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Knowledge, attitude, barriers, professional behaviour and possible interventions: a survey on healthcare-associated infections among the healthcare workers of an intensive care unit in a large teaching hospital in Rome

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Abstract

Background. *Healthcare-associated infections are the main complications of hospitalization. A bottom-up approach, where the Healthcare workers involved play a key role, can be adopted to limit the Healthcare-associated infections burden. To this end, a survey was conducted in the main intensive care unit of Umberto I Teaching Hospital of Rome, where an active surveillance system has been in place since April 2016.*
Methods. *A questionnaire of 36 questions was developed and administered to assess socio-occupational characteristics, knowledge of Healthcare-associated infections, attitudes and barriers encountered in compliance with hygiene standards, self-analysis of professional behaviour, and proposals for new interventions. Variables were evaluated by univariate analysis, and multivariable logistic regression models were constructed to identify predictors of adequate knowledge, positive attitude and appropriate professional behaviour.*
Results. *Overall, 79/89 Healthcare workers completed the questionnaire. Multivariate analysis showed that Healthcare workers, who participated in ward meetings to share active surveillance reports, were more likely to have adequate knowledge (aOR=4.21, 95% CI: 1.36-13.07). Only job type seemed to be a predictor of adequate behaviour, since nurses and physicians were more likely to show adequate behaviour than residents in training (aOR=0.21, 95% CI: 0.06-0.74). Direct observation of compliance with standard hygiene precautions and the identification of 'local champions' to manage Healthcare-associated infections' issues were the most requested interventions.*

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Conclusions. *Our study suggests that the training of healthcare professionals is a key factor in preventing and containing the spreading of Healthcare-associated infections. Moreover, by encouraging greater Healthcare workers' involvement, we conclude that a bottom-up approach is likely to improve Healthcare-associated infections' prevention and management.*

Introduction

Healthcare-associated infections (HAIs) represent a serious threat to hospitalized patients, causing significant increases in morbidity and mortality rates (1, 2), especially among patients admitted to intensive care units (ICUs), where prevalence estimates range from 9% to 37% (3, 4). For this reason, in April 2016, the main surgical/medical ICU of the Umberto I Teaching Hospital of Rome, in collaboration with the Department of Public Health and Infectious Diseases of the Sapienza University, implemented an active multimodal HAI surveillance system (5). This system collects data daily on patients and HAIs with the aim of monitoring the infectious risk and evaluating the effectiveness of targeted interventions, as suggested by several international institutions (6, 7). To support the HAI prevention and control measures, meetings with the ICU's Healthcare workers (HCWs) were organized in May 2017. During these meetings, the surveillance results were presented and evidence on clonal transmission and environmental isolation was discussed. Furthermore, the intensive care staff were encouraged to motivate colleagues during care activities, to raise their awareness and to promote long-lasting behavioral changes (8, 9). Also, training courses on correct hand washing procedures were held in July 2017 (8). These courses covered the definition, impact and burden of HAIs, highlighted the main patterns of pathogen transmission and called attention on the role of good hand hygiene practice and the proper use of gowns and gloves in reducing rates of infection (8).

Knowledge, attitude and professional behaviour are fundamental in the healthcare field (10). Indeed, evidence suggests that knowledge and staff involvement may increase compliance with standard hygiene precautions and, consequently, have a positive impact on the containment of HAIs (10, 11). Some studies have also found that HCWs with better knowledge acquired through training courses show more appropriate professional behaviour (10) and better compliance with hand hygiene guidelines (9, 12-15). In addition, despite some authors' observations that a positive attitude may not directly correlate with the number of years of work experience of HCWs on the ward (12), other studies have shown that a positive attitude is more likely to be present in those with a higher level of knowledge (11). Hence, it is crucial to understand the extent of HCWs' knowledge and to investigate factors that could affect HCWs' attitudes and practices so that the delivery of healthcare can be improved and the HAIs burden limited (8, 13).

Various methods have been described in the literature to identify interventions in the health sector that aim to improve best practices. One of these is a bottom-up approach, which promotes interventions

suggested by HCWs themselves as a product of experience and knowledge gained during their time in the profession (16, 17). This process has, in a few cases, led to the identification of particular solutions in the healthcare field, which take into account the needs and opinions of the HCWs involved and which improve medical practice in general (18-20). In this study, we used a bottom-up approach in the ICU of the Umberto I Teaching Hospital of Rome: the purpose was to investigate the knowledge, attitude, and professional behaviour of the HCWs in respect of HAIs, and to identify the most appropriate interventions that might be implemented in the future.

Materials and Methods

Study population

This is a cross-sectional study conducted from March to April 2019 by the Department of Public Health and Infectious Diseases of Sapienza University of Rome. The target population consisted of all HCWs in the ICU (attending physicians, nurses, and resident physicians). The study protocol was approved by the Ethics Committee of the Umberto I Teaching Hospital (reference number: 991/2019). Before the study took place, all HCWs were provided with information about the study's methods and objectives. A link directed to an online questionnaire was sent to their email accounts, after obtaining consent to process sensitive data for the study. To minimize the risk of confidentiality breaches for participants, questionnaires were completed anonymously and no demographic or identifying information was used. Completed questionnaires were accessible only to the study investigators. Missing questionnaires were requested from participants through periodic reminder emails and telephone calls, until the closing date of the online survey, which was set two months after the first notice.

The questionnaire

The content of the questionnaire was derived from a literature review (21-30). The questions were pre-tested by all co-authors to verify language, flow, clarity, readability and completeness, together with acceptability and response alternatives, as previously suggested (31). It took approximately 30 minutes to complete, and it was made up of 36 questions (35 multiple-choice questions and one open-ended), grouped into five sections: (i) socio-occupational characteristics (questions 1-8); (ii) knowledge of the characteristics of the HAIs affecting patients in the ICU unit (questions 9-16); (iii) attitude and barriers to manage hygiene compliance (questions 17-22 and question 23, respectively); (iv) self-reporting of professional behaviour concerning compliance with standard hygiene precautions (questions 24-30); (v) proposals for interventions to be implemented on the ward (questions 31-36).

