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Prevalence and risk factors of inappropriate use of intravenous and urinary catheters in surgical and medical patients

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SUMMARY

Background: Previously, the RICAT (Reduction of Inappropriate use of intravenous and urinary CATheters) study had been conducted by ourselves to reduce inappropriate use of intravenous and urinary catheters in medical wards to prevent healthcare-associated infections.

Aim: To compare surgical and medical wards, and to determine risk factors for inappropriate catheter use.

Methods: A cross-sectional study was performed from October, 2017, to May, 2018, in surgical wards of two university hospitals in the Netherlands. Patients were prospectively observed every other week for seven months. Inappropriate use was compared with non-surgical wards in the RICAT study.

Findings: In all, 409 surgical patients were included, and they were compared with 1781 medical patients. Inappropriate use occurred in 36 (8.5%) out of 425 peripheral intravenous catheters in 373 surgical patients, compared to 400 (22.9%) out of 1747 peripheral intravenous catheters in 1665 medical patients, a difference of 14.4% (95% confidence interval (CI): 11.1–17.8; $P < 0.001$). Inappropriate use of urinary catheters occurred in 14 (10.4%) out of 134 surgical patients, compared to 105 (32.4%) out of 324 medical patients, a difference of 22.0% (95% CI: 14.7–29.2; $P < 0.001$). Subgroup analysis in the two university hospitals confirmed these differences. The main risk factor for inappropriate use of peripheral intravenous catheters was admission in medical wards (odds ratio (OR): 3.50; 95% CI: 2.15–5.69), which was also one of the main risk factors for urinary catheters (OR: 2.75; 95% CI: 1.36–5.55).

Conclusion: Inappropriate use of catheters is more common in medical wards compared to surgical wards. Prevention strategies to reduce healthcare-associated infections should primarily focus on sites with high prevalence of inappropriate use.

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Introduction

Healthcare-associated infections are important safety risks for patients. A large number of healthcare-associated infections, especially catheter-associated bloodstream infections (CABSIs) and urinary tract infections (CAUTIs), are preventable. Therefore, the incidence of catheter-associated infections is considered a marker for quality of care [1]. Device-associated infections, such as catheter-associated infections, account for 25% of all healthcare-associated infections [2]. The most important intervention to prevent healthcare-associated infections is therefore to limit the use of catheters, by strict indication and timely removal of catheters as soon they are no longer necessary.

Earlier research has suggested that inappropriate use of short peripheral intravenous catheters (PIVCs) is associated with adverse patient outcomes, including PIVC bloodstream infections and phlebitis [3]. Guidelines for prevention of CABSIs and CAUTIs recommend reducing the use of (inappropriate) intravenous and urinary catheters [4,5]. Appropriate use of intravenous and urinary catheters was defined in a multi-disciplinary iterative panel using the RAND/UCLA appropriateness method in 2015 (Box 1) [6,7]. Nevertheless, inappropriate use is still a frequent phenomenon in clinical practice. A recent cross-sectional study in 406 hospitals in 51 countries found a prevalence of inappropriate use of PIVCs of 14% (5796 out of 40,620 PIVCs) [8]. For urinary catheters, rates of inappropriate use are even higher, namely 21–54% [4].

We had previously conducted a project entitled the RICAT (Reduction of Inappropriate use of intravenous and urinary CATheters) study, to reduce inappropriate use of PIVCs and urinary catheters in medical wards of seven hospitals in the Netherlands [9]. If inappropriate use of catheters is frequent in all hospitalized patients, our de-implementation strategy could be implemented as a national prevention programme to reduce healthcare-associated infections. However, there are many differences between surgical and medical wards with respect to patient care, e.g. more nurse-driven and protocolized care in surgical wards. Whether these differences result in different rates of inappropriate catheter use between surgical and medical wards is unknown. Only one study mentioned the incidence of CABSIs and CAUTIs specifically in surgical and medical wards, finding no clinical differences [10].

In this cross-sectional study, the aim was to evaluate the use of intravenous and urinary catheters in surgical wards. If there was room for improvement, defined as more than 15% inappropriate catheter use, we planned to start our de-implementation strategy in the surgical wards [11]. Further, we compared inappropriate use of catheters between surgical and medical wards, and assessed risk factors for inappropriate catheter use. Our hypothesis was that inappropriate use of catheters was less frequent in surgical wards compared to medical wards.

