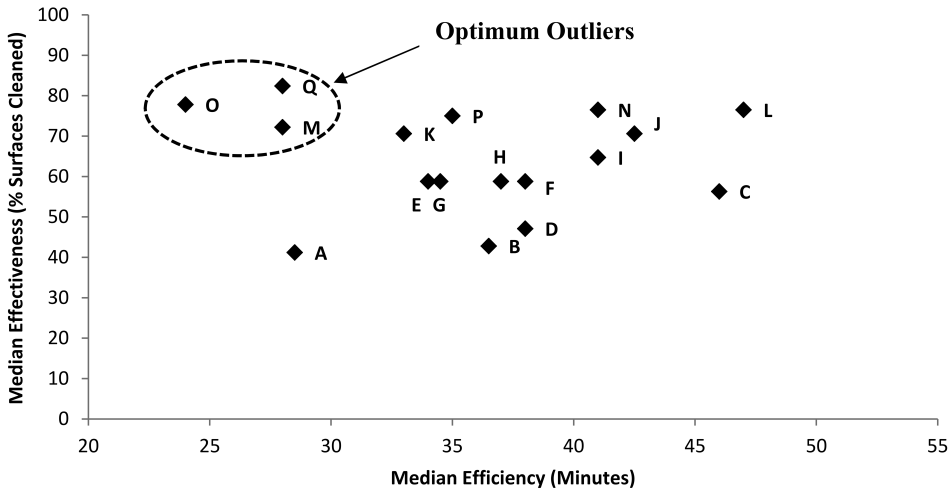

FIGURE 1. Median efficiency (time required to clean rooms in minutes) versus median effectiveness (percentage of surfaces cleaned) for 17 housekeepers (A–Q). The oval indicates those housekeepers (M, O, and Q) who were significantly better cleaners than their coworkers (ie, the "optimum outliers").

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latory groups that our data could be used for punitive purposes, and because housekeepers were not asked to grant informed consent, the identity of the housekeepers was obscured. Finally, this was a single-center study, and our observations may not be generalizable. However, 3 diverse areas of the hospital, including critical care and routine care units, were studied, and it is likely that other institutions have similar opportunities to improve effectiveness and efficiency of cleaning.

In conclusion, we confirmed that a greater amount of time spent by a housekeeper cleaning a hospital room does not translate into a better level of cleaning as assessed by ATP levels on high-touch surfaces. More importantly, we clearly demonstrated that there is a small subset of housekeepers who function at a higher level of efficiency and effectiveness of cleaning compared with their coworkers. There is an opportunity to use these optimum outliers to improve cleaning, which may result in a decreased risk of HAI.

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