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Major Article

Comparison of infection control practices in a Dutch and US hospital using the infection risk scan (IRIS) method

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Benchmarking

Background: The infection risk scan (IRIS) is a tool to measure the quality of infection control (IC) and antimicrobial use in a standardized way. We describe the feasibility of the IRIS in a Dutch hospital (the Netherlands, NL) and a hospital in the United States (US).

Methods: Cross-sectional measurements were performed. Variables included a hand hygiene indicator, environmental contamination, IC preconditions, personal hygiene of health care workers, use of indwelling medical devices, and use of antimicrobials.

Results: IRIS was performed in 2 wards in a US hospital and 4 wards in a Dutch hospital. Unjustified use of medical devices: none in the US hospital, 2.2% in the Dutch hospital; inappropriate use of antibiotics: 11.7% (US), 19% (NL); items considered not clean: 10% (US); 36% (NL); shortcomings preconditions: 6 of 20 (US), 6 of 40 (NL); health care workers with rings, watches, or long sleeves: 34 of 43 (US), none in the NL hospital; and hand hygiene actions per patient/day: 41 (US) and 10 (NL). US data judged against the Dutch guidelines and vice versa revealed remarkable differences.

Conclusions: We showed the feasibility of using the IRIS in a US hospital. The method provided insight in IC local performance. This method could be the first step to standardize the measurement of the quality of IC and antimicrobial use. However, if the IRIS is used for benchmarking between hospitals in different regions, this should be done in the context of regional guidelines and policies.

A tool has been developed that provides insight in the quality of infection prevention by investigating a bundle of infection control (IC) process and outcome parameters in a standardized way—the infection risk scan (IRIS).[1] The results are visualized in a diagram using traffic light color codes to provide easy to understand feedback to health care workers. The IRIS has been implemented in a Dutch teaching hospital, in multiple medical specialties, with a repeated quality loop. Using the IRIS method, compliance with IC practices improved,[1,2] especially consumption of hand hygiene products and reduced environmental contamination.

The objective of this project was to explore the feasibility of a Dutch IC method, the IRIS, in a US hospital as a proof of concept study.

METHODS

Setting

The IRIS was performed in the second quarter of 2016 in 4 surgical patient care units of a 900-bed Dutch teaching hospital (Amphia hospital), and 1 surgical and 1 medical patient care unit of a 719-bed US teaching hospital (Rhode Island hospital).

Patient risk profile and improvement spider plot

The IRIS consists of cross-sectional measurements and investigates patient, ward, and care delivery-related variables. Patient-related risks were visualized in a patient risk profile; ward and care