Statistical analysis

Descriptive statistical tests on the items included in the questionnaire were performed. Continuous variables were expressed as mean ± standard deviation, whereas categorical variables were expressed as proportions. An adequate level of knowledge was attributed to respondents providing correct answers to at least 70% of the questions assessing knowledge. Responders with positive attitudes were those who agreed "enough" or "completely" with the statements about attitudes, whereas professional behaviour was considered adequate if the participants correctly answered at least six out of seven questions. Univariate analysis was performed with the chi-squared test, or with the exact Fisher test where appropriate, for categorical and dichotomous variables, while for continuous variables the Student's *t*-test was used. Multivariable logistic regression models were constructed to identify predictors of adequate knowledge

(Model 1), positive attitude (Model 2) and adequate professional behaviour (Model 3). Variables were included in the models when the *p*-value for the univariate test was lower than 0.25; other variables of known relevance were also included. Regression coefficients were expressed as odds ratio (OR) and their 95% confidence intervals (CIs) were also presented to provide additional data regarding the relative importance of each independent variable for the outcome variable. *P*-values ≤ 0.05 were considered statistically significant and all tests were two-sided. All analyses were performed with STATA version 13 (StataCorp LLC, 4905 Lakeway Drive College Station, Texas, USA).

Results

Out of a total of 89 HCWs invited to participate in the survey, 79 completed the questionnaire (response rate: 89%). Mean age of the respondents was 37.7 ± 10.4 years. Most respondents were women (68.4%), and nurses (57%), followed by medical residents in the Department of Anaesthesiology and Resuscitation (22.8%) and attending physicians (20.2%). Mean length of service in the hospital ward was 6.7 ± 7.2 years. More than half of the respondents reported owning a university degree (55.7%). Thirty respondents (38%) reported having participated in the training meetings that took place in July 2017 about standard hygiene precautions, which included a meeting and open discussion on the contents of the WHO Hand Hygiene Technical Reference Manual (32), while 40.5% of the respondents took part in meetings in May 2017 on sharing surveillance results. These meetings also discussed which microorganisms were most prevalent on the ward and which were the most contaminated surfaces (Table 1).

Table 1 - Demographic and professional characteristics of the healthcare workers surveyed (N=79).

	N	(%)
Gender		
Male	25	(31.7)
Female	54	(68.3)
Age		
<30 years	23	(29.1)
31-34 years	19	(24.0)
35-45 years	16	(20.3)
>45 years	21	(26.6)
Educational level		
High school	5	(6.3)
University degree	44	(55.7)
Post-graduation	30	(38.0)
Profession		
Nurse	45	(57.0)
Resident	18	(22.8)
Physician	16	(20.2)
Employment contract		
Employee	39	(49.4)
Cooperative	22	(27.8)
Residency / training	18	(22.8)
Work experience		
1-5 years	36	(45.6)
6-10 years	13	(16.4)
>10 years	30	(38.0)
Work experience in the ICU		
<1 year	23	(29.1)
1-5 years	23	(29.1)
6-10 years	12	(15.2)
>10 years	21	(26.6)
Participation in training meetings on standard hygiene precautions (July 2017)		
Yes	30	(38.0)
No	49	(62.0)
Participation in meetings to share surveillance results (May 2017)		
Yes	32	(40.5)
No	47	(59.5)

Supplementary Table 1.1 - Absolute and relative frequencies of the healthcare workers' responses to the questionnaire (N=79). Domain: knowledge. Results are expressed as N (%).

	< 10%	About 30%	About 50%	About 70%	> 90%
Patients hospitalized in the ICU who develop HAIs	4 (5.0)	24 (30.4)	23 (29.1)	26 (33.0)	2 (2.5)
Multidrug-resistant microorganisms responsible for HAIs	14 (17.7)	27 (34.2)	29 (36.7)	8 (10.2)	1 (1.2)
Which are the microorganisms most responsible for HAI in the ICU?					
A. baumannii	49 (62.0)				
K. pneumoniae	72 (91.2)				
P. aeruginosa	37(46.8)				
S. aureus	33 (41.8)				
C. albicans	24 (30.4)				
E. faecium	2 (2.5)				
E. faecalis	10 (12.7)				
E. coli	7 (8.9)				
Which are the most frequent HAIs in the ICU?					
VAP	31(39.2)				
CLABSI	30 (38.0)				
CAUTI	8 (10.1)				
BSI	10 (12.7)				
Which is the main route of transmission of microorganisms responsible for HAIs in the ICU?					
Hands	62 (78.5)				
Air	2 (2.5)				
Surfaces	13 (16.5)				
Non-invasive tools	2 (2.5)				
Which is the most contaminated surface in the ward?					
Bed Edge	41 (51.9)				
Medicine Cabinet	4 (5.1)				
PC Keyboard	31 (39.2)				
IV Drip Pole	3 (3.8)				
Are microorganisms found at environmental level the same as the microorganisms responsible for HAIs?					
Yes	49 (62.0)				
No	13 (16.5)				
I do not know	17 (21.5)				
Can the same microorganism cause HAIs in different patients, transmitting from one patient to another?					
Yes	74 (93.7)				
No	3 (3.8)				
I do not know	2 (2.5)				

ICU: intensive care unit. HAI: healthcare-associated infection. VAP: ventilator-associated pneumonia. CLABSI: central line-associated blood stream infection. CAUTI: catheter-associated urinary tract infection. BSI: blood stream infection.

Knowledge

Overall, most respondents had an adequate level of knowledge of the main features of the ward's HAIs. In fact, there was good knowledge of the identification of the most prevalent microorganisms on the ward. Specifically, the four most frequent microbes encountered were *Acinetobacter baumannii,* indicated by 62.0% of the respondents; *Klebsiella pneumoniae,* 91.2%; *Pseudomonas aeruginosa,* 46.8%; *Staphylococcus aureus,* 41.8%.

