

ORIGINAL ARTICLE

Estimation of mean number of daily hand hygiene procedures per patient can represent an effective and easy understandable method to evaluate adherence experience in a tertiary care pediatric hospital of Northern Italy

P. TATARELLI¹, I. LORENZI², I. CAVIGLIA², R.A. SACCO², D. LA MASA², E. CASTAGNOLA²

¹Infectious Diseases Division, University of Genoa (DISSAL) and IRCCS San Martino-IST, Genoa, Italy; ²Istituto Giannina Gaslini, Children's Hospital, Genoa, Italy

Keywords

Healthcare associated infections • Infection control • Hand hygiene • Hand washing

Summary

Introduction. Hand decontamination with alcohol-based antiseptic agents is considered the best practise to reduce healthcare associated infections. We present a new method to monitor hand hygiene, introduced in a tertiary care pediatric hospital in Northern Italy, which estimates the mean number of daily hand decontamination procedures performed per patient.

Methods. The total amount of isopropyl alcohol and chlorhexidine solution supplied in a trimester to each hospital ward was put in relation with the number of hospitalization days, and expressed as litres/1000 hospitalization-days (World Health Organization standard method). Moreover, the ratio between the total volume of hand hygiene products supplied and the effective amount of hand disinfection product needed for a correct procedure

was calculated. Then, this number was divided by 90 (days in a quarter) and then by the mean number of bed active in each day in a Unit, resulting in the mean estimated number of hand hygiene procedures per patient per day (new method).

Results. The two methods had similar performance for estimating the adherence to correct hand disinfection procedures. The new method identified wards and/or periods with high or low adherence to the procedure and indicated where to perform interventions and their effectiveness. The new method could result easy-to understand also for non-infection control experts.

Conclusions. This method can help non-infection control experts to understand adherence to correct hand-hygiene procedures and improve quality standards.