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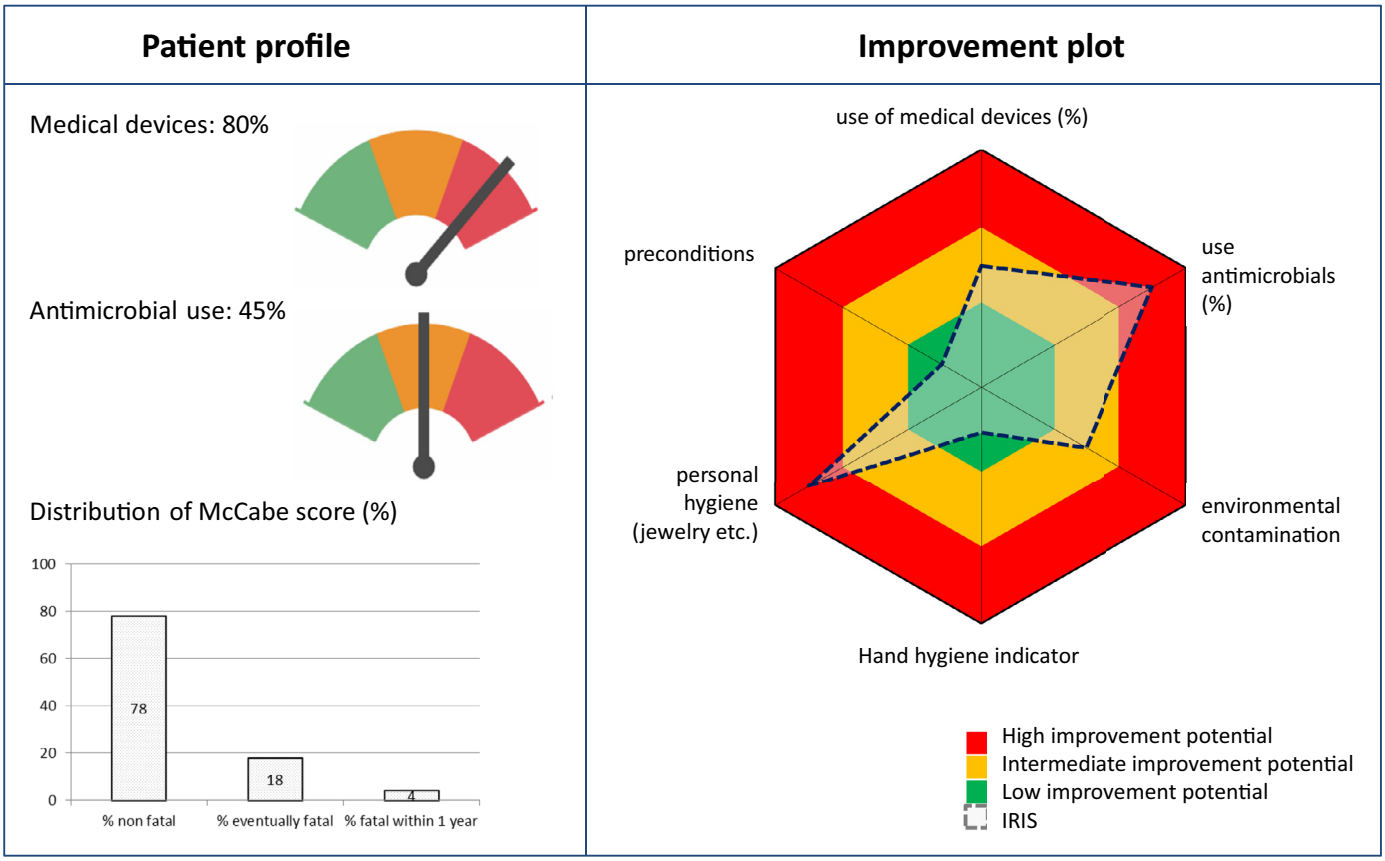

Fig. 1. Example of the IRIS. The left side of the figure shows the risk profile, and the right side of the figure shows the improvement plot. *IRIS*, infection risk scan.

delivery-related risk were visualized in an improvement spider-plot with 7 variables (Fig 1).

Risk profile

The risk profile shows the vulnerability of the patient population, and consist of 3 variables:

1. Prevalence of indwelling urethral or suprapubic catheters and intravascular devices (including peripheral intravenous catheters not in active use) on the day of the survey.[3,4]
2. Prevalence of intravenous or oral antibacterial antimicrobial therapy on the day of the survey.[5] Inhalation medication, cement beads, topical antibiotics, antiviral and antifungal therapy were not included, nor did we include antibiotic prophylaxis administrated in the operating theater.
3. The McCabe score was used as an indication of the severity of the patient population. The McCabe score classifies all patients into 3 categories: (1) nonfatal, (2) ultimately fatal, and (3) rapidly fatal.[6]

Improvement plot

The improvement plot shows 7 ward- and care delivery-related risk factors. These factors can be influenced by the health care professional or organization.

1. Appropriate use of indwelling medical devices.

Appropriateness of the indication for intravascular devices was based on local guidelines. Appropriateness of the indication of urethral catheters was based on the flowchart used in the national Dutch prevalence survey for hospital-associated infections.[3] The proportion of patients with a medical device that was considered inappropriate was presented in the improvement plot. The flowcharts for judgment of appropriateness are presented as supplementary figures (Supplementary Figs 1 and 2).

