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Research Article

Assessment of Soiling on Highly Touched Clinical Surfaces in Intensive Care Units

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Abstract

AIM: The aim of this study is to evaluate highly touched clinical surfaces using visual inspection methods and adenosine triphosphate by bioluminescence to identify soiling in intensive care units.

METHOD: Descriptive, cross-sectional study carried out in three intensive care units located in Belo Horizonte, MG, Brazil. Data collection included 142 assessments of environmental surfaces. For data analysis, the Pareto diagram and descriptive statistics were used through measures of central tendency.

RESULTS: The visual inspection identified dirtiness in the infusion pump, alcohol dispenser, and telephone. The surface that showed a high level of contamination by organic matter identified by the adenosine triphosphate bioluminescence test was the telephone, with a median of 1012 RLU/cm^2 (±348.8).

CONCLUSION: The surface evaluation methods used in the intensive care units made it possible to identify dirt on surfaces highly touched by hands, reinforcing the need for investments in training and audits in the process of cleaning and disinfecting surfaces.

Keywords: Disinfection, equipment contamination, intensive care units, nursing

Introduction

The occurrence of health-care-associated infections (HAIs) may be associated with several factors, attributing it to the patient's state of health, poor hand hygiene, an ineffective program for managing the use of antimicrobials, breach of care protocols, and environmental conditions (Chaoui et al., 2019). They can correlate endogenously, where the patient's own flora is the source of infection, and/or exogenously when the microorganism comes from other patients, health professionals, and environments, such as water, air, or contaminated surfaces (Chaoui et al., 2019).

In general, clinical environmental surfaces present a low risk of direct transmission of HAIs. However, they can contribute to cross-contamination through hand contact with instruments or equipment used in patient care. Highly touched clinical environmental surfaces are at a greater risk of harboring microorganisms characteristic of the hospital microbiota and eventually colonizing or infecting susceptible individuals (Dresch et al., 2018).

Researchers emphasize the importance of cleaning and disinfecting clinical environmental surfaces as part of a comprehensive multimodal strategy to reduce the occurrence of HAIs (Frota et al., 2017). In addition, with the period of the coronavirus disease 2019 (COVID-19) pandemic, the relevance of strict control of environmental cleaning became more evident (Hollis et al., 2021). Some clinical surfaces, such as the bed rail, the stretcher, the doorknobs, the infusion pump, and other places, can act as a reservoir of microorganisms of epidemiological importance (Espíndola et al., 2021; Rawlinson et al., 2019).

Especially in intensive care units (ICUs), most patients have severe clinical conditions, are often subjected to invasive procedures, and require continuous advanced monitoring and support, making them more susceptible to HAIs. Another important aspect refers to the fact that surfaces, clinics, and ICU equipment are constantly touched by different health professionals, specifically, the nursing team, requiring periodic surveillance due to the risk of contamination in these places (Espíndola et al., 2021).

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Several methods are used to evaluate the effectiveness of cleaning and disinfection of clinical environmental surfaces in health services, emphasizing visual inspection, fluorescent markers, microbiological cultures, and adenosine triphosphate (ATP) test by bioluminescence (Frota et al., 2017). The literature presents results on the effectiveness of cleaning highly touched clinical environmental surfaces, highlighting dirt that can compromise patient safety (Espíndola et al., 2021; Wang et al., 2022). However, the simultaneous evaluation of surfaces in the ICU using visual inspection and the bioluminescence ATP test still requires investigations to validate the cleaning and disinfection process of environmental surfaces, thus justifying the elaboration of this study.

The aim of this study is to evaluate highly touched clinical environmental surfaces using visual inspection and ATP bioluminescence methods to identify soiling in ICUs.

Research Questions

1. Is it possible to identify soiling in the ICU through visual inspection and bioluminescence ATP test?
2. Do highly touched clinical environmental surfaces in the ICU have a high level of contamination?

Method

Study Design

This is a descriptive, cross-sectional study carried out in three ICUs of a large private hospital located in the city of Belo Horizonte, MG, Brazil.

Sample

For this research, non-probabilistic sampling was used for convenience. It was decided to select environments of the ICUs that contained hospitalized patients and the nursing station, considered a place of high turnover of health professionals and risk for contamination of environmental surfaces. Clinical surfaces were defined based on the frequency of contact and proximity to care points, as they are strongly related to the spread of pathogens and the occurrence of HAIs (Cobrado et al., 2017; Villacís et al., 2019).