The question on the multi-drug resistance profile was answered correctly 36.7% of the times (i.e., on the ICU ward about 50% of microorganisms identified are multidrug resistant), and most respondents (78.5%) correctly identified the main route of microbial transmission (i.e., HCWs' hands). Most respondents recognized that the most contaminated surfaces of the ward were the edge of the bed (51.9%) and the computer keyboard (39.2%), followed by the medicines cabinet (5.1%) and the intravenous drip pole (3.8%). On the question about the frequency of patients hospitalized on the ICU ward, who actually develop at least one HAI during their stay, 33% of the respondents overestimated it by answering "about 70%", while 30.4% answered correctly "about 30%". Lastly, a lower level of knowledge was found in relation to the HAI type: most respondents wrongly believed that ventilator-associated pneumonia (39.2%) and central line-associated bloodstream infection (38.0%) were the most prevalent HAIs, whereas only 12.6% gave the correct answer, i.e. bloodstream infection (Supplementary Table 1.1).

This section required respondents to demonstrate adequate knowledge of the ward's main HAI features, the most frequent microorganisms on the ward, their multidrug resistance profile, the most contaminated surfaces of the ward, the proportion of patients hospitalized on the ward who develop HAI over their ICU stay, and the HAI type.

As shown in Table 2, univariate analysis found significantly higher percentages of adequate knowledge in older respondents (p=0.028) and in HCWs with longer hospital stay (p=0.045). Moreover, a higher percentage of adequate knowledge was found in males than in females (p=0.017). Respondents who participated in internal meetings where surveillance results were shared, scored significantly better (p=0.020) than those who did not, and those who had participated in the hand-washing training courses showed greater knowledge, although this was not statistically significant. Multivariable analysis was performed to identify predictors of adequate knowledge, which, overall, were detected in 26.6% of respondents (Table 3). Participants in ward meetings where active surveillance reports were shared, were more likely to have adequate knowledge than HCWs who did not take part in these meetings (aOR= 4.21, 95% CI: 1.36-13.07). Additionally, male HCWs were more likely to have adequate knowledge than females (aOR= 4.40, 95% CI: 1.40-13.81).

Attitudes and barriers

Most respondents showed a positive attitude (Supplementary Table 1.2). Specifically, almost 98% believed that correct hand hygiene procedures could sufficiently prevent the onset of HAIs (41.8%) or completely (56.9%). The vast majority of respondents thought that HAIs could be prevented, should they change their professional behaviour, and only 20% did not believe that this was his/her responsibility. No significant difference between the various professional roles was found on the question of the control of HAIs being an internal responsibility of the ward. Only 10% of respondents believed that it was not a responsibility of the Health Directorate. Interestingly, 30% thought that HAIs could be spread by patients' relatives entering the ward. Also, almost 90% of the respondents

Table 2 - Univariate analysis. Results are expressed as mean ± standard deviation or absolute frequency (percentage).

Variable	Adequate knowledge	Inadequate knowledge	p-value	Positive attitude	Negative attitude	p-value	Adequate behaviour	Inadequate behaviour	p-value
Age									
Years	42 ± 12.77	36.19 ± 9.10	0.028	36.66 ± 9.81	39.92 ± 11.50	0.194	38.38 ± 10.59	36.78 ± 10.31	0.507
Work experience									
Years	14.37 ± 10.78	9.54 ± 8.66	0.045	9.73 ± 9.16	13.22 ± 9.84	0.130	11.30 ± 9.06	10.16 ± 10.18	0.610
Work experience in the ICU									
Years	9.17 ± 8.74	5.82 ± 6.37	0.067	5.88 ± 6.96	8.42 ± 7.46	0.142	7.06 ± 7.04	6.22 ± 7.49	0.617
Gender									
Male	11 (44.0)	14 (56.0)	0.017	19 (76.0)	6 (24.0)	0.251	13 (52.0)	12 (48.0)	0.356
Female	10 (18.5)	44 (81.5)		34 (63.0)	20 (37.0)		34 (63.0)	20 (37.0)	
Educational level									
High school	3 (60.0)	2 (40.0)	0.134	1 (20.0)	4 (80.0)	0.025	3 (60.0)	2 (40.0)	0.718
University degree	9 (20.4)	35 (79.6)		28 (63.6)	16 (36.4)		28 (63.6)	16 (36.4)	
Post-graduation	9 (30.0)	21 (70.0)		24 (80.0)	6 (20.0)		16 (53.3)	14 (46.7)	
Profession									
Nurses	10 (22.2)	35 (77.8)	0.254	28 (62.2)	17 (37.8)	0.266	30 (66.7)	15 (33.3)	0.036
Residents	4 (22.2)	14 (77.8)		15 (83.3)	3 (16.7)		6 (33.3)	12 (66.7)	
Physicians	7 (43.8)	9 (56.2)		10 (62.5)	6 (37.5)		11 (68.8)	5 (31.2)	
Employment contract									
Hospital worker	14 (35.9)	25 (64.1)	0.160	26 (66.7)	13 (33.3)	0.153	24 (61.5)	15 (38.5)	0.018
Freelance	3 (13.6)	19 (86.4)		12 (54.5)	10 (45.5)		17 (77.3)	5 (22.7)	
Residency/training	4 (22.2)	14 (77.8)		15 (83.3)	3 (16.7)		6 (33.3)	12 (66.7)	
Participation at internal meetings*									
Yes	13 (40.6)	19 (59.4)	0.020	21 (65.6)	11 (34.4)	0.819	20 (62.5)	12 (37.5)	0.653
No	8 (17.0)	39 (83.0)		32 (68.1)	15 (31.9)		27 (57.5)	20 (42.5)	
Participation at internal courses**									
Yes	10 (33.3)	20 (66.7)	0.288	16 (53.3)	14 (46.7)	0.042	19 (63.3)	11 (36.7)	0.586
No	11 (22.4)	38 (77.6)		37 (75.5)	12 (24.5)		28 (57.1)	21 (42.9)	
Knowledge									
Adequate				14 (66.7)	7 (33.3)	0.962	10 (47.6)	11 (52.4)	0.196
Inadequate				39 (67.2)	19 (32.8)		37 (63.8)	21 (36.2)	
Attitude									
Positive							29 (54.7)	24 (45.3)	0.217
Negative							18 (69.2)	8 (30.8)	

*Meetings on the ward to share surveillance results ** Courses performed on the ward on hand washing

Supplementary Table 1.2 - Absolute and relative frequencies of the healthcare workers' responses to the questionnaire (N=79) on a scale from 1 to 4 (1=not at all; 4=completely). Domain: attitude and barriers.

