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RESEARCH ARTICLE

Frequency of hand contact with hospital surfaces in hospitalized pediatric patients

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Abstract

Background: *Hand hygiene (HH) is an important strategy for preventing health-care-associated infections (HAIs). Few programs focus on HH for family members and primary caregivers but fewer for patients. This study aimed to estimate the frequency with which hospitalized pediatric patients have hand contact with hospital surfaces.* **Methods:** *We conducted a cross-sectional descriptive observational study consisting of three phases: the first was the creation of an observation and data collection tool, the second was the training of the monitors, and the third was the observational study of hand contact and HH opportunities in hospitalized pediatric patients.* **Results:** *Over 3600 minutes of observation, 2032 HH opportunities were detected, averaging 33.8/h (SD 4.7) as determined by hand contact with hospital surfaces of hospitalized pediatric patients. In our study, infants and preschool children had the highest frequency of hand contact.* **Conclusion:** *The high frequency of hand contact of hospital surfaces by children suggests that hourly hand disinfection of patients and caregivers, objects and surfaces around the patients may be prevention measures that could be incorporated to reduce HAIs in pediatric hospitals.*

Keywords: *Pediatrics. Hand hygiene. Infection control. Health-care-associated infection.*

Frecuencia de contacto de manos de pacientes pediátricos hospitalizados

Resumen

Introducción: *La higiene de manos es una estrategia importante para la prevención de infecciones asociadas a la atención sanitaria. Existen pocos programas centrados en la higiene de manos para los familiares y cuidadores primarios, y aún menos para el paciente. El objetivo de este estudio fue cuantificar la frecuencia con la que los pacientes pediátricos hospitalizados tienen contacto manual con superficies hospitalarias.* **Métodos:** *Se llevó a cabo un estudio observacional descriptivo transversal que constó de tres fases: la primera fue la creación de una herramienta de observación y registro de datos; la segunda fue la capacitación de los monitores y la tercera fue el estudio observacional del contacto manual y de las oportunidades de higiene de manos en pacientes pediátricos hospitalizados.* **Resultados:** *Durante los 3600 minutos de observación, se detectaron 2032 oportunidades, con una media de 33.8 (DE 4.7) por hora de oportunidades de higiene de manos establecidas por contacto manual con superficies de pacientes pediátricos hospitalizados. Los lactantes y los niños en edad preescolar presentaron la mayor frecuencia de contacto manual.* **Conclusiones:** *La alta frecuencia de contacto manual por parte del niño indica que medidas como la desinfección de las manos cada hora del paciente y del cuidador,*

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así como de los objetos y superficies alrededor del paciente, podrían ser medidas útiles que deberían incluirse para prevenir las infecciones asociadas a la atención de la salud en los hospitales pediátricos.

Palabras clave: *Pediátricos. Lavado de manos. Control de infección. Infecciones relacionadas con la asistencia sanitaria.*

Introduction

Health-care-associated infections (HAIs) are the most frequent adverse events associated with providing health-care services. According to the World Health Organization (WHO), approximately 1.4 million people worldwide acquire an HAI each year. However, in developing countries[1], the risk of acquiring an HAI can be as much as 20 times greater than in developed countries. The prevalence of hospitalized patients who acquire one or more HAIs in developed countries ranges from 3.5% to 12%. In contrast, in developing countries, the HAI prevalence varies between 5.7% and 19.1%, with some studies reporting over 25% of hospitalized patients being affected[2].

According to the General Directorate of Epidemiology, in 2011, the prevalence of HAIs in general hospitals in Mexico was 21%, which is higher than international statistics[3]. In the pediatric population, the global incidence rate for nosocomial infections is 8.8-17.5/1000 patient days in developing countries[4]. In 2014, it was reported that the HAI incidence rate for our hospital was 19.64 HAIs per 1000 patient days[5].