Data Collection

Data collection was carried out by the researchers themselves between March 4 and May 30, 2022. Two evaluation methods were used to identify dirt on environmental surfaces: (i) visual inspection and (ii) ATP test by bioluminescence.

The hospital is responsible for the care of various medical–surgical specialties. It has 200 hospital beds, including 50 intensive care beds. In addition, emergency care, a surgical center with 13 rooms for elective, urgent, and emergency procedures, hemodynamics, and endoscopy. In the case of the ICUs, the infrastructure is made up of three units for post operative patients, general and cardiovascular care.

The sample consisted of 22 alcohol dispensers, 16 infusion pumps, 10 bed rails, 10 doorknobs, 10 auxiliary tables, and 3 telephones, totaling 71 surfaces. Inclusion criteria were having a patient hospitalized for more than 3 days and receiving direct assistance from the multidisciplinary team. In the case of the telephone, located at the nursing station, it is noteworthy that all were included, as there was only one device in each sector.

The institutional protocol, described as the Standard Operating Procedure (SOP), was revised and updated in January 2022 by the coordination of the hygiene service, infection control service related to health-care and the nursing manager. Regarding the disinfection of surfaces, WypAll® X60 cloths composed of polypropylene and cellulose, disposable 35 × 28 cm (Kimberly-Clark, São Paulo, SP, Brazil). The cloths were moistened immediately before use with Perox 4D composed of 4.25% Hydrogen Peroxide and Cocobenzyl Chloride. Alkyl dimethyl ammonium, 5.6% didecyl dimethyl ammonium chloride, which performs cleaning and disinfection in a single step and has a residual action of Quaternary Ammonium for 72 hours (Spartan do Brasil Produtos Químicos LTDA, Sumaré, SP, Brazil).

At the study site, the surface cleaning and disinfection protocol must be performed daily by the cleaning team (concurrent cleaning). In the case of terminal cleaning, the periodicity was weekly. In the absence of discharge, transfer or death of patients hospitalized for more than 7 days, the routine was partially carried out, excluding walls and ceilings. Nursing professionals are responsible for cleaning and disinfecting health-care materials and equipments, including infusion pumps and auxiliary tables—at the beginning of each shift.

The first considered surface is rejected if it presented any of the following variables: the presence of dust, adhesive tapes or other adhesive residues, secretion and/or excretion, inorganic liquids, moisture, and/or stains.

The ATP test by bioluminescence was performed with a *swab* (3M™ *Clean-Trace™ ATP Surface Test Swab*) and a portable luminometer (*Clean Trace* model NG2). According to the manufacturer, the reading of the ATP test by bioluminescence considered the following parameters: between 0 and 250 relative light units (RLU)/cm^2 (approved) and above 250 RLU/cm^2 (failed). In this way, the researchers removed the *swab* from the tube and applied it directly to the surface, performing movements both vertically and horizontally, with the collection sites specified in Figure 1.

Statistical Analysis

Data analysis was performed using descriptive statistics to present absolute and relative numbers in relation to the visual inspection method. Measures of central tendency (median and mean) and standard deviation were used to evaluate ATP results by bioluminescence. The categorization of ATP test results (pass or fail) considered the median values of each evaluated surface. All analyses were performed using the *Epi Info* 7 ® software. To evaluate the failure rate, the following formula was used: number of items that failed divided by the total surfaces evaluated × 100.

A Pareto diagram was created in *Microsoft Excel* ® with the objective of evaluating the highest accumulated percentage of occurrences of surface dirtiness in the ICUs. The development of the tool included the following steps: identification of