	1 N (%)	2 N (%)	3 N (%)	4 N (%)
In your opinion…				
Are HAIs avoidable?	0 (0.0)	11 (13.9)	60 (75.9)	8 (10.2)
Can changes in staff behavior prevent HAIs?	0 (0.0)	4 (5.1)	56 (70.9)	19 (24.0)
Can hand hygiene prevent HAIs?	0 (0.0)	1 (1.3)	33 (41.8)	45 (56.9)
Is HAIs control your responsibility?	1 (1.3)	15 (18.9)	40 (50.6)	23 (29.2)
How much is HAI control a responsibility of…				
a) healthcare workers in the ICU?	2 (2.5)	6 (7.6)	35 (44.3)	36 (45.6)
b) nursing officers?	4 (5.0)	10 (12.7)	36 (45.6)	29 (36.7)
c) HAI Chief?	5 (6.3)	12 (15.2)	36 (45.6)	26 (32.9)
d) health directorate/CIO?	8 (10.2)	15 (18.9)	35 (44.3)	21 (26.6)
How much is the spread of HAI attributable to the behaviour of…				
a) doctors on the ward?	0 (0.0)	8 (10.1)	51 (64.6)	20 (25.3)
b) nurses on the ward?	1 (1.2)	7 (8.9)	49 (62.0)	22 (27.9)
c) staff of the wards from which patients come?	2 (2.5)	8 (10.2)	55 (69.6)	14 (17.7)
d) external medical advisors?	3 (3.8)	16 (20.3)	42 (53.2)	18 (22.7)
e) relatives of patients?	13 (16.5)	32 (40.5)	25 (31.7)	9 (11.3)
f) cleaning staff?	14 (17.7)	36 (45.6)	21 (26.6)	8 (10.1)
g) occasional attendants of the ward (e.g. students)?	9 (11.4)	20 (25.3)	38 (48.1)	12 (15.2)
h) sanitizing staff environmental disinfection?	12(15.2)	21 (26.6)	34 (43.0)	12 (15.2)
How much do the following issues hinder your adherence to hand hygiene guidelines?				
a) scarcity/difficulty in finding dispenser of hydroalcoholic solution	41 (51.9)	28 (35.5)	9 (11.4)	1 (1.2)
b) difficulty in finding sinks	42 (53.2)	27 (34.2)	9 (11.4)	1 (1.2)
c) excessive workload / lack of time	13 (16.4)	22 (27.9)	37 (46.8)	7 (8.9)
d) forgetfulness	25 (31.7)	26 (32.9)	24 (30.4)	4 (5.0)
e) discomfort/irritation of the skin caused by continuous use of products	23 (29.1)	31 (39.2)	19 (24.1)	6 (7.6)

HAI: healthcare-associated infection. ICU: intensive care unit. CIO: Hospital Infections Committee.

affirmed that the spread of HAIs is partially or completely due to other HCWs working in the wards where the patients were previously admitted before being transferred to the ICU. The most frequent barriers to compliance with standard hygiene precautions seemed to be workload or lack of time (more than 55%) and forgetfulness (35.0%). Less importance was given to the availability/proximity of sinks (12.6%) and to the skin irritation caused by soap and disinfectants (31.7%).

The items in this section required respondents to demonstrate a positive attitude and to indicate the most frequent barriers to compliance with hygiene precautions (Supplementary Table 1.2). Respondents were asked to indicate; a) the occupational profiles most responsible for monitoring the HAI (for example healthcare workers, HAI Chief, nursing officers); b) which figures with their behaviour could have a greater influence on the dissemination of

Table 3 - Results of the multivariable logistic regression models to identify predictors of adequate knowledge (Model 1), positive attitude (Model 2) and adequate behaviour (Model 3). Results are expressed as odds ratio (OR) and 95% confidence interval (CI).

	OR	95% CI	p-value
Model 1: adequate knowledge			
Participation in internal meetings* (yes)	4.21	1.36-13.07	0.013
Sex (male)	4.40	1.40-13.81	0.011
Model 2: positive attitude			
Knowledge (adequate)	0.97	0.30-3.18	0.960
Age (years)	0.98	0.93-1.03	0.415
Sex (male)	1.82	0.58-5.73	0.304
Profession (0=others; 1=resident)	2.48	0.61-10.12	0.205
Model 3: adequate behaviour			
Knowledge (adequate)	0.47	0.16-1.35	0.161
Attitude (adequate)	0.62	0.21-1.81	0.377
Profession (0=others; 1=resident)	0.21	0.06-0.74	0.015
Participation in internal courses** (yes)	0.70	0.23-2.15	0.536

* Meetings on the ward to share surveillance results.
** Courses performed on the ward on hand washing.

the HAI (for example doctors or nurses on the ward, external medical advisors, relatives of patients); c) the most frequent barriers to compliance with standard hygiene precautions (for example scarsity/difficulty in finding dispensers of hydroalcoholic solution, insufficient availability of sinks, lack of time).

In the univariate analysis, no significant difference in attitude between male and female professionals were shown (Table 2). By contrast, attitudes differed according to educational level, since there were more individuals with a positive attitude in the post-graduation group (p=0.025). Despite having a more positive attitude, there were no significant differences between those who participated in the internal meetings and those who did not, while participation in hand-washing courses seemed to have an impact on the outcome (p=0.042). Lastly, knowledge did not seem to influence an individual's attitude significantly. A total of 67.1% of HCWs showed a positive attitude in all the questions, but in the multivariable analysis no significant results were obtained to indicate potential predictors of adequate attitudes (Table 3).