2. Appropriate use of antimicrobial therapy.

Appropriateness of treatment (indication and choice of antimicrobial) was judged against the local antibiotic formulary using a standardized method.[5,7] The following classifications were used: appropriate use (ie, justified use and appropriate choice), inappropriate use (ie, unjustified use and/or justified use, but inappropriate choice and/or inappropriate administration route, duration, or dosage), or insufficient information. The proportion of patients with 1 or more antimicrobials that was considered unjustified or inappropriate choice was presented in the improvement plot.

The use of antibiotics was judged according to the local antimicrobial stewardship guidelines.

3. Environmental contamination.

Detection of adenosine triphosphate (ATP) was used to identify the level of environmental contamination with organic material.[8,9] Samples were taken, using an ATP device (3M Incorporated, St Paul, MN), from a fixed amount of predefined objects or surfaces within each unit, at least 2 hours after routine cleaning and in accordance to the manufacturer's guidelines (Table 1). Results below 1,500 relative light units (RLU) were considered clean (0 points); 1,500-3,000 RLU intermediate (1 point); 3,000-10.000 RLU contaminated (2 points); and above 10.000 RLU extremely contaminated (3 points). The total score of all measured objects tested within the unit was presented in the risk plot.

Table 1
Overview of all tested surfaces for environmental contamination and tested infection control preconditions

ATP test points	Infection control preconditions
Bedrail (twice, in 2 rooms)	Trash bin(s) are closed and foot-operated (entire department)
Over bed table	The (clean) linen is stored in a clean place, protected against dust and moisture
Shower chair (NL); handle and nozzle from the hose for bedpan cleaning (US)	The bedpan washer meets the following requirement: disinfection with steam or hot water of at least 80°C (for at least 60 seconds)
Washstand	Sterile medical devices (catheters, IVs) are kept in a closed cabinet
Support bar in the toilet room	Medical supply and bandages are kept in closed cabinets
Toilet seat (sitting area)	Halter aprons to protect clothing are present at the ward
Door handle nursing office	Surgical masks are present at the division
Patient alarm bell	Nonsterile gloves (NEN-EN 420+A1, NEN-EN374, NEN-EN) are present in every patient room
IV pole (most frequently touched part of the pole)	Hand alcohol (is present in every patient room and at point of care [EN1500])
Keyboard PC in the nursing office	No fabric chairs or benches are present in the patient and/or treatment room
Telephone	
Control panel bedpan washer (NL); bedpan (US)	
Bedside commode	
Cabinet for medical supply and bandages	
Blood pressure cuff	
Ear thermometer (ear tip)	
Glucometer	
Work surface of the bench for drug preparation	
Keyboard computer on wheels	

ATP, adenosine triphosphate; *EN*, European standard; *IV*, intravenous; *NL*, Dutch hospital; *NEN*, Netherlands norm; *PC*, personal computer; *US*, US hospital.

4. Shortcomings in infection prevention preconditions.

Several preconditions are essential for an effective IC policy. The tested items are listed in Table 1.

5. Personal hygiene of health care workers.

At least 20 health care workers (nurses, staff physicians or house officers, and other hospital employees in hospitals) were tested for the basic hygiene rules: no rings, no watch or wrist jewelry present, forearms uncovered (bare below the elbow), uniform worn correctly, and coat closed.[10]

6. Hand hygiene indicator.

The indicator for hand hygiene was of the consumption of hand hygiene product instead with observations.[11] The amount of hand hygiene product was divided by the amount of patient-days in the ward in the same period, divided by the amount of hand hygiene product that was delivered per application. This results in the number of hand hygiene moments per patient-day. A surrogate compliance rate was calculated with the assumption that on average 50 hand hygiene moments should be performed per day, per patient to obtain 100% "compliance."[12]

The selection of risk factors was based on the importance, as judged by a group of experienced infection preventionists, as well as the possibility of an objective and reproducible assessment.