Hand hygiene (HH) is the most important strategy for preventing HAIs. In 2009, the WHO integrated the HH Guide for Global Health in Healthcare guidelines[6]. Since then, remarkable progress has been made in reducing HAIs rates, accompanied by various studies and programs that confirm and support this initiative. These programs implement specific measures that healthcare workers must follow to break the chain of microbial transmission among hospitalized patients. As outlined in the WHO Five Moments, adherence to HH practices significantly reduces the risk of patients acquiring HAIs[6]. Most programs initiated by various health agencies focus primarily on promoting HH among healthcare workers.

It is widely recognized that children have frequent hand contact with the environment, people, and their mucous membranes during development. Furthermore, emphasizing hand washing among children is an important public health measure to reduce various types of infections[7]. Surprisingly, little attention has been paid to HH opportunities for patients, with most studies focusing on adult patients[8]. The timing of proper HH practice among hospitalized pediatric patients has not been studied. There is not enough information about the participation of hospitalized pediatric patients in the chain of transmission of microorganisms for the prevention of HAIs. This study aimed to estimate the frequency with which hospitalized pediatric patients have hand contact with hospital surfaces and could intervene in the chain of transmission of microorganisms by hand contact. These moments could eventually be turned into patient HH opportunities or be useful in developing other prevention strategies for hospitalized children.

Methods

Study design

We conducted a cross-sectional descriptive observational study conducted in a 290-bed national pediatric referral teaching hospital.

The research, ethics, and biosafety committees approved the protocol.

Settings

The research study consisted of three phases: the first was the development of a data collection form, the second was the training of the monitors, and the third was the observational study of HH opportunities of hospitalized pediatric patients.

Phase 1: Development of the data collection form. Based on the WHO 2009 Guidelines for HH in Health Care and consultation with specialists in pediatric neurodevelopment, pediatricians, hospital epidemiologists, and infection control nurses, the situations in which the hospitalized patient could transmit pathogens through their own hands were identified. According to this review, four categories of contact were considered: mucosal or surgical wound contact, invasive devices, people, and objects outside the patient's area. The tool is shown in Table 1.

All the moments were placed in a format along with general patient data, date, start and end time of the observation, and duration of the observation. In the format, the number of times the patient had any of the contacts was scored. One contact was considered

Table 1. Tool to measure hand contact in hospitalized children

	Register of hand contact of the pediatric patient	Total
Category 1: Objects outside the patient/'s area Cellphone or tablet Toys Crib or bed railing Dresser or urinal Food tray Others		
Category 2: People Healthcare personnel Primary caregiver Others		
Category 3: Mucous membranes or surgical wounds Ears Nostrils Eyes Mouth Anus Genitals Surgical Wounds Others		
Category 4: External objects Peripheral venous accesses Central venous catheter Urinary catheter Body drains (ileostomies, colostomies) Tracheostomy Others		

if the patient touched the area in question once or several times without touching another area. For example, it was considered a single moment if the patient touched a toy several times without touching the caregiver, mucous membranes, or other objects or devices. On the contrary, if the patient touched a toy, then touched the caregiver, and returned to the toy, two contacts were considered for the first moment and one for the second.

Phase 2: Training of the monitors. A group of medical students and pediatric residents was trained through a workshop. The workshop included the following topics: transmission of healthcare-associated pathogens through the hands according to the WHO HH guidelines[6], WHO moments of HH, the importance of HAIs and the benefits in their prevention, and filling out the data collection form of Phase 1. The instruction was face-to-face with slides and videos; the trainers were a pediatrician and a hospital epidemiologist. Five 1-h training sessions were held in groups.

Phase 3: Execution. Prior informed consent of the parents and assent of those over 8 years of age, both requested by the principal investigator, the observers went to pediatric hospitalization services. They stood outside the patient's room while simulating doing another activity. Covert observation was facilitated since the patient rooms have transparent glass walls, and every room has 2-5 patients with their respective caregivers.