Methods

Study design and patients

Surgical patients were observed while admitted on one of the five participating surgical wards (general surgery, gastrointestinal surgery, surgical oncology, trauma surgery, and vascular surgery) in two university hospitals in the Netherlands from October 12th, 2017, to May 1st, 2018. The primary research physician visited the hospitals every other week for seven months to observe patients at that time present in their

Box 1
Panel of appropriate indications for use of catheters.

Central venous catheter.

- Delivery of cyclical or episodic chemotherapy that can be administered through a peripheral vein, provided that the proposed duration of such treatment is ≥3 months (PICC)
- Delivery of non-peripherally compatible infusate (e.g. irritants or vesicants)
- Delivery of peripherally compatible infusate, with a duration of use which will likely confine ≥6 days (PICC). PIVCs are preferred over use of PICCs for infusion of peripherally compatible infusates up to 14 days
- For infusions or palliative treatment during end-of-life care (PICC)
- Frequent phlebotomy (every 8 h), provided that the proposed duration of such use is ≥6 days
- Intermittent infusions or infrequent phlebotomy in patients with poor/difficult peripheral venous access, provided that the proposed duration of such use is ≥6 days (PICC)
- Invasive haemodynamic monitoring or requirement to obtain central venous access in critically ill patients

Peripheral intravenous catheter.

- Delivery of peripherally compatible infusate (intravenous fluids and medications), at least once in 24 h
- Injection of contrast fluids
- Intravenous access for cardiac dysrhythmia
- Transfusion of blood and blood products

Urinary catheter.

- Accurate measurements of urinary output in critically ill patients required for treatment
- Acute urinary retention or bladder outlet obstruction (≥150 cc)
- Assist in healing of open sacral or perineal wounds in patients with urinary incontinence
- Continuous bladder irrigation for haematuria
- Palliative care for terminally ill if needed
- Patient requires prolonged immobilization

PICC, peripherally inserted central catheter; PIVC, peripheral intravenous catheter.

respective wards for having one or more catheters. The primary research physician and a junior researcher, under the supervision of the primary research physician, collected data, including the indication for catheter use, from medical and nursing records. To assure the validity of data collection, a random 10% sample of all data was audited. If the junior researcher had doubts or could not find the indication by chart review, the indications for catheter use were audited by the primary research physician. For reasons of convenience, patients were included every other week during the same time and day of the week for each hospital. Data collection was similar for medical patients.

For the comparison with medical patients, our previously obtained data from the pre-intervention period of the RICAT study were used, in which we included patients of non-surgical wards (internal medicine, gastroenterology & hepatology, geriatrics, pulmonology, and non-surgical patients admitted to acute medical units) in seven hospitals (three university and four general hospitals) [9]. The two university hospitals of the surgical patients were part of the RICAT study, and data from surgical patients were collected one year after the RICAT study.

Adult patients admitted to surgical wards with an intravenous (peripheral and/or central) and/or urinary catheter on the day of screening were eligible for inclusion. Patients with chronic use of catheters were excluded, defined as having their catheter prior to the current admission. Patients admitted for elective short stay, terminally ill patients, and patients who had previously been included in the study were also excluded. The in- and exclusion criteria were similar for medical patients.

Ethical approval was obtained on June 22nd, 2016, from Medical Ethics Research Committee of the Academic Medical Centre, with a waiver for individual informed consent. Local feasibility was approved by the local institutional review boards of the participating hospitals. The results are reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [12]. This trial was registered at Netherlands Trial Register, trial NL5438 (trialregister.nl/trial/5438).

Outcomes

The primary outcomes were the percentages of patients with an inappropriate indication for a PIVC and for a urinary catheter on the days of data collection. Secondary endpoint was an inappropriate indication for a central venous catheter. The indications for catheter use were based on international guidelines, namely the MAGIC and Ann Arbor criteria (Box 1) [6,7]. The following variables were collected for possible risk factors for inappropriate catheter use: age, sex, updated version of the Charlson comorbidity index, acute admission, returned from ICU, isolation in a single room, duration of hospitalization, and number of catheter-days on day of inclusion [13]. A comorbidity score $\geq$3 or $<$3 was used for severity of comorbidities.