Data collection, preparation of feedback data, and visualization

Point-prevalence surveys were performed by 1 trained infection preventionist, using standardized electronic case record forms, according to the Dutch national surveillance protocol for hospitals (PREZIES).[3,4] The electronic medical record was the data source. Any ambiguity was verified with the nurse manager of the unit. The records of all patients on the study units during the study period were reviewed to assess basic patient characteristics and length of stay.

The collection, interpretation, and cutoff points for the risk classification was used as described in Table 2. Risk classification was based on prevalence rates from (inter)national surveillance[13-15] or expert opinion, and previous measurements if no reference values were available in the peer-reviewed literature.[5,16-20]

Compliance to guidelines and appropriateness of use was based on the local guidelines of the hospital. Using IRIS as a benchmark tool, a universal standard is needed. To provide insight in differences in local guidelines, US data were judged against the Dutch guidelines, and Dutch data were judged against US guidelines.

To visualize all surveillance data in 1 graph, data were converted into a scale from 0-100 using an algorithm. In the spider plot, each axis of the plot represents an outcome variable or risk factor (Fig 1).

Ethics

According to the Dutch regulation for research with human subjects, neither medical nor ethical approval was required to conduct the surveillance because it was part of the local hospital/nursing home policy, patients/residents provided oral informed consent and all data were processed anonymously. In the US hospital, the institutional review board approval and consent were waived because the project plan met the definition of a quality improvement project.

Statistical methods

Data were analyzed with Statistical Package for Social Science software Version 19 (IBM Corporation, Armonk, NY). Categorical variables were analyzed by the Pearson χ^2 test or the Fisher exact test when appropriate, and continuous variables were analyzed using the Mann–Whitney U test. Statistical significance was accepted when the chance for coincidence was <5%.

RESULTS

IRIS in the US hospital

Patient profile: Fifty-three patients were investigated: medical specialty surgery (n = 24) and internal medicine (n = 29). Average age was 56.5 years (range 19-92; SD = 22.6), and median length of stay was 4 days (range 0-25; SD = 5.8). The McCabe score was reported for 51 patients: 31 (60.8%) nonfatal, 11 (21.6%) eventually fatal, and 9 (17.6%) fatal within 1 year (Table 3).

Table 2
Overview of all collected variables, the method used, outcome variables that are visualized in the risk profile and improvement plot, and breakpoints for the risk classification

Risk profile			**Risk classification**		
Variables	*Method*	*Outcome variable*	*Low*	*Intermediate*	*High*
Severity of underlying diseases, according to the McCabe score	Prevalence survey (file research and interview)	The percentage per category is presented in the risk profile	NA		
Indwelling medical devices, including venflon not in use	Prevalence survey (file research and interview)	Percentage (n = total number inclusions)	≤15	>15 and ≤50	>50
Antibiotic use	Prevalence survey (file research and interview)	Percentage (n = total number inclusions)	≤15	>15 and ≤50	>50

Improvement plot			**Improvement potential**		
Variables	*Method*	*Outcome variable*	*Low*	*Intermediate*	*High*
Inappropriate use of medical devices	Prevalence survey (file research and interview)	Percentage (n = total number of patients with medical devices in use)	≤15	>15 and ≤25	>25
Inappropriate use of antibiotics	Prevalence survey (file research and interview)	Percentage (n = total number of patients administered 1 or more antibiotics)	≤15	>15 and ≤25	>25
Hand hygiene noncompliance	Direct observations of hand hygiene moments per unit	% noncompliance overall (n >200 moments)	≤40	>40 and ≤60	>60
Environmental contamination	ATP detection on predefined surfaces/objects per ward Per tested surface/object, RLU is converted to a score (1, 2, 3, or 4)	Total score per ward/setting (in case of multiple wards within 1 setting, breakpoints will be adjusted as needed)	≤4	>4 and ≤12	>12
Shortcomings in infection control preconditions	Ten preconditions are observed per ward	Score from 1 to 10	≤1	>1 and ≤3	>3
Personal hygiene of health care workers	Twenty nurses and other health care employees, per ward, were checked for compliance with the dress code	Score from 1 to 20 (in case of less observations, breakpoints will be adjusted as needed)	≤1	>1 and ≤4	>4

ATP, adenosine triphosphate; *NA*, not available; *RLU*, relative light units.