Study size

According to what is considered a minimum to make comparisons in HH, 200 opportunities[6] and considering an average of one opportunity every 5 min and 20% of invalid observations, a time observation sample size was calculated in 1200 min. A monitor observed the participants at 20-min intervals from 8:00 to 12:00 in the morning.

Participants

Hospitalized patients from 1 month to 18 years of age were included in the study. Patients whose primary caregivers did not give informed consent or children > 8 years of age who did not give an asset, patients under the effects of sedation, and patients with a serious medical condition according to the record or in a critical situation during the visit were excluded from the study. The study was immediately stopped, and the nurse and attending physician were informed if the patient manipulated the central venous catheter, peritoneal dialysis catheter, or hemodialysis catheter, touched a surgical wound without HH, or had unintentional removal of any device.

The age groups were as follows: infants (0-3 years), preschool (3-5 years), school-age (6-12 years), and adolescents (13-18 years).

Variables

- Mucous membranes or surgical wounds: contact with ears, nostrils, mouth, anus, genitals, eyes, surgical wounds, and others were considered.
- Invasive devices: peripheral venous accesses, central venous catheters, urinary catheters, body drains (ileostomies, colostomies), tracheostomies, and

others (open section to describe another object not included in the category).
– People: refers to those who enter the patient's area, that is, health-care personnel, primary caregiver, or other (open section to describe another object not mentioned in the category).
– Objects outside the patient's area: cell phone or tablet, toys, crib or bed rail, dresser or urinal, food tray, and other (open section to describe another object not mentioned in the category).

Statistical methods

Statistical analyses were performed using SPSS (Statistical Package for the Social Sciences) version 20 software (SPSS Inc.) and Excel. Frequencies, percentages, means, and medians were used for descriptive analysis. The description of the frequency of missed moments of HH in hospitalized pediatric patients was based on these estimates: incidence of contacts/observation time, variability of contacts by age groups, by category, and by items within each category.

Results

A total of 3600 minutes of observation were performed in 60 patients of whom 34 (56.6%) were females. The time of observation was distributed as follows: 1800 min (50%) in infants, 900 minutes (25%) in school-age patients, 780 min (22%) in preschoolers, and 120 min (3%) in adolescents. The distribution of services was 22 (36.7%) in pediatric internal medicine and 17 (28.3%) in gastroenterology; the rest was observed in cardiology (10; 16.7%), infectious diseases (9; 15%), and endocrinology (2; 3.33%). Half of the patients (30, 50%) were infants, and about a quarter were schoolchildren (15, 25%). Moreover, there were 13 preschoolers (21.7%) and two adolescents. During the 3600 min of observation, 2032 opportunities were detected, and the mean of incidence of contacts was 33.8 SD 4.7/h.

Differences by age group

Significant differences in the frequency of hand contact per hour were observed between age groups. The most frequent age group was infants, with 37 occasions per hour, as opposed to adolescents, with < 1 occasion per hour. It is observed that the older the age, the lower the frequency of hand contact (Fig. 1).

Differences by category

Among the categories, "Objects outside the patient area" was the most common, with 20 contacts per hour. The least common category was invasive devices, with < 2 contacts per hour (Table 2).

Differences by subcategory

For the subcategories, the mouth was the most frequently touched site; for invasive devices, the peripheral venous catheter was the most frequently touched one; for contact with people, contact with the primary caregiver was almost 5 times more frequent than contact with health-care personnel; finally, in the category of external objects, the subcategory "other" was the one with the highest number of contacts.

Comparison of hand contacts between age groups and categories

For all categories evaluated in this study, the preschool group is the group with more hand contacts in each category ($p = 0.001$), followed by the school-age group, and then the infants. The results are shown in Table 3.

Discussion

The safety of the patient environment in the public sector is compromised by its communal nature, as it is a shared space with other patients and their caregivers. This communal environment increases the likelihood of exposure to various pathogens, thereby increasing the risk of HAIs. Therefore, monitoring interactions with hospital surfaces and developing risk-reduction strategies are critical. Particular attention should be paid to contact with medical devices as they serve as direct entry points for pathogens. Therefore, it is imperative that healthcare workers who care for pediatric patients are supported in maintaining clean hands.