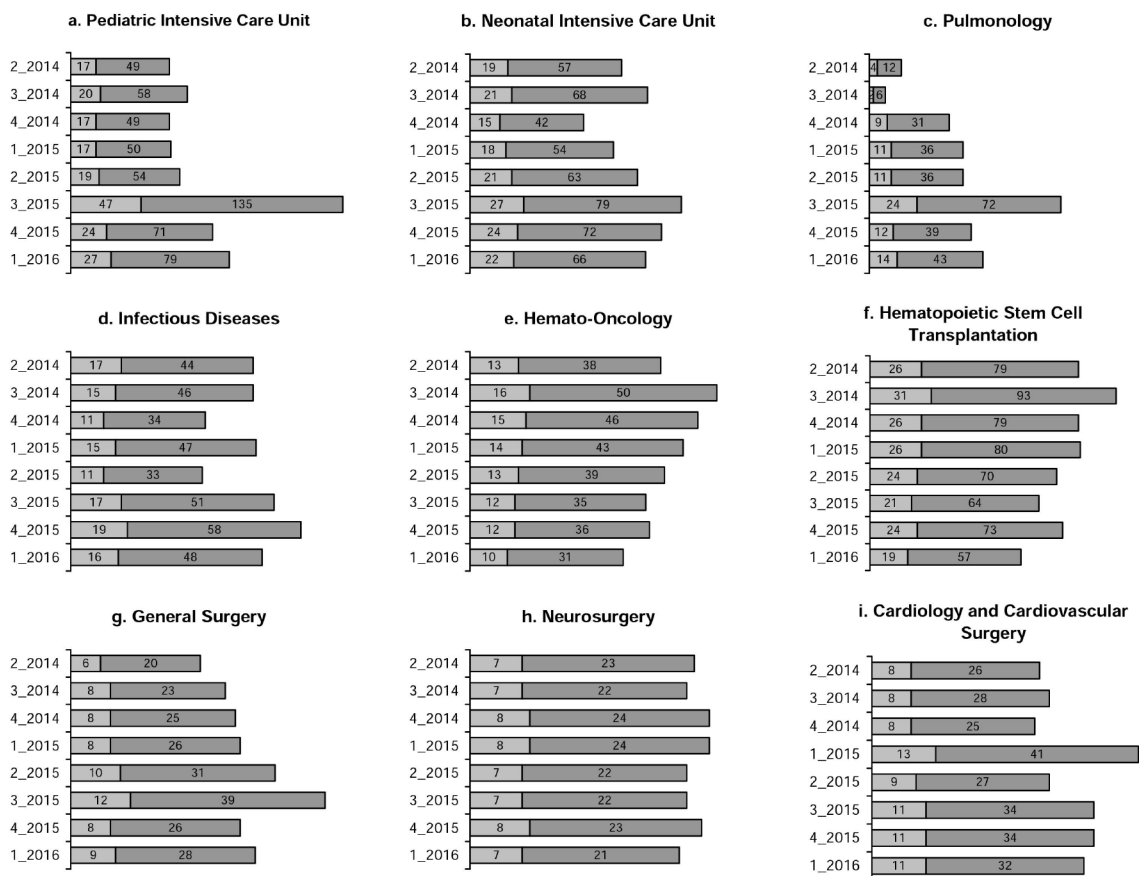
Introduction

Healthcare associated infections (HAI) represent an increasing problem in modern medicine. The impact of HAI includes prolonged hospital stay, long-term disability, increased resistance of microorganisms to antimicrobials, massive additional financial burden, high costs for patients and their families, and excess deaths [1-3]. In October 2005 the World Health Organization (WHO) started the "Clean Care is Safer Care" program to promote safe hand hygiene practices globally and at all levels of health care as a first step in ensuring high standards of infection control and patient safety [4]. The program provided technical recommendations and strategies to improve hand hygiene and included the development of WHO Guidelines on Hand Hygiene in Health Care along with a package of practical tools to facilitate implementation activities at a facility level [5]. WHO recommends hand rub with alcohol-based antiseptic agents as the gold standard procedure to protect patients from the multitude of harmful resistant and non-resistant organisms transmitted by health care workers' hands, and

this easy and fast (20-30 seconds) procedure has been associated with reduction in nosocomial infections. Differently, standard hand washing with water and soap, is indicated only in case of visibly dirty hands or infection due to spore-forming pathogens [6, 7]. The monitoring of hand hygiene adherence is an integral part of infection control strategies. The Infection Control Team can use it to evaluate the effectiveness of specific interventions, as well as to introduce changes that minimize the risk of HAI. Several methods have been suggested to monitor hand hygiene compliance (direct observation, product use measurement, surveys, electronic systems), but the ideal one has not yet been identified [8, 9]. WHO considers direct observation the most effective method to monitor the health care workers adherence to the hand hygiene recommendations, meanwhile the alcohol-based antiseptic agents consumption is a proxy indicator of hand hygiene.

In 2006, Italy officially adopted the WHO program as a mainstay of its strategy for the promotion of hand hygiene in health care settings. "Istituto Giannina Gaslini" (IGG) Children Hospital, Genoa-Italy, a tertiary care

Fig. 1. Quarterly supply hand-hygiene products (litres/1000 hospitalization days, dark-gray bars) and estimates of hand-hygiene procedures (light-gray bars) and in different wards over 2 years of observation.



pediatric hospital in Northern Italy, complied with this program since 2007.

The aim of this study was to present a new method to estimate and report on adherence to correct hand hygiene procedures (CHHP) introduced in our hospital since 2007.

Methods

Istituto Giannina Gaslini (IGG), Genoa-Italy is a tertiary care children’s hospital in Northern Italy serving as local pediatric hospital for the Genoa area, but representing a tertiary care referring hospital for the whole Italy and many foreign countries.

