Monitoring the effectiveness of cleaning in four British hospitals

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Background: A survey of cleaning effectiveness was conducted in two wards in four acute hospitals in England and Wales. Surfaces were monitored immediately before and after cleaning on three separate occasions using visual assessment, adenosine triphosphate (ATP) bioluminescence, expressed in relative light units (RLUs), and microbiological methods (aerobic colony counts [ACC]), expressed in colony forming units (cfu) per cm^2.
Methods: Comparison of data from a total of over 3000 assessments showed highly significant differences in failure rates between visual assessment and either ATP or microbiological counts. There was no significant difference in failure rates between ATP and microbiological counts. Using visual assessment, failure rates were significantly lower after cleaning than before. Using ATP or microbiological methods, failure rates were not significantly different after cleaning.
Results: Data obtained using both ATP and ACC, indicated considerable variability after cleaning and that failed surfaces were often well in excess of benchmark values.
Conclusions: Cumulatively, the results indicate that visual assessment is not a reliable indicator of surface cleanliness or of cleaning efficacy. Concerns also arise about the standards of surface cleanliness achieved after cleaning in the hospitals. (Am J Infect Control 2007;35:338-41.)

Hospital cleaning in the UK, and elsewhere, has a high media profile and has attracted adverse comments concerning lack of effectiveness and poor management.[1,2,3,4] Concerns have been expressed in the UK that cuts in cleaning budgets as a means to save money have led to a deterioration in hospital cleanliness.[5] The government, in an attempt to improve standards, has launched a number of initiatives.[6,7] These often make use of ''audits'' (although most of these should be more correctly described as inspections or checks) to assess standards of cleanliness. However, rather than evaluate how cleaning was undertaken, or take a scientific approach to assessment,[8] they rely on visual surface inspection and often provide little advice on how surface cleanliness is to be assessed. Cleanliness can be difficult to define[9] and attempts have been made to make the visual assessment less subjective. Typical guidance found in one UK inspection includes ''surface visually clean with no blood or body spillages, dust, dirt, debris, and spillages.''[6] Other countries have also tried to both define and assess cleanliness. In the Netherlands, a standard (EN 2075) was developed that has more recently become a European Standard.[10] However, this argues that an assessment of cleanliness must always be made in the context of how and when cleaning should have been undertaken. The INSTA800 is a Nordic standard for the evaluation of cleaning efficacy and considers ''friction, gloss, static electricity and hygienic quality indoors,'' again with an emphasis on visual assessment.

In food manufacturing and processing, emphasis is placed on environmental surface cleanliness to control pathogens, and a more scientific approach to assessment has been adopted where routine use of microbiological and rapid test methods are linked to trend analysis.[9] Concerns have been expressed about relying on visual assessment as the sole means for assessing cleanliness in hospitals,[11] and a previous study in one hospital indicated that it may overestimate cleaning efficacy.[12] Although routine environmental microbiological testing is not normally undertaken in hospitals, in the UK, microbiological surface standards have been proposed.[8]

Following on from previously published work,[12] the aims of the present study were to:

- Assess the efficacy of visual methods to assess cleanliness in relation to other techniques
- Compare surface cleanliness of common ward surfaces across four hospitals before and after cleaning

METHODS

The study was conducted across four opportunistically selected acute hospitals up to 250 miles apart in

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Table 1. Failure rates before and after cleaning using different assessment methods

	% Failure					
	Before cleaning			After cleaning		
	Visual	ATP	ACC	Visual	ATP	ACC
Hospital A						
Paediatric	28	94	76	20	97	65
Surgical	27	98	86	15	97	66
Hospital B						
Paediatric	24	83	80	3	96	65
Surgical	25	92	75	15	97	66
Hospital C						
Paediatric	19	89	67	7	90	90
Surgical	11	88	75	7	90	81
Hospital D						
Paediatric	11	100	81	13	100	86
Surgical	15	100	81	6	97	84

ATP, adenosine triphosphate; *ACC*, aerobic colony counts.

Table 2. Differences in failure rates after cleaning, between visual and two other assessment methods

	After cleaning	
	ATP (%)	ACC (%)
Hospital A		
Paediatric	77	45
Surgical	82	51
Hospital B		
Paediatric	93	62
Surgical	82	51
Hospital C		
Paediatric	83	83
Surgical	83	84
Hospital D		
Paediatric	77	73
Surgical	91	77

ATP, adenosine triphosphate; *ACC*, aerobic colony counts.