Behaviour

Most respondents self-reported correct hand-washing behaviour ("always washing hands before touching the intact skin of patients", 72.0%; "always washing hands after touching the intact skin of patients", 84.8%; "always washing hands before performing an invasive procedure on a patient", 95.0%; "always washing hands after performing an invasive procedure on a patient", 93.7%). However, only 2.5% correctly answered "never" to the question "how often do you wear gloves to touch the intact skin of a patient?", while 62.1% stated unnecessary wearing (Supplementary Table 1.3).

The items in this section required respondents to demonstrate self-reported

Supplementary Table 1.3 - Absolute and relative frequencies of the healthcare workers' responses to the questionnaire (N=79). Domain: self-reported professional behaviour.

	Never N (%)	Sometimes N (%)	Often N (%)	Always N (%)
How often do you...				
a) wash your hands *before* touching the intact skin of a patient?	0 (0.0)	8 (10.1)	14 (17.7)	57 (72.0)
b) wash your hands *after* touching the intact skin of a patient?	0 (0.0)	3 (3.8)	9 (11.4)	67 (84.8)
c) wear gloves to touch the intact skin of a patient?	2 (2.5)	14 (17.7)	14 (17.7)	49 (62.1)
d) wash your hands *before* performing an invasive procedure?	0 (0.0)	2 (2.5)	2 (2.5)	75 (95.0)
e) wash your hands *after* performing an invasive procedure?	0 (0.0)	2 (2.5)	3 (3.8)	74 (93.7)
f) wear gloves to perform an invasive procedure?	1 (1.3)	0 (0.0)	0 (0.0)	78 (98.7)
g) wear gowns to perform an invasive procedure?	0 (0.0)	6 (7.6)	4 (5.1)	69 (87.4)

correct behaviour, i.e. washing hands before and after touching a patient's intact skin, washing hands before and after performing an invasive procedure on a patient, and wearing gloves appropriately.

Univariate analysis revealed statistically significant differences according to job type, with residents showing less adequate professional behaviour (p=0.036) (Table 2). The same was found for employment contract, where residents again showed less adequate behaviour (p=0.018). Also, behaviour was better in those who had attended the training courses, although not significantly. Lastly, neither attitude nor knowledge seemed to influence professional behaviour. Overall, adequate behaviour was demonstrated by 59.5% of the respondents. The results of the multivariable analysis showed that nurses and physicians were more likely to show adequate behaviour than residents in training (aOR=0.21, 95% CI: 0.06-0.74) (Table 3).

Proposals for intervention

All respondents stated that they would like the surveillance program to continue (Supplementary Table 1.4). Among the interventions proposed, direct observation of compliance with standard hygiene precautions was the most requested (79.7%), followed by environmental microbiological surveillance (63.3%) and active surveillance of patients' HAIs (62.0%). It was also found that more than 85% of the respondents thought it could be useful to identify on the ward one or more 'local champions', i.e., professionals responsible for monitoring and containing HAIs. Moreover, 59.5% affirmed that they would prefer to have meetings to share the results of HAI surveillance every three months.

Discussion

In this study we developed and used a questionnaire to collect information about knowledge, attitude, professional behaviour and possible interventions concerning HAIs from HCWs of the main ICU of Umberto I, a large teaching hospital in Rome.

The participants' level of knowledge about the various aspects of HAIs on their own ward was heterogeneous. Encouraging results, as in other published surveys (26, 27), were found regarding the identification of the most contaminated surfaces on the ward (e.g.

Supplementary Table 1.4 - Absolute and relative frequencies of the healthcare workers' responses to the questionnaire (N=79). Domain: proposals of interventions.

	Yes N (%)	No N (%)
Do you agree to…		
a) continue the HAI surveillance activity?	79 (100)	0 (0.0)
b) have inside the department one or more reference persons to monitor the activities of HAI surveillance (local champion)?	69 (87.4)	10(12.6)
c) have one or more reference persons responsible for monitoring and encouraging the correct application of rules/procedures (local champion)?	68 (86.1)	11 (13.9)
d) implement bundles/checklist with recommendations for CVC-related infection prevention?	70 (88.6)	9 (11.4)
Which types of surveillance activity would you find most useful to continue?		
a) environmental microbial surveillance	50 (63.3)	29 (36.7)
b) monitoring of professional behaviour	63 (79.7)	16 (20.3)
c) active surveillance of patient HAIs	49 (62.0)	30 (38.0)
d) monitoring of micro-organisms with molecular typing	38 (48.1)	41 (51.9)
e) none	0 (0.0)	79 (100.0)
How often should periodic meetings be held to share the results of HAI surveillance?		
a) once a month	13 (16.5)	
b) once every 3 months	47 (59.5)	
c) once every 6 months	19 (24.0)	
d) never	0 (0.0)	

HAI: healthcare-associated infection. CVC: central venous catheter.

bed edge, PC keyboard). Generally, the level of knowledge increased with the number of years worked and with age, outlining the need for more training of young HCWs, particularly of residents, in line with other studies (11, 33, 34). Moreover, the level of knowledge was higher in those who had participated in meetings where the results of the surveillance activity were shared. This finding confirms the usefulness of these meetings in providing periodic feedback and increasing HCWs' awareness (28, 33, 35, 36).

In general, the survey's respondents showed a substantially positive attitude towards HAIs prevention, consistent with other studies (10, 27). They seemed to be aware that appropriate professional behaviour and compliance with standard hygiene precautions can have a crucial role in the containment of HAIs. Unlike a few national and international studies that showed an association between good knowledge and positive attitude (11, 33), and between a positive attitude and more years of work experience (15), we did not find any significant predictor. This may suggest that the positive attitude our survey revealed was not attributable to any particular characteristic in our sample, but rather depended on multiple factors.