In November 2007, IGG joined the “Clean Care is Safer Care” WHO program. This was firstly applied in the pediatric intensive care unit (PICU), and then gradually extended to all hospital wards. From January to March 2008, health care workers started a hand care hygiene educational program, conducted by the nurses of the IGG Infection Control Team. “How to” and “5 Moments” posters about hand washing were displayed close to the sinks. Beyond the standard antiseptic hand washing, hand decontamination with isopropyl alcohol gel was also recommended. Its use was implemented placing alcoholic gel dispenser at the ward entrance and

next to each patient location. As the program began, random audits were performed to check the proper application of the procedures; re-training sessions and meetings with the Infection Control Team nurses were performed when needed. Retraining programs were performed in the following years.

Adherence to hand hygiene was initially estimated by means of the amount of antiseptic product supplied, expressed in terms of litres of isopropyl alcohol gel supplied to the Unit per 1000 hospitalization-days. However, since this approach could be hard to understand for non-infection control experts, in 2010 another hand hygiene reporting method was introduced, and associated to the first one. As the amount needed for an effective hand hygiene procedure is known for each product (manufacturer’s instructions), we estimated the number of the performed procedures by dividing the total volume of isopropyl alcohol gel (hereinafter referred also as hand hygiene product) supplied in a period (a quarter) by the volume of the product indicated for an effective hand hygiene procedure. This number was then divided by 90 (days in a quarter) and then by the mean number of beds active in each day in the Unit in that period (average bed occupancy in a quarter). This calculation should estimate the number of daily CHHP procedures performed at each patient’s bed. Data about alcoholic gel consump-

Tab. I. Changes in litres of hand hygiene products/1000 hospitalization days (l/1000 hd) and estimated hand hygiene (ehh) products in different quarters in different wards.

	Quarter	2_2014	3_2014	4_2014	1_2015	2_2015	3_2015	4_2016	1_2016	Correlation coefficient
Pediatric intensive care unit	l/1000 hospitalization days	48	58	49	50	54	135	71	79	0.9996
	Estimated hand hygiene procedures	17	20	17	17	19	47	24	27	
Neonatal intensive care unit	l/1000 hospitalization days	57	68	42	54	63	79	82	66	0.9528
	Estimated hand hygiene procedures	19	21	15	18	21	27	24	22	
Pulmunology	l/1000 hospitalization days	12	6	31	36	36	72	39	43	0.9966
	Estimated hand hygiene procedures	4	2	9	11	11	24	12	14	
Infectious diseases	l/1000 hospitalization days	44	46	34	47	33	51	58	48	0.9447
	Estimated hand hygiene procedures	17	15	11	15	11	17	19	16	
Hemato-oncology	l/1000 hospitalization days	38	50	46	43	39	35	36	31	0.9887
	Estimated hand hygiene procedures	13	16	15	14	13	12	12	10	
Hemopoietic stem cell transplant	l/1000 hospitalization days	79	93	79	80	70	64	73	57	0.9942
	Estimated hand hygiene procedures	26	31	26	26	31	39	26	28	
General surgery	l/1000 hospitalization days	20	23	25	26	31	39	26	28	0.9802
	Estimated hand hygiene procedures	6	8	8	8	10	12	8	9	
Neurosurgery	l/1000 hospitalization days	23	22	24	24	22	22	23	21	0.8133
	Estimated hand hygiene procedures	7	7	8	8	7	7	8	7	
Cardiovascular surgery	l/1000 hospitalization days	25	28	25	41	27	34	34	32	0.9663
	Estimated hand hygiene procedures	8	8	8	13	9	11	11	11	

tion were collected by each Unit head nurse, crossed with data from the Pharmacy service supply to any given Unit in a given period (a quarter), and communicated to the Infection Control Team. Since 2010 the program was gradually extended and in April 2014, after 4 years of progressive extension to different wards, the method was considered adequate to involve all IGG wards. From that moment the Infection Control Team drafted quarterly reports including both the amount of hand hygiene products used by each Unit and the estimated number of CHHP procedures performed. Moreover, the presence of epidemic clusters, defined as an aggregation of cases of infection, without regard to whether the number of cases was more than expected, was evaluated and reported in real time, and it was followed by specific retraining sessions [10].