Of all patients, 49 (92.5%) had 1 or more indwelling medical device in situ. More specifically, 2 (3.8%) patients had a urinary catheter; 46 (86.8%) patients had a peripheral catheter; and 3 (5.7%) patients had a central venous catheter. Seventeen patients (32.1%) were receiving antimicrobial therapy on the day of the survey (Table 3).

Improvement plot: All intravascular and urinary catheters were considered justified according to local guidelines. Two patients (11.7%) were receiving antibiotics that were not consistent with local guidelines. Of 40 tested items, 36 were considered clean, 1 intermediate, 2 contaminated, and 1 extremely contaminated. This resulted in a score of 8 for 2 wards. Considering the IC preconditions, in both wards bedpans were cleaned manually instead with bedpan washer or alternative system, and furniture with damaged material was in use. One trash bin and storage of (clean) linen did not meet the criteria, which resulted in a score of 6 out of 20.

Forty-three health care workers (20 nurses, 10 physicians, 3 cleaning, 8 other) were observed, and all were clothed according to the local hospital regulation. A waterless foam alcohol hand hygiene product (Purell, GOJO, Cuyahoga Falls, OH) was used, dispensing 0.8 mL per application. Some 136,000 mL of hand disinfectant was consumed in the second quarter of 2016 in 2 investigated units. Dividing this number by the number of patient-days in these wards (4,411) results in a 30.8 mL of hand hygiene product consumed per patient-day. Considering the volume per application, 41 (30.8 mL/0.8 mL) hand hygiene actions per patient per day were calculated, revealing a hand hygiene indicator of 82.1%.

Table 3
Patient characteristics

	Dutch hospital	*US hospital*	*RR (95% CI)*	*P value*
Female	47% (101/213)	49% (26/53)		ns
Mean age (years) (range)	67.3 (19-95), SD = 16.5	56.5 (19-92), SD = 22.6		.003
Median length of stay (days)	5 (0-103), SD = 12.9	4 (0-25), SD = 5.8		ns
Medical specialty				
Surgery	97% (207/213)	45% (24/53)		
Medicine	0.5% (1/213)	55% (29/53)		
Other	2.5% (6/213)			
McCabe score				
Total	213	53		
Unknown	6	2		
Nonfatal (>5 years)	79.6% (164/207)	60.8% (31/51)		< .001
Eventually fatal (1-5 years)	18.4% (38/207)	21.6% (11/51)		
Fatal within 1 year	2.4% (5/207)	17.6% (9/51)		
Indwelling medical devices	65.3% (139/213)	92.5% (49/53)	0.71 (0.66-0.83)	< .001
Urinary catheter	25.4% (54/213)	3.8% (2/53)	6.72 (1.75-39.60)	< .001
Peripheral catheter	56.3% (120/213)	86.8% (46/53)	0.65 (0.58-0.79)	< .001
Central venous catheter	9.4% (20/213)	5.7% (3/53)	1.66 (0.50-6.93)	ns
Antimicrobial therapy	37.1% (79/213)	32.1% (17/53)	1.16 (0.76-1.90)	ns

CI, confidence interval; *ns*, not significant; *RR*, relative risk.