In this study, we found interesting and scarcely published information about hand contact by hospitalized pediatric patients. First, on average, children make contact with their hospital environment, themselves, or caregivers more than once every 2 min, potentially participating in the chain of microbial transmission. Second, infants and preschool children had a higher incidence (about once every minute and a half) and a higher variability of contacts.

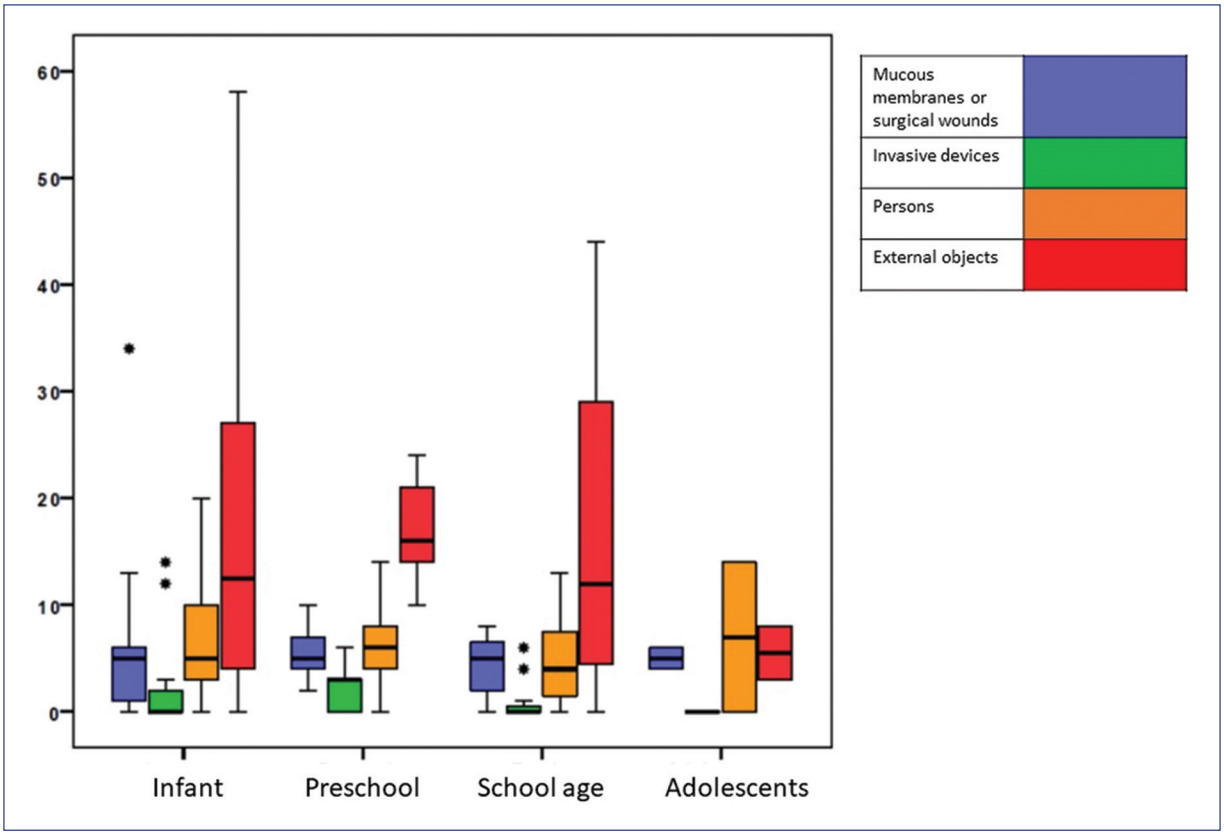

Figure 1. Hand contacts by age and category. *Outlier.

In pediatric populations, it is crucial to consider age groups. In this study, we observed that pediatric patients are exposed to various infectious risks depending on their age and their interactions with the environment and themselves.