Data were collected on an electronic spread sheet and graphically reported. In order to compare the 2 methods to report on CHHP we calculated the Pearson correlation coefficient that is a measure of the linear dependence

between the 2 methods (litres/1000 hospitalization days and CHHP estimates). Graphics and correlation coefficient were obtained by means of Microsoft Office Excel 2007 (Microsoft Corporation Redmond WA).

Results

Figure 1 presents the quarterly reports from April 2014 to March 2016 (eight trimesters) of nine selected Unites: Intensive Care Units [Pediatric Intensive Care Unit (PICU), Neonatal Intensive Care Unit (NICU)], Pulmonology, Infectious Diseases, Hemato-Oncology, Hematopoietic Stem Cell Transplantation, General Surgery, Neurosurgery, Cardiology and Cardiovascular Surgery. Table I reports data on adherence to the hand hygiene program estimated according to two different methods, together with the Pearson correlation coefficients between the 2 methods, and show the presence of a positive correlations between the 2 systems that described in

the same way changes in procedures for hand hygiene, while Figure 1 is the graphic representation of these results. For example, during the third trimester of 2015 in PICU, a cluster of *Acinetobacter baumannii* colonization/infection was followed by an intervention of the Infection Control Team and we observed an increase in hand hygiene procedures compared to the previous trimester, which is reported by both methods (47 CHHP vs. 19 and 135 litres of hand hygiene products vs 54, respectively) (Fig. 1a). During the third trimester of 2015 Pulmonology ward experienced a cluster of carbapenem resistant *Enterobacter* colonization, and after an intervention of the Infection Control Team we observed an increase of both parameters compared to the previous trimester (24 CHHP vs 11 and 72 litres of hand hygiene products vs 36, respectively). However, during the fourth trimester of 2015, when the Infection Control Team intervention became less pressing (and maybe less persuasive), a reduction in the number of hand hygiene procedures (from 24 to 12) was observed: this trend was considered worrisome and induced the Infection Control Team to retrain health workers. The result obtained in the following period (14 procedures per patient per day in the first trimester of 2016) was still considered not adequate, even if improving, so that a new educational intervention was programmed (Fig. 1c).

In general, in ICUs (Fig. 1a, Fig. 1b) the number of CHHP was generally larger compared to medical wards, like Pulmonology or Infectious Disease (Fig. 1c, Fig. 1d). On the other hand, in surgical wards (General Surgery, Neurosurgery, Cardiovascular Surgery) (Fig. 1g, Fig. 1h, Fig. 1i) the number of estimated procedures was quite similar, constant and relatively low, even if within the standard indicated by the WHO (20 liters/1000 hospitalization days), and in absence of any epidemic clusters or high levels of surgical site infections rate. In these wards, the decision was made to periodically retrain the health staff, though with quite frustrating results.

Discussion

Hand hygiene is the most important precaution to reduce HAI and enhancing patient safety [11]. Thus, no effective infection control strategy can afford to neglect its monitoring. Unfortunately, all the methods currently used to monitor both standard hand washing and CHHP show some limits. For example, direct observation of staff members is currently considered the gold standard in hand hygiene compliance monitoring, but it is time-consuming and requires an adequate number of monitors to be performed frequently in a large number of hospital wards in a reasonable time. On the other hand, direct observation can influence and modify behaviour of health workers when realizing that they are being observed (so called Hawthorne effect), leading to falsely elevated compliance rates [12]. Starting from a conventional approach, based on measuring litres of isopropyl alcohol gel consumed per 1000 hospitalization-days, the IGG introduced a new method, still based on the amount of hand hygiene product, that