England and Wales. A paediatric and a surgical ward was studied in each hospital (labeled A, B, C, and D) without discussion with cleaning staff, in order to minimize behavioral changes in cleaning practices. None of the hospitals had a comprehensively documented cleaning strategy. Hospitals were visited on three occasions to evaluate cleanliness of selected environmental sites immediately before and after cleaning. Experimental methods and the selection of environmental surfaces were based on previous research.[11,12] In total, 27 surface sites distributed throughout patient sleeping areas, ward kitchens, sluice rooms, treatment rooms, and bathroom areas were chosen for monitoring. Sites were selected to include those with high frequency of contact by staff and patients, with the potential to be involved in cross-infection transmission routes.[13] These included hand contact surfaces such as the handles of doors, toilet flushes, trolleys, cupboards, fridges, microwave ovens, faucet handles, the front and central area of bin lid tops, worktops, bedside cabinets, bed frames, and toilet seats. The materials at testing sites were mostly stainless steel or laminate plastic. For each site, general surface condition, the presence of moisture, and visual cleanliness were noted. In general, surface conditions were found to be good. The visual assessments were done by one person using standardized descriptors.[12] The presence of adenosine triphosphate (ATP), which is derived from organic soil and microorganisms, at each site was assessed by a rapid hygiene test of ATP bioluminescence, using the Biotrace Cleantrace system (Biotrace Ltd, Bridgend).[12] Conventional microbiological tests using dip slides coated with plate count agar were used to produce aerobic colony counts (ACC).[12] Colonies were counted and are expressed as colony forming units (cfu) per cm^2, according to the manufacturers' instructions. The ATP measures organic debris and is a measure of cleaning efficacy, whereas microbiological analysis reflects the degree of disinfection achieved. The ATP measurements may or may not correlate with surface microbiological counts.[9] Comparing sensitivity of the two methods is not productive, but relating the data to proposed standards[8,12] gives more meaningful information in terms of pass and failure rates.

The presence of soil, dust, smears, or stains on a surface were regarded as unclean and constituted a fail. Raw data from ATP bioluminescence and microbiological sampling were interpreted as passes or failures using benchmark values that were obtained after cleaning over 5000 different surfaces using good cleaning practice.[9,14] On this basis, ATP values of less than 500 relative light units (RLUs) and less than 2.5 cfu/cm^2 for microbial counts were considered a pass and measurements of at least 500 RLUs ATP and at least 2.5 cfu/cm^2 as a fail. The microbiological benchmark values are similar to those proposed in Sweden for surfaces after cleaning in the food industry,[15] slightly higher than those proposed for operating theatres in Scandinavia,[16] but slightly lower than those suggested for UK hospitals.[8] Using this test system, the hospital ATP benchmark value equates to those surfaces after cleaning that are in contact with ready-to-eat foods.[17]

STATISTICS

Percentage failures before and after cleaning were analyzed for statistical significance using Minitab (version12.1) by the Wilcoxon matched paired test. Further comparisons in pass/fail rates used the chi-square test; in all cases significance was at least $P < .05$.

Table 3. Mean values and ranges for ATP and microbiological data

	Before cleaning						After cleaning					
	ATP			ACC			ATP			ACC		
	Mean (RLU)	n	Range	Mean	n	Range	Mean (RLU)	n	Range	Mean	n	Range
Hospital A												
Paediatric	9032.62	75	66–>500,000	23.22	75	<1–>200	13775.28	75	435-119946	33.35	74	<1–>200
Surgical	9881.41	68	70–>500,000	30.81	64	<1–>200	10361.27	68	323-46550	29.56	64	<1–>200
Hospital B												
Paediatric	6204.99	72	22–52410	16.58	69	<1–>100	7922.33	70	181- >500,000	22.07	69	<1–>100
Surgical	8897.90	61	100–24262	23.45	59	<1–>100	10584.24	59	307-181477	23.30	58	<1–>100
Hospital C												
Paediatric	3155.97	63	135–10124	12.07	65	<1–>50	4818.31	64	89-27775	14.36	65	<1–>100
Surgical	7048.25	69	181–45580	18.23	68	<1–>200	6588.19	66	68-27412	34.06	67	<1–>200
Hospital D												
Paediatric	5364.20	72	565–10319	25.12	69	<1–>100	4634.27	72	544-15691	23.45	69	<1–>100
Surgical	11795.32	72	565–>500,000	27.62	71	<1–>200	5440.26	73	48-19469	22.26	70	<1–>100

ATP, adenosine triphosphate; *ACC*, aerobic colony counts; *RLU*, relative light unit.