In the opinion of the HCWs surveyed, continuous improvement in compliance with good hygiene procedures can only occur through regular training. This highlights their willingness to receive regular training in hand hygiene and other correct behaviour aimed at preventing HAIs, as reported in other studies (8, 10-12, 14, 15, 33, 37). Furthermore, although skin problems

due to frequent hand washing and the use of irritating agents have been reported in the literature as the main obstacles to appropriate hand washing (14), in our study the lack of time/excessive workload and forgetfulness were the main barriers, which might be partly explained by the difficulty of managing the amount of work in such an urgent care setting (11, 27).

The HCWs' self-reported behaviour appeared to conform to correct procedure in most situations, except for wearing gloves to touch a patient's intact skin, which is deemed unnecessary and may favour cross-contamination (38-40). However, as hypothesized in many studies (9, 13, 14, 40), compliance with WHO guidelines may be over-reported by healthcare personnel, particularly given that the current results partially contradict those obtained by direct observation of compliance with standard hygiene procedures previously reported on the same ward (8). Nevertheless, the fact that appropriate behaviour was associated with professional category may indicate that training residents, with their limited professional experience, require additional, targeted training (10, 11, 33).

As already observed in another study (5), the importance of continuing the surveillance activities was recognized by all personnel, particularly considering the damage that can arise from any failure to monitor these infections over time (41, 42).

Interestingly, the behavioural survey was highly appreciated, suggesting that the healthcare professionals were aware of the benefits of greater adherence to standard hygiene precautions (43). Lastly, the willingness to identify one or more "local champions" on the ward to take charge of surveillance activities, whose role would be to monitor and encourage correct behavior, and to carry out regular meetings to share the results of surveillance activities, shows that the staff have an appropriate level of sensitivity to the problem (5, 42).

This study has some strengths and limitations, that should be considered when interpreting the results. Firstly, given that we used a self-administered questionnaire, there is a possibility of response bias in the participants' answers, especially for self-reported behaviour (26, 37, 39). Secondly, since this study has a cross-sectional design, it does not evaluate the actual usefulness and effectiveness of the training courses, because to draw such a conclusion would require a comparison with the knowledge, attitude and behaviour prior to participation in the meetings. Lastly, the small sample size may have limited the statistical power of our study and thus the ability to reveal significant differences in some of the data. Conversely, the most important strength of this study is the in-depth analysis of the setting where the HAI surveillance is routinely carried out, which allowed the participants to be involved in supporting HAI prevention and in developing targeted interventions in the future. Additionally, this study could represent the starting point for the monitoring of HCWs' knowledge, attitude and behaviour over time, as well as providing a useful instrument for evaluating the effectiveness of the interventions that will be implemented.

Conclusions

This study used a bottom-up approach in collaboration with the HCWs of the main ICU of Umberto I teaching hospital of Rome, to investigate possible interventions that might reduce the incidence and increase thr management of HAIs. There was a good response rate to the survey and participants showed good knowledge and attitudes. The respondents were interested in the problem of containment of HAIs on their ward and wanted to continue the surveillance activities that were implemented in the department in 2016. The respondents also wished to continue

the surveillance activity on professional behavior, recognizing the positive impact that this monitoring has on clinical practice and HAIs containment, despite it being extremely time-consuming and - to some extent - intrusive. Furthermore, the HCWs underlined their willingness to meet periodically to discuss the results of the surveillance system and to identify a figure responsible for the prevention and containment of HAIs (i.e., a "local champion"). This survey represents only the first step in creating a more active collaboration with the ward staff, and - above all - in stimulating their active participation in the development of decisions that are taken on the ward, such as the promotion of some interventions over others. It also provides the possibility to monitor knowledge, attitudes and professional behaviors over time in order to be able to better target the interventions to be carried out. Additionally, this approach could be a useful tool for the management and control of HAIs, which remain an important problem in ICUs, especially given the increase in antibiotic resistance of pathogens (32). Finally, it would be desirable to repeat the investigation both with the staff of the Anaesthesia and Resuscitation Department, to assess the reproducibility of the results over time, and with the staff of all other departments at high risk of developing HAIs.

Riassunto

Conoscenze, attitudini, barriere, comportamenti professionali e possibili interventi: indagine sulle infezioni correlate all'assistenza tra gli operatori sanitari in un reparto di terapia intensiva in un ospedale universitario di Roma

Premessa. Le infezioni correlate all'assistenza (ICA) sono le principali complicanze del ricovero ospedaliero. Un approccio dal basso verso l'alto, in cui gli operatori sanitari coinvolti giocano un ruolo chiave, può essere adottato per limitare la diffusione delle ICA. A tal fine, è stata condotta un'indagine nel reparto di terapia intensiva del Policlinico Universitario Umberto I di Roma, in cui da aprile 2016 è attivo un sistema di sorveglianza.

Metodi. È stato creato ad hoc e poi somministrato un questionario di 36 domande per indagare le caratteristiche socio-professionali, la conoscenza delle ICA, le attitudini e le barriere incontrate nel rispetto delle norme igieniche, l'autoanalisi dei comportamenti professionali e le proposte di nuovi interventi. Le variabili sono state valutate mediante analisi univariata e sono stati costruiti modelli di regressione logistica multivariata per identificare i predittori di conoscenza adeguata, attitudine positiva e comportamenti professionali appropriati**.**

Risultati. Complessivamente hanno compilato il questionario 79/89 operatori sanitari. L'analisi multivariata ha mostrato che gli operatori sanitari, che hanno partecipato alle riunioni di reparto per condividere i rapporti di sorveglianza attiva, avevano maggiori probabilità di avere una conoscenza adeguata (aOR = 4,21, 95% CI: 1,36-13,07). Solo la tipologia di lavoro sembrava essere un predittore di un comportamento adeguato, poiché infermieri e medici avevano maggiori probabilità di mostrare un comportamento adeguato rispetto ai medici in formazione specialistica (aOR = 0,21, IC 95%: 0,06-0,74). L'osservazione diretta del rispetto delle norme igieniche standard e l'identificazione di un "local champion" per gestire le problematiche delle ICA sono stati gli interventi più richiesti.