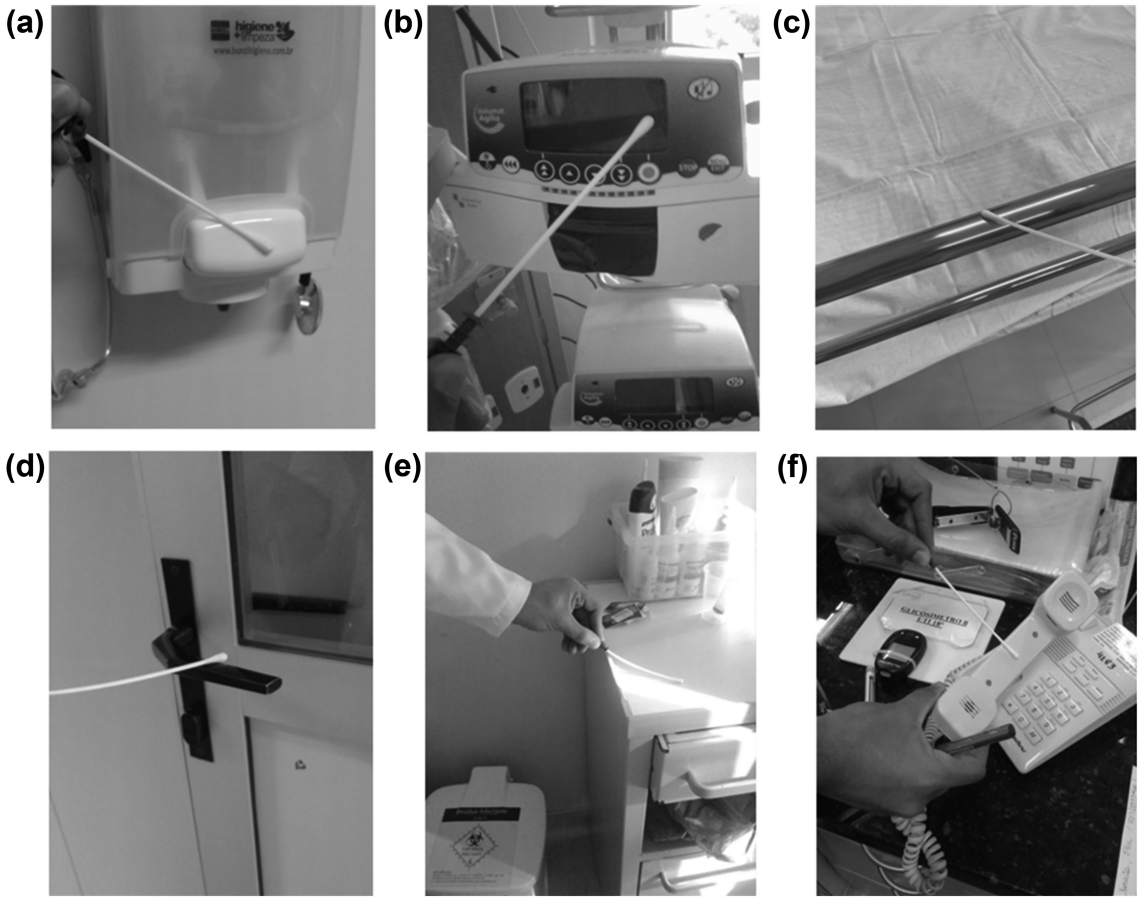

Figure 1.
Clinical Surfaces Highly Touched by Hands. *Note: The* swab *collection sites were: (A) the entire activation area of the 70% alcohol dispenser for hand hygiene; (B) infusion pump display and keys; (C) in the entire length used to raise and lower the bed rail; (D) in the entire external and internal area of the handle located in the box of the intensive care units; (E) throughout the extension of the auxiliary table, including the sides; (F) at the place where the handset of the landline telephone is located (inside and outside).*

the problem; stratification of different causes; data collection through records raised by visual inspection; and the prioritization of problems through the construction of the graph, including the causes and their respective frequencies that must be highlighted (Galdino et al., 2016).

Ethical Consideration

As this is a study that did not involve research with human beings, an opinion from the Ethics Committee on Research with Human Beings was not required. However, there was formal authorization through a letter granted by the nursing manager and a permission has been obtained from the institution.

Results

A total of 142 highly touched clinical environmental surfaces were evaluated, 71 per method. Table 1 shows that the alcohol dispenser (30.9%) and the infusion pump (22.5%) had the highest evaluation frequency. Regarding the places evaluated by the visual inspection method, the telephone (100.0%) and the alcohol dispenser (40.9%) stand out with the highest failure rates.

Figure 2 shows the Pareto diagram, according to the main problems identified by the visual inspection ($n=20$). The alcohol dispenser, the infusion pump, and the telephone were the clinical surfaces that had the highest accumulated percentage of

Table 1.
Distribution of Heavily Touched Clinical Surfaces and Visual Inspection Method Values

			Visual Inspection	
Assessment Locations	***n***	**%**	**Failed**	**Failure Rate* Percentage**
Alcohol dispenser	22	30.9	09	40.9
Infusion bomb	16	22.5	03	18.7
Bed rail	10	14.1	02	20.0
Handle	10	14.1	01	10.0
Side table	10	14.1	02	20.0
Telephone	03	4.2	03	100.0

Note: *Failure rate, by assessed category.