Statistical analysis

For the comparison between medical and surgical patients, it was known from our baseline measurements that the rate of inappropriate use in the medical patients of the RICAT study was 22.0% for PIVCs and 32.4% for urinary catheters [9]. For surgical patients, the first 50 included patients were used as a pilot for the sample size calculation. The rate of inappropriate use in these pilot patients was 12.2% for PIVCs and 11.1% for urinary catheters. Based on this number, a sample size of 251 patients with a PIVC and 67 patients with a urinary catheter per group was necessary to achieve 80% power to detect a difference with a 0.05 two-sided significance level. Due to the study setting, no drop-outs or missing data were anticipated.

Categorical data were calculated as frequency and percentage, and continuous data as mean (standard deviation) or median (range). For comparisons of raw data for surgical and medical patients, unpaired *t*-tests or Mann–Whitney *U*-tests were used for continuous variables and χ^2-tests for categorical variables. To account for a possible cluster effect of hospital on surgical and medical patients, a generalized linear mixed-effects model with a random intercept per hospital was constructed and compared to a model without a random intercept using Akaike's information criterion. To adjust for confounders, bivariate logistic regression analyses were performed for all possible confounders. Variables showing a difference of more than 10% in β for surgical or medical patients were included in the multivariate logistic models to adjust for confounding. Since this study was performed in two of the seven hospitals that had participated in the RICAT study, a subgroup analysis was performed to compare data from surgical and medical patients in these two hospitals.

In addition, risk factors for inappropriate catheter use were determined. First, univariate logistic regression was used to determine the associations between patient characteristics and the primary outcomes. Second, variables showing a univariate association with inappropriate catheter use ($P < 0.10$) were included in stepwise backward multivariate logistic models. Since most patients were medical patients, subgroup analysis of univariate logistic regression was also performed to determine risk factors for inappropriate catheter use specific for only surgical and only medical patients. Two-sided $P < 0.05$ was considered significant.

Descriptive analyses were performed using SPSS Statistics, version 25.0 (IBM Corp., Armonk, NY, USA), and R software, version 3.6.1 (R Foundation, Vienna, Austria). The RICAT study is registered at Netherlands Trial Register, trial NL5438.

Results

Between October 12th, 2017, and May 1st, 2018, a total of 753 clinical admissions in the participating surgical wards were included, of whom 633 patients were screened for inclusion. A total of 107 patients were missing, because these patients were absent during the direct patient observations, resulting in 526 screened patients (Figure 1). A flowchart of the non-surgical wards of all hospitals of the RICAT study are presented in Supplementary Figure S1. Primary endpoint data were available for all included patients. Of 526 screened surgical patients, 373 (70.9%) had one or more PIVCs, 134 (25.5%) a urinary catheter, and 113 (21.5%) patients had no catheter. Differences in the clinical and demographic characteristics between the surgical and medical groups are listed in Table I.

Inappropriate catheter use was less frequent in the surgical group (Table II). For PIVCs, the rate of inappropriate use was 8.5% (95% confidence interval (CI): 6.0–11.5) in the surgical group compared to 22.9% (95% CI: 20.9–24.9) in the medical group (incidence rate ratio (IRR): 0.37; 95% CI: 0.26–0.52;

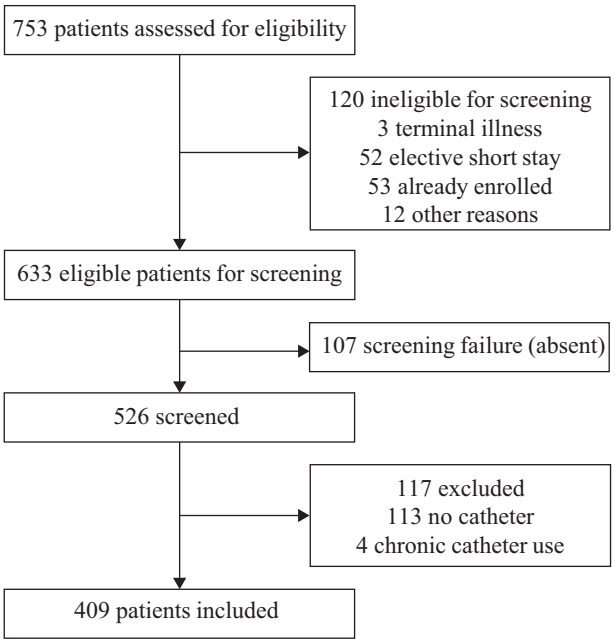

Figure 1. Trial profile of patients included in surgical and medical wards of two university hospitals.