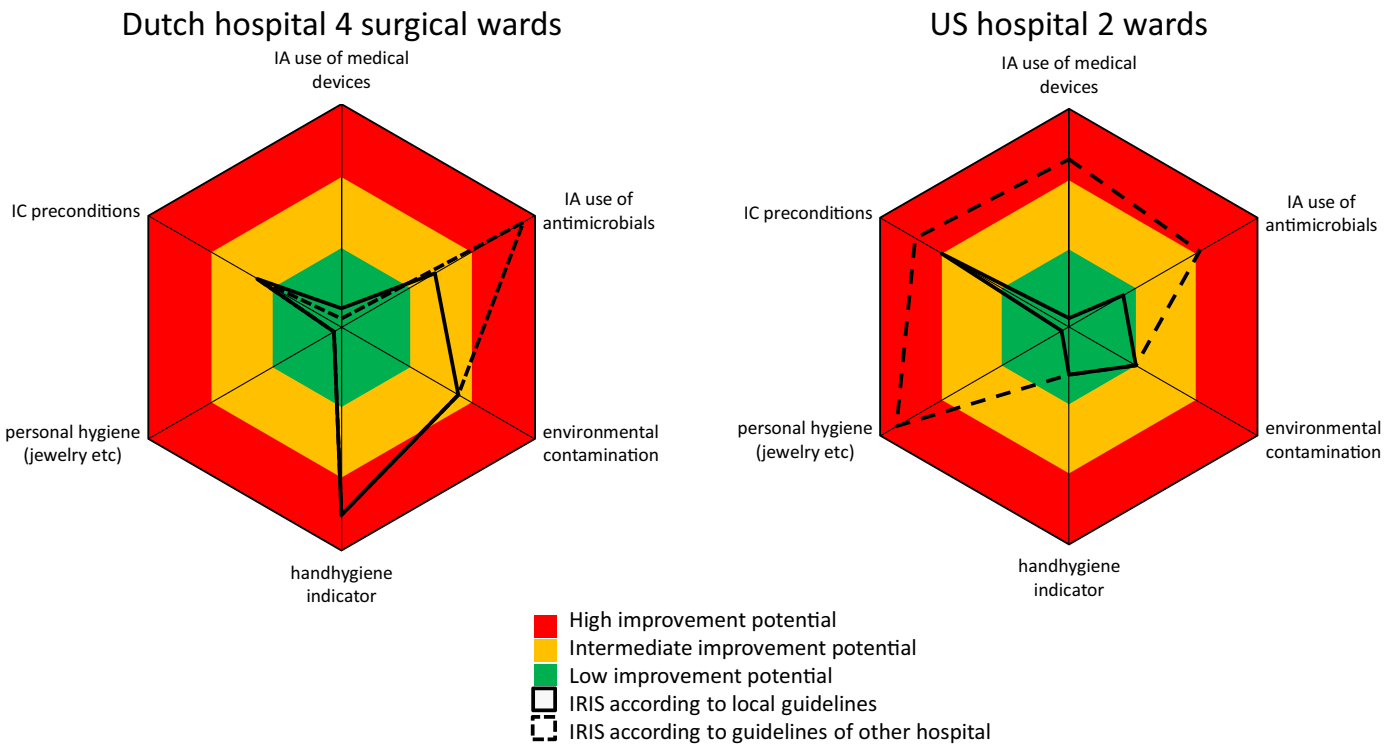

Fig. 2. Improvement plots of the Dutch and US hospital judged against the local guidelines and the guidelines of the other hospital. *IA*, inappropriate; *IC*, infection control; *IRIS*, infection risk scan.

IRIS in the Dutch hospital

Patient profile: A total of 213 patients were investigated: medical specialty surgery (n = 207), internal medicine (n = 1), and other specialties (n = 6). The average age was 67.3 years (range 19-95; SD = 16.5), and length of stay was 5 days (range 0-103; SD = 12.9). The McCabe score was reported for 207 patients: 164 (79.6%) nonfatal, 38 (18.4%) eventually fatal; and 5 (2.4%) fatal within 1 year (Table 3).

Of all patients, 139 (65.3%) had 1 or more indwelling medical device in situ. More specifically, 54 (25.4%) had a urinary catheter; 120 (56.3%) patients had a peripheral catheter; and 20 (9.4%) patients had a central venous catheter. Seventy-nine patients (37.1%) were treated with antimicrobial therapy on the day of the survey (Table 3).

Improvement plot: Three urinary catheters (2.2%) were considered unjustified. Fifteen patients (19%) were treated with antibiotics that were not consistent with the local guidelines. Of 80 tested items, 51 were considered clean, 17 intermediate, and 12 contaminated, resulting in a score of 41 for the 4 wards.