During infancy and preschool years, the spectrum of pathogens and other microorganisms changes; after neonates, this group has the highest risk of HAI mortality. In adolescents, the risk of HAI mortality is similar to that of adults but with fewer comorbidities. The study looked at four age groups, with infants having the highest incidence, followed closely by preschoolers with 37 and 34 hand contacts per patient hour, respectively. Within the age groups, the most common category was external objects, primarily the "other" item. This can be explained by analyzing the stage of psychomotor development according to age group. A preschooler has reached a motor and cognitive development level that allows more frequent interaction with the environment. In addition, preschoolers are in a psychosocial stage dedicated to actively exploring their surroundings[9].

Therefore, it is crucial to emphasize the increased risk of acquiring a HAI faced by patients in these age groups. This happens through perpetuating the transmission chain of hospital microorganisms when they fail to perform HH during risky times. In the school-age group, the frequency of contact with external objects is higher compared to other categories; however, it occurs less frequently than in infants and preschoolers.

The sample for adolescents is scarce, but it is observed that the contact with other people was greater in this group, which can be explained by their high capacity for social interaction.

Several authors have examined the incidence of HAIs concerning the admission service, devices used, or age group. According to one report, bacteremia accounts for 20% of infections in pediatric care, but this figure can rise to 36% in pediatrics and 45% in neonatology[4].

The category recording the highest frequency of hand contacts was external objects, with 1200 instances noted during 60 h of observation. Within this category, the "others" subcategory was the most frequent. Monitors observed various items in this subcategory, including venous access lines, monitoring cables, bedding, and hygiene products, among others.

Table 2. Frequencies of hand contacts between age groups

Categories	Age group									
	Infant		Preschooler		School-age		Adolescent		Total	
	Total	Event/ time	Total	Event/ time	Total	Event/ time	Total	Event/ time	Total	Event/ time
Mucous membranes or surgical wounds	163	5.43	68	5.23	87	5.8	10	5	328	5.47
Ear	14	0.47	11	0.85	13	0.87	4	2	42	0.7
Nose	20	0.67	15	1.15	23	1.53	2	1	60	1
Mouth	102	3.4	28	2.15	34	2.27	4	2	168	2.8
Anus	3	0.1	1	0.08	1	0.07	0	0	5	0.08
Eyes	17	0.57	8	0.62	4	0.27	0	0	29	0.48
Genitals	6	0.2	5	0.38	12	0.8	0	0	23	0.38
Wound	1	0.03	0	0	0	0	0	0	1	0.02
Invasive devices	59	1.97	31	2.38	13	0.87	0	0	103	1.72
Venoclysis	45	1.5	28	2.15	12	0.8	0	0	85	1.42
Central Venous Catheter	11	0.37	2	0.15	0	0	0	0	13	0.22
Urinary Catheter	0	0	0	0	0	0	0	0	0	0
Stoma	0	0	1	0.08	0	0	0	0	1	0.02
Tracheostomy	0	0	0	0	0	0	0	0	0	0
Others	3	0.1	0	0	1	0.07	0	0	4	0.07
People	219	7.3	85	6.54	83	5.53	14	7	401	6.68
Primary Caregiver	176	5.87	67	5.15	71	4.73	4	2	318	5.3
Health workers	43	1.43	18	1.38	12	0.8	10	5	83	1.38
External objects	677	22.57	264	20.31	248	16.53	11	5.5	1200	20
Mobile phone	22	0.73	12	0.92	10	0.67	1	0.5	45	0.75
Toys	110	3.67	61	4.69	53	3.53	0	0	224	3.73
Bed Rail	162	5.4	79	6.08	95	6.33	2	1	338	5.63
Bedpan	2	0.07	0	0	0	0	0	0	2	0.03
Food	57	1.9	28	2.15	7	0.47	0	0	92	1.53
Utensils	0	0	0	0	0	0	0	0	0	0
Others	324	10.8	84	6.46	83	5.53	8	4	499	8.32
Total	1119	37.30	448	34.46	431	7.18	35	0.58	2032	33.87