estimates the mean number of daily CHHP performed per patient. Our estimate of CHHP can be performed using data that can be easily obtained by the hospital administration (litres of hand hygiene products, days of hospitalization, mean number of patients present in a trimester in a given ward). Furthermore, the method we adopted to estimate CHHP is unobtrusive and allows collecting and reporting real-life information without compartmental bias, even if it does not evaluate if the procedure of hand hygiene is performed in a correct way or not. As shown by this paper, these two methods provide overlapping results in terms of the description of hand hygiene performance over time. In fact there was a very strict positive correlation between these measure methods, with a coefficient > 0.80 in all cases (in 8/9 cases > 0.94), a value that can be considered very high in social science, where there may be a greater contribution from complicating factors [13]. However, the quality of information presented by the two methods is quite different. The new one provides the health staff with a (estimated) measure of its hand hygiene performance (estimated mean number of CHHP per patient per day), while the other one refers to the amount of hand hygiene products consumed in a Unit during a certain period (litres of product per 1000 hospitalization-days). This difference can prove relevant for non-infection control experts. Indeed, it is easier to understand one's own hygiene conduct by thinking in terms of number of hand hygiene procedures than in terms of gel consumption. This aspect can be crucial for health care workers training. Figure 1 is a realistic picture of the mean daily number of CHHP performed per patient per day in each Unit. Noteworthy these numbers can fluctuate, sometimes widely, from one trimester to another within the same ward. Therefore, the main helpfulness of this analysis is to compare each Unit against itself over time. However, some observations arise from the comparison among the hand hygiene trend of different Units. For example, the higher number of procedures found in intensive care Units compared to medical wards is probably due to their different case mix. Indeed, intensive care Units usually host critical patients, who require constant assistance and frequent invasive procedures and, therefore, a higher number of CHHP procedures is expected. On the other hand, the low number of procedures observed in surgical wards, even in absence of epidemic clusters or high levels of surgical site infections, can be at least partially explained by the fact that surgical patients undergoing more complex interventions are usually admitted to intensive care Units during the first post-operative phases, which are the most critical periods, while they are referred to surgical wards when a lower level of assistance, and therefore of hand hygiene procedures, is needed. If we consider that the risk of carbapenem resistant *Enterobacteriaceae* transmission can be significantly reduced by performing at least 50% of the required hand washings, it is at least partially understandable that surgical wards could need a relatively low number of procedures to prevent pathogens' transmission, provided that the volumes of products are adequate, at least according to WHO standards [14]. These considerations well applies to our pediatric reality and its type of patients and surgi-

cal procedures, but they cannot be simply transposed to adult or pediatric wards/hospitals with a different case mix. For this reason, we believe that our method of estimating CHHP can be used in each setting to compare its own performance in process of time, but can be roughly used to compare different realities in different hospitals or even in the same one. Further studies in different clinical settings are needed to validate our approach.

The proposed method has also limitations. First, it estimates the adherence to CHHP but does not provide the real number of performed procedures. Second, since it does not include direct observation, it does not allow fixing errors in real time, but only a “post-hoc” retraining. Third, it may underestimate adherence to hand hygiene because it does not consider standard handwashing, which is an effective procedure actually used by many health-care workers (since it is perceived as more secure), even if not the currently recommended standard.

Conclusions

In conclusion, our experience provides a new, reliable method for measuring hand hygiene adherence that non-infection control experts may find easier to understand, compared to conventional ones. This is a key issue, since no satisfactory infection control can be obtained without the health-care workers collaboration and adherence to hygiene interventions.

Acknowledgments

The authors declare no competing interest.

Authors' contributions

P.T. performed data analysis and manuscript preparation.
I.L. carried out data collection and analysis.
I.C. carried out data collection and analysis.
R.A.S. performed data collection and review.
D.L.M. carried out data collection and review.
E.C. performed study design, data analysis and manuscript preparation.