Considering the IC preconditions in all wards, storage of linen and trash bins in 2 wards did not meet the criteria. This resulted in a score of 6 out of 40. A total of 76 health care workers (40 nurses, 18 physicians, 18 other) were observed, and all were clothed according to the local hospital regulation. A waterless liquid alcohol hand hygiene product (Sterilium, Hartman, Nijmegen, the Netherlands) was used, dispensing 2 mL per application. Some 132,850 mL of hand disinfectant was consumed in the second quarter of 2016 in the investigated wards. This volume divided by the number of patient-days in these wards (6,772) results in 19.6 mL hand disinfectant consumed per patient-day. When considering the volume per application, a total of 9.8 (19.6 mL/2 mL) hand hygiene actions per patient per day were calculated, revealing a hand hygiene indicator of 22.9%.

All data were plotted in the IRIS improvement plot (Fig 2). This figure provides transparency in the local performance of IC according to the local guidelines (solid line).

IRIS as a benchmark tool

Significant differences were found in age and McCabe score. Prevalence of urethral catheters was higher in the Dutch hospital, and prevalence of short-term peripheral intravenous catheters was higher in the US hospital.

1. Indwelling medical devices.

In both hospitals, all intravascular catheters were considered justified according to their own local guidelines. However, Dutch guidelines were more restrictive in the use of intravascular catheters and considered 23 of the 46 US patients with an intravascular catheter unjustified. No difference in the judgment of the urethral catheters was found in the 2 hospitals.

2. Large differences were found when the Dutch patients were judged against the US local guideline and vice versa. Narrow-spectrum antimicrobials were considered inappropriate by the US infectious diseases specialist, and the broad-spectrum antimicrobials were considered as too broad by the Dutch microbiologist.
3. Fewer contaminated test points and a lower level of contamination at those test points were detected in the US hospital compared with the Dutch hospital because median ATP level in the US hospital was 312 RLU (range 3-16,068) compared with 1,007 RLU (range 44-7,318; $P = .008$) in the Dutch hospital.
4. Shortcomings in infection prevention preconditions.

Difference in use of personal protection equipment (eg, reusable vs disposable isolation gowns and manual vs thermal mechanical cleaning of bedpans) were observed.

5. Personal hygiene of health care workers.

No employees were seen wearing rings, watches, or wrist jewelry in the Dutch hospital, and all forearms were uncovered. However, in the US hospital, 44% of employees were wearing 1 or more rings (19 of 43), 49% wore a watch or wrist jewelry (21 of 43), and 37% had their forearms covered (16 of 43).

6. Hand hygiene indicator: a large difference in hand hygiene actions per patient per day was found. Hand hygiene dispensers were available in the hallway, at the entrance of each room, and at point of care in the US hospital. In the Dutch hospital, dispensers were available at the bedside, above the sink inside the room, but no hand hygiene dispensers were available in the hallway. Furthermore, there were more single rooms in the US hospital units than in the Dutch hospital units.

The US data judged against the Dutch guidelines and the Dutch data judged against the US guidelines are visualized in Figure 2 (dashed line).

DISCUSSION

We demonstrated the feasibility of performing an IRIS in a US and Dutch hospital, providing insight regarding catheter and antimicrobial use, cleanliness, health care worker hygiene, hand hygiene, and IC preconditions. Based on the IRIS, opportunities for improvement in the US hospital center around the basics of IC, the IC preconditions. In the Dutch hospital, opportunities for improvement center around hand hygiene, environmental cleaning, and appropriate antibiotic use. The IRIS results provided targets for interventions, and these interventions can be assessed in a future IRIS.

However, when we compare the results of both hospitals, it is important to do so in the context of local guidelines. For example, antibiotic use guidelines in the Netherlands are much more restrictive than in the US.[17,21,22] To investigate differences in local guidelines, all data were estimated by both local guidelines.

Indwelling medical devices: Guidelines for intravascular catheter use in the Dutch hospital were more restrictive than guidelines in the US hospital.[23,24] Differences in patient populations may also be a contributing factor.