$P < 0.001$). For urinary catheters, inappropriate use was 10.4% (95% CI: 5.8–16.9) in the surgical group and 32.4% (95% CI: 27.3–37.8) in the medical group (IRR: 0.32; 95% CI: 0.18–0.56; $P < 0.001$). The most frequent inappropriate indication in surgical patients was prolonged use of PIVCs after intravenous fluid and/or medication, and prolonged use of urinary catheters postoperatively (Supplementary Table S1).

Mixed effects models to account for clustering showed no differences; based on Akaike's information criterion, no cluster effect was found. Bivariate logistic regression analyses showed no confounders for inappropriate use of PIVCs. The medical group was independently associated with inappropriate use (odds ratio (OR) 3.50; 95% CI: 2.15–5.69; $P < 0.001$). The covariables 'acute admission' and 'returned from ICU' were confounders for urinary catheters. However, multivariate analyses to adjust for confounders still confirmed an independent association between the medical group and inappropriate use of urinary catheters (OR: 3.41; 95% CI: 1.74–6.68; $P = 0.005$).

No inappropriate use of central venous catheters was present in the surgical group, which was not significantly different from the 6.4% in the medical group ($P = 0.066$). Inappropriate use of PIVCs was greater in patients with two PIVCs in both groups. Inappropriate use of these second PIVCs was 21.2% (95% CI: 11.1–34.7) in the surgical group and 41.5% (95% CI: 30.7–52.9) in the medical group ($P = 0.015$).

Subgroup analysis of the two university hospitals with data from both surgical and medical patients showed comparable results (Supplementary Table S2). Inappropriate use of catheters was lower in the surgical group compared to the medical group, respectively 59% for PIVCs ($P < 0.001$) and 61% for urinary catheters ($P < 0.001$). Adjusted analyses of the subgroup in the two university hospitals showed similar results for PIVCs (OR: 2.65; $P < 0.001$). However, this was not significant for urinary catheters (OR: 2.18; $P = 0.057$).

Table I
Baseline characteristics of surgical ward patients in two university hospitals and of medical ward patients of all participating hospitals (including the two university hospitals)

Variable	Surgical group ($N = 409$)	Medical group ($N = 1781$)
Age (years), mean (SD)	59.2 (15.3)	64.8 (17.6)
Sex		
Male	258 (63.1%)	939 (52.7%)
Female	151 (36.9%)	842 (47.3%)
Charlson comorbidity index, median (IQR)	2 (4)	2 (3)
Charlson comorbidity index, score ≥3	130 (31.8%)	587 (33.0%)
Type of catheters during inclusion[a]		
PIVC	373 (70.9%)	1665 (62.8%)
Urinary catheter	134 (25.5%)	324 (12.2%)
CVC	62 (11.8%)	78 (2.9%)
2nd PIVC	52 (9.9%)	82 (3.1%)
Days from admission to inclusion, median (IQR)	4 (7)	3 (5)
Acute admission	154 (37.7%)	1611 (90.5%)
Returned from ICU	89 (21.8%)	206 (11.6%)
Isolation in a single room	5 (1.2%)	200 (11.2%)
Catheter-days on day of inclusion, median (IQR)		
PIVC	3 (6)	3 (4)
Urinary catheter	2 (5)	3 (5)
CVC	6 (7)	6 (8)

SD, standard deviation; IQR, interquartile range; PIVC, peripheral intravenous catheter; CVC, central venous catheter; ICU, intensive care unit.
[a] Denominators are the screened patients by direct observations.

Stepwise backward multivariate analyses showed that admission to medical wards was a main risk factor for inappropriate use of PIVCs (OR: 3.50; 95% CI: 2.15–5.69) and urinary catheters (OR: 2.75; 95% CI: 1.36–5.55). Other risk factors are found in Table III. The subgroup analysis for risk factors in only surgical or only medical patients showed similar risk factors for inappropriate catheter use in surgical and medical patients. However, we found that acute admissions was only a risk factor for medical patients (Supplementary Table S3).