Conclusioni. Il nostro studio suggerisce che la formazione degli operatori sanitari è un fattore chiave per prevenire e contenere la diffusione delle ICA. Inoltre, incoraggiando un maggiore coinvolgimento degli operatori sanitari, concludiamo che un approccio dal basso verso l'alto potrebbe migliorare la prevenzione e la gestione delle infezioni correlate all'assistenza.

References

1. Lewis, SS, Moehring, RW, Chen, LF, et al. Assessing the relative burden of hospital-acquired infections in a network of community hospitals. Infect Control Hosp Epidemiol. 2013 Nov; **34**(11): 1229-30. doi: 10.1086/673443.
2. World Health Organization (WHO). Health care-associated infections. Fact Sheet; 2017. Available on: https://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf [Last accessed: 2021 May 24].
3. Vincent, JL. Nosocomial infections in adult intensive-care units. Lancet. 2003 June 14; **361**(9374): 2068-77. doi: 10.1016/S0140-6736-(03)13644-6.
4. Barbato D, Castellani F, Angelozzi A, et al. Prevalence survey of healthcare-associated

infections in a large teaching hospital. Ann Ig. 2019 Sep-Oct; **31**(5): 423-35. doi: 10.7416/ai.2019.2304.
5. Migliara, G, Di Paolo C, Barbato D, et al. Multimodal surveillance of healthcare associated infections in an intensive care unit of a large teaching hospital. Ann Ig. 2019 Sep-Oct; **31**(5): 399-413. doi: 10.7416/ai.2019.2302.
6. The Council of European Union. Council Recommendation of 9 June 2009 on patient safety, including the prevention and control of healthcare associated infections. Off J Eur Union 6 2009.
7. Ducel G, Fabry J, Nicolle L, eds. Prevention of hospital-acquired infections: a practical guide. 2nd ed. Geneva, Switzerland: World Health Organization, 2002. Available on: https://apps.who.int/iris/handle/10665/67350 [Last accessed: 2021 May 24].
8. Baccolini V, D'Egidio V, de Soccio P, et al. Effectiveness over time of a multimodal intervention to improve compliance with standard hygiene precautions in an intensive care unit of a large teaching hospital. Antimicrob Resist Infect Control. 2019 May 31; **8**: 92. doi: 10.1186/s13756-019-0544-0.
9. World Health Organisation (WHO). A Guide to the Implementation Multimodal Hand Hygiene Improvement Strategy. Contents Definition of terms. New South Wales Premiers Dep. 2009; 47. Available on: https://www.who.int/gpsc/5may/Guide_to_Implementation.pdf [Last accessed: 2021 May 24].
10. Parmeggiani C, Abbate R, Marinelli P, Angelillo IF. Healthcare workers and health care-associated infections: knowledge, attitudes, and behavior in emergency departments in Italy. BMC Infect Dis. 2010 Feb 23; **10**: 35. doi: 10.1186/1471-2334-10-35.
11. Nobile CGA, Montuori P, Diaco E, Villari P. Healthcare personnel and hand decontamination in intensive care units: knowledge, attitudes, and behaviour in Italy. J Hosp Infect. 2002 Jul; **51**(3): 226-32. doi: 10.1053/jhin.2002.1248.
12. Hosseinialhashemi M, Sadeghipour Kermani F, Palenik CJ, Pourasghari H, Askarian M. Knowledge, attitudes, and practices of health care personnel concerning hand hygiene in Shiraz University of Medical Sciences hospitals, 2013-2014. Am J Infect Control 2015 Sep 1; **43**(9): 1009-11. doi: 10.1016/j.ajic.2015.05.002. Epub 2015 Jun 23.
13. Allegranzi B, Gayet-Ageron A, Damani N, et al. Global implementation of WHO's multimodal strategy for improvement of hand hygiene: a quasi-experimental study. Lancet Infect Dis. 2013 Oct; **13**(10): 843-51. doi: 10.1016/S1473-3099(13)70163-4. Epub 2013 Aug 23.
14. World Health Organisation (WHO). WHO Guidelines on Hand Hygiene in Health Care: First Global Patient Safety Challenge Clean Care Is Safer Care. Geneva: World Health Organization; 2009.
15. Di Muzio M, Tartaglini D, De Vito C, La Torre, G. Validation of a questionnaire for ICU nurses to assess knowledge, attitudes and behaviours towards medication errors. Ann Ig. 2016 Mar-Apr; **28**(2): 113-21. doi: 10.7416/ai.2016.2090.
16. Caudell MA, Dorado-Garcia A, Eckford S, et al. Towards a bottom-up understanding of antimicrobial use and resistance on the farm: A knowledge, attitudes, and practices survey across livestock systems in five African countries. PLoS One. 2020 Jan 24; **15**(1): e022027. doi: 10.1371/journal.pone.0220274.
17. Matsumoto-Takahashi ELA, Tongol-Rivera P, Villacorte EA, Angluben RU, Jimba M, Kano S. Bottom-up approach to strengthen community-based malaria control strategy from community health workers' perceptions of their past, present, and future: a qualitative study in Palawan, Philippines. Trop Med Health. 2018 Jul 4; **46**: 24. doi: 10.1186/s41182-018-0105-x.
18. Vaucher C, Bovet E, Bengough T, et al. Meeting physicians' needs: a bottom-up approach for improving the implementation of medical knowledge into practice. Health Res Policy Syst. 2016 Jul 18; **14**(1): 49. doi: 10.1186/s12961-016-0120-5.
19. Bentur N, Sternberg SA. Dementia care in Israel: top down and bottom up processes. Isr J Health Policy Res. 2019 Feb 20; **8**(1): 22. doi: 10.1186/s13584-019-0290-z.
20. Vansteenkiste M, Williams GC, Resnicow K. Toward systematic integration between self-determination theory and motivational interviewing as examples of top-down and bottom-up intervention development: autonomy or volition as a fundamental theoretical principle. Int J Behav Nutr Phys Act. 2012 Mar 2; **9**: 23. doi: 10.1186/1479-5868-9-23.
21. World Health Organisation (WHO). Hand Hygiene Knowledge Questionnaire for Health-Care Workers. 3 (2009).