Antimicrobial use: No significant difference in prevalence of antimicrobial use was measured, but the type of antimicrobial therapy varied considerably. This is not surprising, given the difference in antimicrobial resistance between the 2 countries. For example, the incidence of hospital-onset and community-onset methicillin-resistant *Staphylococcus aureus* bloodstream infections declined 74% and 40%, respectively.[25] However, methicillin-resistant *Staphylococcus aureus* incidence is still much higher in the US than in the Netherlands.[26] In addition, the prevalence of extended-spectrum β-lactamase-producing bacteria is higher in the US than the Netherlands.[27] Therefore, broad-spectrum antimicrobials were used much more frequently in the US hospital. In both hospitals there is an opportunity for improvement; however, the room for improvement in the Dutch hospital is limited.

Environmental contamination: Cleanliness, determined using an ATP illuminometer, revealed more contaminated test points and higher levels of RLUs in the Dutch hospital. In the Netherlands, rooms are daily dry-cleaned using microfiber cloths. In the US hospital, rooms are cleaned daily using wet cleaning methods. Rooms were cleaned and disinfected after every discharge in the US hospitals. In the Dutch hospital, except for the bed and bedside table, rooms were only disinfected after discharge of patients carrying multidrug-resistant microorganism. It is unclear how these results relate to the risk of transmission of bacteria, but we can conclude that the environment in the Dutch hospital was more contaminated using the ATP measurement.

Shortcomings in infection prevention preconditions: Most of the tested infection prevention preconditions are part of the universal precautions to prevent transmission of microorganisms. The Dutch guidelines defining standard precautions are based on the Centers for Disease Control and Prevention and World Health Organization guidelines, and therefore not significantly different from guidelines in the US hospital.[15-17] However, discrepancies were found, mostly caused by differences in interpretation of the guideline or national regulations.

Personal hygiene of health care workers: The Centers for Disease Control and Prevention guideline was followed in the US hospital.[28] In this guideline, rings are highlighted as a risk factor for carriage of gram-negative bacilli and *S aureus*, and the concentration of microorganisms correlates with the number of rings worn. Whether the wearing of rings results in a higher likelihood of transmission is not stated. Therefore, no recommendation is given about wearing jewelry in health care settings. In the Dutch hospital, no jewelry was worn, in accordance with the Dutch guidelines.[29]

Another cultural difference regarding the dress code in the 2 hospitals is the “bare below the elbow policy.” In the Netherlands, all health care workers wear a short sleeves uniform or coat provided by, and washed by, the hospital. Health care workers change clothes at the beginning and end of their shift. In the US hospital, some health care workers wash their uniforms at home, which does not provide a guarantee for adequate cleaning.

Hand hygiene indicator: The hand hygiene indicator revealed higher compliance in the US hospital, which was likely caused by the better availability of dispensers. A limitation in the use of a hand hygiene indicator is the use of different hand disinfectants in the 2 countries. In the United States a foam alcohol dispenser was used, and in the Netherlands a dispenser with 2 mL liquid alcohol product was dispensed. It is questionable if we can compare the use of 2 different hand hygiene products with completely different volumes.

The IRIS method is practical, concrete, and uniform. However, difference in national guidelines, and therefore local guidelines are substantial. The results demonstrate a substantive variation between these 2 settings. It is unclear how these differences relate to the outcome as we did not perform screening for carriage, and transmission, of multidrug-resistant organisms, which has been used as an outcome variable of the IRIS in the Netherlands.[6]

There are several limitations to this proof of concept study. The number of units studied was limited, impacting generalizability of the data. The number of environmental samples and observations of staff were limited. We did not measure interrater reliability. However, we believe performance of the IRIS by a single infection preventionist led to consistency in methodology.

CONCLUSIONS

The IRIS provides a tool to measure the local performance of IC and can be used to measure improvement after interventions. When IRIS is used for benchmarking between hospitals in different regions, there is need to assess local guidelines and policies. Nevertheless, careful scrutiny at the hospital unit level using this tool has allowed both institutions to gain insights otherwise unrealized, which we will further pursue in the hopes of mitigating risk to future patients.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2019.09.020.

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