Discussion

The study results affirmed the hypothesis that inappropriate use of catheters is not a general problem of the same size in different inpatient wards, but that it is less frequent in surgical wards. In surgical wards compared to the medical wards, the rate of inappropriate use was only 9% compared to 23% for PIVCs, and 10% compared to 32% for urinary catheters. Even though surgical patients were younger, more often male and with less acute admissions – which were protective factors for inappropriate catheter use – admission to a medical ward was still one of the biggest independent risk factors for inappropriate catheter use.

In a single-centre point-prevalence study in Spain, 126 (22%) out of 575 patients had an inappropriate peripheral or central intravascular catheter, but in contrast to our findings no differences between surgical and medical wards were found [14].

Table II
Inappropriate use of catheters

Variable	Surgical group ($N = 409$)	Medical group ($N = 1781$)	Risk difference (95% CI)	IRR (95% CI)	*P*-value
Inappropriate use of PIVCs[a,b]	36/425 (8.5%)	400/1747 (22.9%)	−14.4% (−17.7% to −11.1%)	0.37 (0.26–0.52)	<0.001
1st PIVC	25/373 (6.7%)	366/1665 (22.0%)	−15.3% (−18.5% to −12.1%)	0.30 (0.20–0.46)	<0.001
2nd PIVC	11/52 (21.2%)	34/82 (41.5%)	−20.3% (−35.7% to −4.9%)	0.51 (0.26–1.01)	0.015
Inappropriate use of urinary catheters[a]	14/134 (10.4%)	105/324 (32.4%)	−22.0% (−29.2% to −14.7%)	0.32 (0.18–0.56)	<0.001
Inappropriate use of CVCs[c]	0/62 (0.0%)	5/78 (6.4%)	−6.4% (−13.3% to −0.5%)	NA	0.066

CI, confidence interval; IRR, incidence rate ratio; PIVC, peripheral intravenous catheter; CVC, central venous catheter.
[a] Primary outcome.
[b] Some patients have more than one PIVC.
[c] Secondary outcome.

We found high percentages of inappropriate use of second PIVCs in both surgical (21%) and medical (42%) patients. This was also found in a prospective observational study in a medical–surgical ward in a single centre in Nebraska, USA, that examined all catheter-days of peripheral and central venous catheters and showed that 31% were inappropriate, which increased in patients with multiple catheters [15]. Similar to our findings, age and duration of catheterization were associated with inappropriate catheter use. Another prevalence survey of 28 hospitals in the Netherlands in 2009 and 2010 showed lower inappropriate use (7.5%), but also found an association between inappropriate use and not having surgery [16].

One explanation of our findings could be that higher overall use of catheters in surgical wards resulted in more awareness, and thereby less inappropriate use. Further, we noticed another possible explanation during the observations, where most surgical patients had a postoperative pathway, a predefined pathway for nursing staff with postoperative dates written when catheters or other devices should be removed. This pathway empowered nurses to remove catheters 48–72 h after surgery without physicians' individual approval per patient. These practices in wards with low rate of inappropriate use could be used for targeted prevention strategies in other wards. For example, to introduce a similar protocol in medical wards, where nurses might be empowered to remove all catheters after 48–72 h by a checklist of appropriate indications.

To the best of our knowledge, there have been no other studies identifying specific wards as risk factors for inappropriate catheter use. A systematic review from 2016 about prevalence and risk factors for inappropriate PIVCs stated that patient age and other demographic factors were not consistently found to be important risk factors, but only a few

Table III
Univariate and multivariate associations of inappropriate catheter use of the whole study population[a]

Variable	Univariable OR (95% CI)	*P*-value	Multivariable OR (95% CI)	*P*-value
Inappropriate use of PIVCs				
Age	1.015 (1.008–1.022)	<0.001	1.011 (1.004–1.018)	0.002
Male sex	1.021 (0.817–1.274)	0.857		
Charlson comorbidity index	1.021 (0.973–1.072)	0.394		
Days from admission to inclusion	1.011 (0.997–1.024)	0.129		
Acute admission	2.348 (1.652–3.337)	<0.001	1.424 (0.935–2.170)	0.100
Returning from ICU	1.055 (0.757–1.469)	0.752		
Isolation in a single room	0.883 (0.593–1.315)	0.541		
Catheter-days on day of inclusion	1.025 (1.006–1.044)	0.009	1.039 (1.018–1.059)	<0.001
Medical group	3.922 (2.572–5.982)	<0.001	3.499 (2.153–5.687)	<0.001
Inappropriate use of urinary catheters				
Age	1.008 (0.994–1.022)	0.278		
Male sex	0.518 (0.339–0.793)	0.002	0.464 (0.288–0.747)	0.002
Charlson comorbidity index	0.948 (0.858–1.048)	0.296		
Days from admission to inclusion	1.027 (1.009–1.045)	0.003		
Acute admission	3.447 (1.994–5.958)	<0.001	2.569 (1.310–5.037)	0.006
Returning from ICU	2.423 (1.536–3.824)	<0.001	2.195 (1.252–3.848)	0.006
Isolation in a single room	4.364 (2.153–8.843)	<0.001	3.189 (1.462–6.957)	0.004
Catheter-days on day of inclusion	1.050 (1.021–1.079)	0.001	1.044 (1.011–1.078)	0.008
Medical group	4.110 (2.254–7.491)	<0.001	2.750 (1.364–5.547)	0.005