Each hospital unit should implement a strategy to minimize the exposure of hospitalized pediatric patients to potentially contaminated external objects, including microorganisms. While restricting children's exploratory behavior is challenging and not advisable, it is essential to ensure that every object is thoroughly cleaned and disinfected before and after being touched by the child. In addition, an element observed within the patient's area, such as the rails of a bed or crib, must be meticulously cleaned. The patient's unit, whether a bed or crib, requires high-quality cleaning, which is a significant element in the patient's area. If

Table 3. Comparison of hand contacts between age groups and categories

Categories	Infant			Preschooler			School-age			Adolescent			p-value
	Median	Percentile 25	Percentile 75	Median	Percentile 25	Percentile 75	Median	Percentile 25	Percentile 75	Median	Percentile 25	Percentile 75	
Total	53.2	30	90	65	51	77	64	38	94	49.5	40	59	0.001
Mucous membranes or surgical wounds	5	1	6	5	4	7	5	2	7	5	4	6	0.5
External objects	0	0	2	3	0	3	0	0	1	0	0	0	0.7
People	5	3	10	6	4	8	4	1	8	7	0	14	0.02
Objects outside the patient´s area	12.5	4	27	16	14	21	12	4	34	5.5	3	8	0.001

not properly maintained, its surface can contribute to the transmission chain of microorganisms.

In a study conducted in a low-income informal settlement in Kisumu, Kenya, Davis et al.[10] reported 264 oral contact events over 142 h of observation of 25 infants. This averaged 1.76 contact events per child per hour, with a mean of 10.6 oral contact events per observation period, or 1.8 events per hour of observation. One of the study's goals was to observe oral contact behavior in infants aged 3-9 months. However, this study was not conducted in a hospital setting. In contrast, we report a total of 3.4 events per hour in the same age group of hospitalized patients, where it is well-known that surfaces can be contaminated with various types of microorganisms.

In 2015, Sunkesula et al.[11] published "Four Moments for Patient HH: A Patient-Centered, Provider-Facilitated Model for Improving Patient HH." Before conducting an observational study, they proposed four critical moments for HH in hospitalized adult patients: before and after touching devices and probes, before eating, upon entering or leaving their room, and after using the toilet. Out of 606 observations of HH opportunities, only 59 patients (approximately 10%) practiced HH. Specifically, HH was observed in 52 of 389 instances (13%) before meals, in 2 of 160 instances (1%) at room entrance or exit, and in 5 of 60 instances (8%) after using the toilet.

The study mentioned above highlights the low adherence to HH among hospitalized patients despite their understanding of its benefits and prior education about the appropriate times for its practice. This issue is even more complex for pediatric patients, who often rely on the support of their primary caregivers. Special training tailored to each age group is necessary.

In a study published by Lee et al.[12], the overall rate of HH compliance was 10.3% (72 out of 701 observations). Specifically, pediatric patients had an overall HH rate of 4.1% (2 out of 49 observations). The researchers concluded that HH among patients, families, and visitors is significantly suboptimal and should be prioritized for improvement.

Education about the importance of HH is crucial for patient compliance. In 2019, Lary et al.[13] published an article aimed to assess whether interactive educational interventions could increase compliance with HH among children and their visitors. The study reported a 24.4% increase in HH compliance following educational interventions, with a 40.8% increase in children and 50.8% in visitors. The study notes that educational interventions raised awareness about the importance of HH. Another study by Wong et al.[14] concluded that despite these efforts, HH rates among patients and visitors remain low. The study suggests that strategies need to be developed to improve compliance further. While typical multimodal programs have some impact, their effectiveness could be enhanced by incorporating additional change strategies that influence culture and behavior. This is why understanding the opportunities for HH in patients is essential, as recognizing these statistics clearly indicates the need for patient-targeted strategies, particularly age-specific ones, to prevent HAIs.