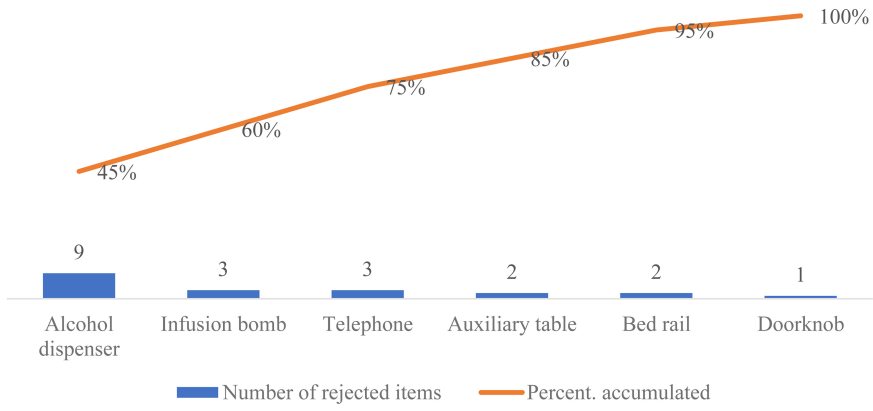

Figure 2.
Pareto Diagram for Dirty Surfaces Identified by the Visual Inspection Method.

dirtiness in the ICUs, with the three categories responsible for 75% of the occurrences.

As shown in Table 2, the values of the ATP test by bioluminescence reinforce the high level of dirt identified in the telephone, ranging from 784 to 1469 RLU/cm^2, with a median of 1012 (±348.8). Of the six surfaces included in this study, five (83.3%) passed after cleaning and disinfection, remaining below 250 RLU/cm^2.

Discussion

This study showed that the visual inspection methods and the ATP bioluminescence testing identified soiling on heavily touched clinical environmental surfaces in ICUs. One of the results that drew attention was the high level of contamination of the telephone, used by health professionals in the ICUs. The alcohol dispenser and the infusion pump, according to the Pareto diagram, should also be prioritized in cleaning and disinfecting surfaces, as dirt detected by visual inspection can compromise patient safety.

The cleaning and disinfection processes carried out in the hospital environment are necessary since the surfaces are related to a true reservoir of microorganisms (Lourenzo et al., 2020). Associated with this, hand hygiene should be a priority, as the sites selected for this study are touched more frequently and represent a risk for vulnerable patients (Adams et al., 2017). This fact undoubtedly requires the implementation of effective cleaning and disinfection methods (Rawlinson et al., 2019).

In this research, visual inspection revealed the highest frequency of dirt on surfaces such as alcohol dispensers, infusion pumps, and telephones. A similar study reinforced that the analysis of the effectiveness of hospital cleaning using only this method should not be considered as the only reliable indicator (van Arkel et al., 2020).

Complementarily, the ATP test by bioluminescence is suggested as a promising, reliable, and reproducible alternative in the quantification of values related to dirtiness. However, the literature highlights that the latter method still does not allow detection of the presence of microorganisms since it reflects the amount of all organic material (van Arkel et al., 2020; Wang et al., 2022).

In this context, cleaning and disinfecting the infusion pump, which had the secondhighest failure rate, is an activity performed by the nursing team. One of the possibilities refers to valuing training and qualification that promote significant improvements in the routine of cleaning and disinfecting surfaces in the short and long term (Lourenzo et al., 2020).

Table 2.
Adenosine Triphosphate-Bioluminescence Test Values Detected on Heavily Touched Clinical Surfaces

	Relative Light Units/cm ^{2}					
Assessment Locations	**Minimum**	**Maximum**	**Average**	**Median**	**SD**	**Result***
Alcohol dispenser	101	144	128	139	23.5	Approved
Infusion bomb	41	146	83	63	55.3	Approved
Bed rail	20	46	30	26	13.6	Approved
Handle	89	99	94	95	5.1	Approved
Side table	102	226	144	106	70.7	Approved
Telephone	784	1469	1088	1012	348.8	Disapproved

Note: *Considered the median values of each evaluated category.

A systematic review that evaluated environmental contamination in highly complex sectors before and after the cleaning and disinfection process highlighted hospital surfaces as potential places with the presence of organic matter (Lourenzo et al., 2020). Another study reinforced that weaknesses raised through the ATP test should be worked on periodically in the ICU, using health education and internal audits (Frota et al., 2017).

It is worth mentioning that half of the surfaces included in this study showed dirtiness observed by visual inspection after the cleaning and disinfection process, a fact that compromises the quality of care. The literature has shown a higher incidence of dirt on fomites where there is greater contact by health professionals, such as bed rails, faucets, keyboards, monitors, and doorknobs, which is related to the fact that surfaces that are touched a lot become more contaminated (Dresch et al., 2018).