OR, odds ratio; CI, confidence interval; PIVC, peripheral intravenous catheter; ICU, intensive care unit.
[a] Patients from the surgical wards in two university hospitals and of the medical wards in all participating hospitals (including the two university hospitals).

studies assessed risk factors for inappropriate use of PIVCs [3]. Likewise, we found that patient age was a minor but statistically significant risk factor for inappropriate use of PIVCs. Other studies also found that female sex and admission to a non-ICU ward were risk factors for inappropriate use of urinary catheters, but they did not assess the other factors [16,17].

The strength of this study is the prospective design with a seven-month period, which represents a reliable sample for both surgical and medical patients. Thereby, we assessed risk factors for both intravenous and urinary catheter use. This combination yielded insight into similar risk factors, which could be used in prevention strategies for all catheters to prevent catheter-related infections and other complications. Next, we collected the data in the same way for both groups, and the assessment methods of the indications for catheter use were similar. Finally, this study reveals variations of inappropriate catheter use in different medical disciplines, which might be used to identify high risk patients or wards for targeted interventions, and at the same time to prevent broad-scale implementation of prevention programmes in wards already performing optimally.

There are some important limitations of the study to be considered. First, a different patient mix was assessed for catheter use in surgical and medical patients, since surgical patients were observed in two of the seven hospitals that participated in the RICAT study [9]. The two hospitals with surgical patients were both university teaching hospitals. Patients' comorbidity scores in university hospitals are generally higher, but no association was found between comorbidity and inappropriate catheter use. Nevertheless, the outcome might not be generalizable for surgical patients in general hospitals. However, we could make adjustments for this difference in patient mix by making subgroup analyses of differences between surgical and medical patients in the same hospitals. Further, due to a lack of statistical power, results from the subgroup analyses of inappropriate use of urinary catheters in the two university hospitals were not significantly different between surgical and medical wards.

Furthermore, we do not know which surgical patients had a postoperative pathway on the day of data collection. Moreover, the indications for urinary catheters were different between surgical and medical patients (Supplementary Table S1), which could introduce confounding by indication. Adjusting by using propensity score matching techniques was not possible due to the sample size. However, the number of days on which a urinary catheter was considered appropriate was the same for the indications in surgical (e.g. postoperative) and in medical (e.g. monitoring during critically illness) patients, namely 48—72 h. Thus, most inappropriate indications were prolonged use of catheters after 48—72 h in both surgical and medical patients. Therefore, their risk of potentially inappropriate use is similar and confounding by indication is probably not applicable. Lastly, the study periods did not occur during the same timeframe: medical patients were included one year prior to surgical patients. This could potentially have introduced bias, but we conducted a de-implementation strategy only in the medical and not in the surgical wards. However, inappropriate use of catheters in surgical patients is even lower than in the same time-period in medical patients of the two university hospitals after a de-implementation strategy [9].

More catheter use leads to more healthcare-associated infections, and each infection due to an inappropriate catheter is one too many. Although inappropriate use of catheters is substantially lower in surgical wards compared to medical wards, prevention strategies could still have clinical impact. However, if there are limited resources for prevention strategies, resources should firstly be used in wards with high prevalence of inappropriate catheter use, namely non-surgical wards. Next, inappropriate use of a second PIVC was frequent in both wards, which should be taken into account by implementation strategies. Early removal strategies could be physician reminders, e.g. automatic stop orders after 48 or 72 h, and empowerment of nurses and physician assistants by a protocol, similar to a postoperative pathway, to remove catheters without appropriate indications [18]. Insight into prevalence and risk factors for inappropriate catheter use is crucial to understand barriers for timely removal of catheters, and to implement targeted interventions, for example specifically for second PIVCs or in wards with high prevalence of inappropriate use.