Pokrywka et al.[15] implemented an intervention to reduce HAIs in a 520-bed tertiary care hospital. Educational pamphlets, HH reminders, and alcohol wipes were distributed to patients with their meal trays. Staff and volunteers also

assisted in handwashing at mealtimes. As a result, the rate of HAIs decreased from 10.45/10,000 patient days in the year before the intervention to 6.95/10,000 patient days during the year of the intervention.

Gagné et al.[16] implemented a hospital intervention that involved meeting with all patients and visitors for 346 days to educate them about the benefits of HH and distributing brochures on HAIs. In addition, staff cleaned patients' hands with hand sanitizer twice daily on weekdays. As a result, methicillin-resistant *Staphylococcus aureus* infections decreased from 10.6/1000 admissions in the 385 days before the intervention to 5.2/1000 admissions during the intervention period. A cost-benefit analysis of the intervention showed a net saving of $688,840, attributed to reductions in nosocomial infections, including sepsis, surgical wound infections, bone and soft-tissue infections, and respiratory tract infections.

The HH practices among hospitalized children need standardization. Children have been implicated in infection outbreaks in hospitals and community organizations, such as schools and nurseries. Therefore, HH in this patient group is essential[17]. Based on the obtained results, we suggest the following HH moments for hospitalized pediatric patients: before and after eating or having contact with food-related objects (cutlery, plates, food trays, bottles), after using the bathroom or commode, and before and after using objects outside the patient's area (electronic devices and toys, among others). Prior cleaning of the device or toy is also strongly recommended as part of the HH routine. It may be logistically challenging to perform HH for the patient before and after every contact, such as every two minutes. We believe that maintaining the described HH moments, disinfecting the objects, and adding HH for both the patient and their caregivers could be feasible and help keep hands disinfected. The present work opens the door to many research opportunities. These opportunities include studying and analyzing the behavior of pediatric patients in the hospital environment and their role in the transmission chain of microorganisms. Maintaining good HH is challenging, which is why there are several strategies to improve adherence. However, as previously mentioned, most strategies focus on health-care personnel since these programs are easier to implement and monitor. Nonetheless, it is not just the hospital staff who are important; patients, caregivers, and visitors constitute a large group that must be involved in adhering to hygiene practices. The challenge of controlling HAIs persists. However, the more people who become aware of the importance of hand washing, the better the infection control rates that could be achieved. As demonstrated in our study, hospitalized pediatric patients are in constant contact with various surfaces, objects, and people. Therefore, implementing HH opportunities for hospitalized patients could help reduce infection rates.

Considering the limited number of studies on HH in hospitalized pediatric patients, which are predominantly from gray literature, there is scant knowledge in this area. One limitation of this study is the non-uniformity of the patient sample. Observations were consistently conducted in the morning, and the study was confined to a single hospital. Following the research committee's recommendation, this project was initiated as a pilot study to validate the instrument developed by the working group. While the monitors' training achieved an acceptable Kappa coefficient, their training program lacks validation from an external institutional body.

As this is the first study focused on estimating the number of times a pediatric patient has hand contact with different hospital surfaces, there were several limitations, such as the lack of records of the sequence of contacts as objects were touched immediately before or after the mouth. Another limitation was that the study was conducted only during the morning shift.

In conclusion, hospitalized pediatric patients, especially those in preschool and infancy, can be significant and frequent contributors to the transmission of microorganisms. Considering the substantial economic costs, the high morbidity, mortality, and disease burden associated with HAIs in children, our findings strongly support the integration of HH practices for patients and their caregivers, along with cleaning of objects and the patient environment, as key components of infection prevention policies to reduce their occurrence.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that they have followed the protocols of their work center on the publication of patient data.

Right to privacy and informed consent. The authors have obtained the written informed consent of the patients or subjects mentioned in the article. The corresponding author has this document.

Conflicts of interest

The authors declare no conflicts of interest.

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