RESULTS

Twenty-seven locations within two wards of four hospitals were selected for environmental surface testing, using three different methods. However, structural differences, patient activities, and treatment regimens prevented every site being sampled on every occasion. In total, 993 visual assessments, 1099 ATP measurements, and 1074 ACC determinants were recorded.

Failure rates for surface cleanliness, using the different methods, varied considerably (Table 1). Differences in visual and ATP failure rates (Table 2) were highly significant ($P < .001$) and consistent, and varied from 77% to 91%. The differences between visual and microbiological failure rates were also highly significant ($P < .001$) but more variable and slightly lower, ranging from 45% to 84%. The differences between ATP and ACC failure rates were not significant and varied from 0% to 32%. Within individual hospitals, failure rates were consistent between different wards using each of the three methods.

Using visual assessment, failure rates were significantly lower after cleaning than before. Differences in failure rates before and after cleaning, using ATP, were small and not significantly different, ranging from 0% to 13%, although the majority were within 3%. Differences in microbiological failure rates before and after cleaning ranged from 3% to 20% and were not significantly different.

Failure rates provide an indication of cleaning efficacy in relation to benchmark values but do not provide an indication of the extent of the failure. A summary of the overall ATP and ACC data to illustrate mean values and the range of data points is provided in Table 3. Wide variations in counts, using ATP and ACC, were found between sites and hospitals. The ATP results, after cleaning, varied from 48 RLUs to instrument overload greater than 500,000, with ACCs from less than 1 cfu/cm^2 to greater than 200 cfu/cm^2. Sites most likely to fail were in kitchens and bathrooms. The data contained in Table 3 indicates that sites that were failing were often well in excess of the benchmark values, with mean RLUs after cleaning ranging from 4818 to 13,775 and mean microbial counts from 14 to 33 cfu/cm^2.

DISCUSSION

Reports continue to highlight problems associated with cleaning in hospitals[1,4] and the results of this study, using a range of assessment techniques, reinforce some of these concerns. However, previous reports were based on visual assessment and the present study indicates that failure rates would have been much higher if other forms of assessment had been used. Cleaning can be defined as the physical removal of soil[9,18] (which is defined as ''matter out of place'') or the process which physically removes contamination without necessarily destroying microorganisms.[19] Cleaning does remove some microorganisms but for a greater reduction in surface microorganisms, a disinfectant will need to be used. However, residual surface organic soil can provide nutrients and protection for a range of nosocomial pathogens[20] and reduce the efficacy of disinfection.[18] The present results indicate considerable levels of invisible organic soiling remaining on surfaces after cleaning. While the objectives of cleaning are not contentious, what is clean and acceptable can be difficult to define unambiguously and it has been argued that it is only possible to define cleanliness by including the method of assessment.[9] Acceptable levels of microorganisms on surfaces are likely to be location-specific and depend upon who is making the judgement and why. One approach is to base acceptance on risk, although

background information on this is lacking. The values used for pass/fail adopted in this study, although broadly similar to other standards, were derived differently and were benchmark values (ie, what was attainable on a variety of hard surfaces in good condition) after implementation of good cleaning practice.

The ATP and microbiological results after cleaning were highly variable; this has been previously reported[12] and generally indicates inconsistencies in the quality of cleaning.[18] The sites included in this study were chosen without reference to the cleaning schedules at each respective hospital and it is recognized that some of the sites may have been cleaned at an irregular frequency. In fact the cleaning schedules used at the time of the study did not provide comprehensive instructions on how the surfaces should have been cleaned nor did they require the cleaning process or its efficacy to be monitored.

The results indicate that visual assessment, on its own, was an unreliable indicator of surface cleanliness and as a means for assessing the effectiveness of cleaning protocols. However, it is important for patient/consumer perceptions and can be of use as the first stage in an integrated assessment protocol.[12] Also of concern was the failure to demonstrate a statistically significant difference between ATP and ACC values before and after cleaning at any location in either ward, for any of the four hospitals. The fact that some sites were below benchmark ATP or microbiological values on occasions did, however, indicate they were capable of being cleaned.

Reasons for ineffective cleaning have been documented[9] and it is likely that a number of the higher ATP/microbiological counts after cleaning were as a result of dirt and/or microorganisms being redistributed by cleaning rather than removed. Simple changes to the cleaning processes used in hospitals can achieve substantial improvements leading to a reduction in the residual surface levels of ATP, ACC, indicator organisms, and methicillin-resistant *Staphylococcus aureus*.[21]

Cumulatively the results do not indicate that the hospitals were obtaining value for money. Moreover, the wide variation in the microbiological and ATP results from specific sites raises concerns over the consistency of implementation, and thus the management of the cleaning process.

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