References

- [1] Girou E, Stephan F, Novara A, Safar M, Fagon JY. *Risk factors and outcome of nosocomial infections: results of a matched case-control study of ICU patients*. Am J Respir Crit Care Med 1998;157(4 Pt 1):1151-8. doi: 10.1164/ajrccm.157.4.9701129.
- [2] Blot SI, Depuydt P, Annemans L, Benoit D, Hoste E, De Waele JJ, Decruyenaere J, Vogelaers D, Colardyn F, Vandewoude KH. *Clinical and economic outcomes in critically ill patients with nosocomial catheter-related bloodstream infections*. Clin Infect Dis 2005;41:1591-8. doi: 10.1086/497833.
- [3] Marchetti A, Rossiter R. *Economic burden of health-care-associated infection in US acute care hospitals: societal perspective*. J Med Econ 2013;16:1399-404. doi: 10.3111/13696998.2013.842922.
- [4] World Alliance for Patient Safety. *The Global Patient Safety Challenge 2005–2006 “Clean Care is Safer Care”*. Geneva, World Health Organization, 2005. Available at: http://www.who.int/patientsafety/events/05/GPSC_Launch_ENGLISH_FINAL.pdf. Accessed on 14/04/2016.
- [5] WHO Guidelines on Hand Hygiene in Health Care. *First Global Patient Safety Challenge Clean Care is Safer Care*. Geneva, World Health Organization, 2009. Available at: http://apps.who.int/iris/bitstream/10665/44102/1/9789241597906_eng.pdf. Accessed on 14/04/2016.
- [6] Voss A, Widmer AF. *No time for handwashing!? Handwashing versus alcoholic rub: can we afford 100% compliance?* Infect Control Hosp Epidemiol 1997;18:205-8. doi:10.2307/30141985.
- [7] Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, Perneger TV. *Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme*. Lancet 2000;356:1307-12. doi:10.1016/S0140-6736(00)02814-2. Erratum in: Lancet 2000;356(9248):2196. doi:10.1016/S0140-6736(05)67278-9.
- [8] *Measuring Hand Hygiene Adherence: Overcoming the Challenges*. Geneva, World Health Organization, 2009. Available at: http://www.jointcommission.org/assets/1/18/hh_monograph.pdf. Accessed on 14/04/2016.
- [9] Boyce JM. *Hand hygiene compliance monitoring: current perspectives from the USA*. J Hosp Infect 2008;70 Suppl 1:2-7. doi: 10.1016/S0195-6701(08)60003-1.
- [10] Centers for Disease Control and Prevention. *Principles of Epidemiology in Public Health Practice. Third Edition. An Introduction to Applied Epidemiology and Biostatistics*. October 2006 Updated May 2012. Available at: <http://www.cdc.gov/ophss/csels/dsepd/ss1978>. Accessed on 19/05/2016.
- [11] Pittet D, Allegranzi B, Sax H, Dharan S, Pessoa-Silva CL, Donaldson L, Boyce JM; WHO Global Patient Safety Challenge, World Alliance for Patient Safety. *Evidence-based model for hand transmission during patient care and the role of improved practices*. Lancet Infect Dis 2006;6:641-52. doi:10.1016/S1473-3099(06)70600-4.
- [12] Haas JP, Larson EL. *Measurement of compliance with hand hygiene*. J Hosp Infect 2007;66:6-14. doi:10.1016/j.jhin.2006.11.013.
- [13] Cohen J. *Statistical power analysis for the behavioral sciences*. Lawrence Erlbaum Associates: Mahwah NJ 1988, pp. 1-599
- [14] Sypsa V, Psychogiou M, Bouzala GA, Hadjihannas L, Hatzakis A, Daikos GL. *Transmission dynamics of carbapenemase-producing Klebsiella pneumoniae and anticipated impact of infection control strategies in a surgical unit*. PLoS One 2012;7:e41068. doi: 10.1371/journal.pone.0041068.

■ Received on July 13, 2016. Accepted on September 29, 2016.

■ Correspondence: Elio Castagnola, Infectious Diseases Unit, Istituto Giannina Gaslini, Largo G. Gaslini 5, 16147 Genoa, Italy - Tel. +39 010 56362428 - Fax +39 010 3763436 - E-mail: eliocastagnola@gaslini.org