22. World Health Organisation (WHO). Perception Survey for Health-Care Workers. 7 (2009).
23. World Health Organisation (WHO). Perception Survey for Senior Managers. 3 (2009).
24. De Vito C, Nobile CG, Furnari G, et al. Physicians' knowledge, attitudes and professional use of RCTs and meta-analyses: a cross-sectional survey. Eur J Public Health. 2009 June; **19**(3): 297-302. doi: 10.1093/eurpub/ckn134. Epub 2009 Jan 7.
25. van der Zwaan GL, Oude Hengel KM, Sewdas R et al. The role of personal characteristics, work environment and context in working beyond retirement: a mixed-methods study. Int Arch Occup Environ Health. 2019 May; **92**(4): 535-49. doi: 10.1007/s00420-018-1387-3. Epub 2018 Dec 4.
26. Taffurelli C, Sollami A, Camera C, et al. Healthcare associated infection: good practices, knowledge and the locus of control in heatlhcare professionals. Acta Biomed. 2017 Jul 18; **88**(3S): 31-6. doi: 10.23750/abm.v88i3-S.6611.
27. Sadule-Rios N, Aguilera G. Nurses' perceptions of reasons for persistent low rates in hand hygiene compliance. Intensive Crit Care Nurs. 2017 Oct; **42** :17-21. doi: 10.1016/j.iccn.2017.02.005. Epub 2017 Mar 30.
28. Rinaldi A, Marani A, Montesano M, et al. Healthcare Associated Infections: educational intervention by 'Adult Learning' in an Italian teaching hospital. Ann Ig. 2016 Nov-Dec; **28**(6): 441-9. doi: 10.7416/ai.2016.2126.
29. Abu Yahya O, Ismaile S, Allari RS, Hammoudi BM. Correlates of nurses' motivation and their demographic characteristics. Nurs Forum. 2019 Jan; **54**(1): 7-15. doi: 10.1111/nuf.12291. Epub 2018 Dec 3.
30. Braun BI, Harris AD, Richards CL, et al. Does health care role and experience influence perception of safety culture related to preventing infections? Am J Infect Control. 2013 Jul; **41**(7): 638-41. doi: 10.1016/j.ajic.2012.09.006.
31. Waltz CF, Strickland OL, Lenz ER. Measurement in Nursing and Health Research. 5th ed. Springer Publishing Company; 2010.
32. Migliara G, Baccolini V, Isonne C, et al. Prior antibiotic therapy and the onset of healthcare-associated infections sustained by multidrug-resistant *Klebsiella pneumoniae* in intensive care unit patients: a nested case-control study. Antibiotics (Basel). 2021 Mar 15; **10**(3): 302. doi: 10.3390/antibiotics10030302.
33. Nair SS, Hanumantappa R, Hiremath SG, Siraj MA, Raghunath P. Knowledge, Attitude, and Practice of Hand Hygiene among Medical and Nursing Students at a Tertiary Health Care Centre in Raichur, India. ISRN Prev Med. 2014 Feb 6; 608927. doi: 10.1155/2014/608927.
34. Kirk J, Kendall A, Marx JF, et al. Point of care hand hygiene where's the rub? A survey of us and Canadian care workers' knowledge attitudes and practices. Am J Infect Control. 2016 Oct 1; **44**(10): 1095-01. doi: 10.1016/j.ajic.2016.03.005. Epub 2016 May 10.
35. Lee CM, Colagiuri R, Magliano DJ, et al. The cost of diabetes in adults in Australia. Diabetes Res Clin Pract. 2013 Mar; **99**(3): 385-90. doi: 10.1016/j.diabres.2012.12.002. Epub 2013 Jan 5.
36. Khan HA, Baig FK, Mehboob R. Nosocomial infections: Epidemiology, prevention, control and surveillance. Asian Pac J Trop Biomed. 2017 May; **7**(5): 478-82. https://doi.org/10.1016/j.apjtb.2017.01.019.
37. World Health Organisation (WHO). Evidence of hand hygiene to reduce transmission and infections by multi- drug resistant organisms in health-care settings. (2009). Available on: https://www.who.int/gpsc/5may/MDRO_literature-review.pdf [Last accessed: 2021 May 24].
38. Zimakoff J, Stormark M, Larsen SO. Use of gloves and hand washing behaviour among healthcare workers in intensive care units. A multicentre inves-tigation in four hospitals in Denmark and Norway. J Hosp Infect. 1993 May; **24**(1): 63-7. doi: 10.1016/0195-6701-(93)90090-m.
39. Loveday HP, Lynam S, Singleton J, Wilson J. Clinical glove use: healthcare workers' actions and perceptions. J Hosp Infect. 2014 Feb; **86**(2): 110-6. doi: 10.1016/j.jhin.2013.11.003.
40. Jain S, Clezy K, McLaws ML. Modified glove use for contact precautions: health care workers' perceptions and acceptance. Am J Infect Control. 2019 Aug; **47**(8): 938-44. doi: 10.1016/j.ajic.2019.01.009. Epub 2019 Mar 6.
41. Morsillo F, Gagliotti C, Ricchizzi E, et al. Sorveglianza nazionale delle infezioni in terapia intensiva (Progetto SITIN). Rapporto dati 2016. [National surveillance of infections in intensive care units (SITIN Project). Data report 2016]. Agenzia sanitaria e sociale regionale dell'Emilia-Romagna. (2018).
42. Haley RW, Culver DH, White JW, et al. The efficacy of infection surveillance and control

programs in preventing nosocomial infections in US hospitals. Am J Epidemiol. 1985 Feb; **121**(2): 182-205. doi: 10.1093/oxfordjournals.aje.a113990.

43. World Health Organization (WHO). Hand hygiene technical reference manual: to be used by health-care workers, trainers and observers of hand hygiene practices. Geneva: WHO; 2009.

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