It is noteworthy that, in the ICUs of this study, the cleaning and disinfection process of the studied surfaces uses a disinfectant that has a residual action of 72 hours according to the manufacturer. However, this did not significantly reflect on the effectiveness of cleaning and disinfection. Many factors may have influenced the results, such as how to apply the disinfectant to the cloth, the frictional force applied, the coverage of the area to be cleaned, or even whether the surface was cleaned. Regarding this last example, a study (Anderson et al., 2011) demonstrated that of the 12 sites without specifying which professional was responsible for cleaning the clinical equipment, 11 (92%) failed to reach the benchmark cutoff score lower than 100 RLU/cm^2.

Specifically, a study (Adams et al., 2017) conducted in an ICU concluded that surface bioburden at near-patient sites is associated with the frequency of manual contact by staff and visitors. This indicates the need for a cleaning and disinfection process directed at these surfaces since the ICU is in a high risk health-care environment. It is suggested that hand hygiene, the implementation of evidence-based protocols, the disinfection of surfaces and training of the professionals involved are the fundamental axes for the prevention and control of HAIs.

Although a low risk of transmission of HAIs has been demonstrated, the presence of organic matter and microorganisms on clinical surfaces can lead to cross-contamination between patients, professionals, and/or environments. The main mode of transmission involves direct contact, and the hands of health-care workers can transmit pathogens of epidemiological importance, such as *Clostridioides difficile*, vancomycin-resistant *Enterococci*, or methicillin-resistant *Staphylococcus aureus* (MRSA) (Lourenzo et al., 2020).

In this study, the telephone located at the nursing station alerted us to the elevated contamination levels. The literature shows that health professionals' cell phones and phones in common areas revealed the presence of organic matter at high levels (Deshpande et al., 2020; Ramirez et al., 2019). It is pointed out that the cell phone is individual, remaining with the same professional from the beginning to the end of the shift. However, the sector's telephone is shared among the multidisciplinary team, requiring greater attention from health services regarding the high level of contamination.

Research carried out during the COVID-19 pandemic, in a hospital located in China, showed that the value of the ATP test on surfaces evaluated at the nursing station showed values that reached 1641 RLU/cm^2 (Wang et al., 2022). The telephone is part of this place for carrying out technical and administrative activities, as evidenced in this study. It is observed that there is no specific definition about which professional should perform the cleaning and disinfection of this item, being necessary to define the person responsible for its disinfection in institutional protocol.

Surface cleaning and disinfection protocols do not always specify which professional category is responsible for cleaning each equipment, material, and surface. A study (Anderson et al., 2011) showed that regardless of who cleans what, the level of organic contamination detected by ATP by bioluminescence remains high. These findings indicate the need for a potential review of cleaning practices for clinical equipment, alongside staff education and the standardization of protocols to clearly define the responsibilities of each professional responsible for cleaning various surfaces.

The results will help to re-analyze ICU cleaning and disinfection protocols, as half of the clinical surfaces included in this study showed weaknesses in relation to visual inspection and the ATP test by bioluminescence. In addition, it will be able to subsidize discussions about the attributions of each professional, relevant aspects for the nursing, and hygiene team to promote the work in a qualified way.

Study Limitations

This study has limitations that must be considered. First, there was no microbiological analysis of the surfaces in order to establish associations with the methods used. In addition, the research was carried out in three ICUs of the same institution and in a limited period. Finally, non-probabilistic sampling was necessary due to the financial resources allocated to the acquisition of ATP tests, which did not prevent achieving the research objective.

Conclusion and Recommendations

The methods for evaluating the cleaning and disinfection of surfaces used in the ICUs identified the presence of dirt both by visual inspection and by the ATP test by bioluminescence. These findings suggest that cleaning practices for the analyzed surfaces may require revision, along with educating teams with specific cleaning responsibilities for each.

Ethics Committee Approval: This study did not involve research with human beings, an opinion from the Ethics Committee on Research with Human Beings was not required.

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F.G.P., A.C.O.C., F.C.C., A.A.V., A.M.F., L.M.C., A.G.S.J., D.A., A.F.L.S.; Writing – A.L.S.A., A.M.F.; Critical Review – A.L.S.A., F.G.P., A.C.O.C., F.C.C., A.A.V., A.M.F., L.M.C., A.G.S.J., D.A., A.F.L.S.

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