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Conflict of interest statement
None declared.

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Appendix A. Supplementary data

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References

[1] Umscheid CA, Mitchell MD, Doshi JA, Agarwal R, Williams K, Brennan PJ. Estimating the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs. Infect Control Hosp Epidemiol 2011;32:101—14.
[2] Magill SS, O'Leary E, Janelle SJ, Thompson DL, Dumyati G, Nadle J, et al. Changes in prevalence of health care-associated infections in U.S. hospitals. N Engl J Med 2018;379:1732—44.
[3] Becerra MB, Shirley D, Safdar N. Prevalence, risk factors, and outcomes of idle intravenous catheters: an integrative review. Am J Infect Control 2016;44:e167—72.
[4] Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. Clin Infect Dis 2010;50:625—63.
[5] O'Grady NP, Alexander M, Burns LA, Dellinger EP, Garland J, Heard SO, et al. Guidelines for the prevention of intravascular catheter-related infections. Clin Infect Dis 2011;52:e162—93.
[6] Chopra V, Flanders SA, Saint S, Woller SC, O'Grady NP, Safdar N, et al. The Michigan Appropriateness Guide for Intravenous Catheters (MAGIC): results from a multispecialty panel using the RAND/UCLA appropriateness method. Ann Intern Med 2015;163:S1—40.

[7] Meddings J, Saint S, Fowler KE, Gaies E, Hickner A, Krein SL, et al. The Ann Arbor criteria for appropriate urinary catheter use in hospitalized medical patients: results obtained by using the RAND/UCLA appropriateness method. Ann Intern Med 2015;162:S1—34.
[8] Alexandrou E, Ray-Barruel G, Carr PJ, Frost SA, Inwood S, Higgins N, et al. Use of short peripheral intravenous catheters: characteristics, management, and outcomes worldwide. J Hosp Med 2018;13(5).
[9] Laan BJ, Maaskant JM, Spijkerman IJB, Borgert MJ, Godfried MH, Pasmooij BC, et al. De-implementation strategy to reduce inappropriate use of intravenous and urinary catheters (RICAT): a multicentre, prospective, interrupted time-series and before and after study. Lancet Infect Dis 2020 Mar 6 [Epub ahead of print].
[10] Dudeck MA, Edwards JR, Allen-Bridson K, Gross C, Malpiedi PJ, Peterson KD, et al. National Healthcare Safety Network report, data summary for 2013, Device-associated module. Am J Infect Control 2015;43:206—21.
[11] Hermanides HS, Hulscher ME, Schouten JA, Prins JM, Geerlings SE. Development of quality indicators for the antibiotic treatment of complicated urinary tract infections: a first step to measure and improve care. Clin Infect Dis 2008;46:703—11.
[12] von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. PLoS Med 2007;4:e296.
[13] Quan H, Li B, Couris CM, Fushimi K, Graham P, Hider P, et al. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge abstracts using data from 6 countries. Am J Epidemiol 2011;173:676—82.
[14] Fernandez-Ruiz M, Carretero A, Diaz D, Fuentes C, Gonzalez JI, Garcia-Reyne A, et al. Hospital-wide survey of the adequacy in the number of vascular catheters and catheter lumens. J Hosp Med 2014;9:35—41.
[15] Tiwari MM, Hermsen ED, Charlton ME, Anderson JR, Rupp ME. Inappropriate intravascular device use: a prospective study. J Hosp Infect 2011;78:128—32.
[16] Jansen IA, Hopmans TE, Wille JC, van den Broek PJ, van der Kooi TI, van Benthem BH. Appropriate use of indwelling urethra catheters in hospitalized patients: results of a multicentre prevalence study. BMC Urol 2012;12:25.
[17] Schuur JD, Chambers JG, Hou PC. Urinary catheter use and appropriateness in U.S. emergency departments, 1995—2010. Acad Emerg Med 2014;21:292—300.
[18] Meddings J, Rogers MA, Macy M, Saint S. Systematic review and meta-analysis: reminder systems to reduce catheter-associated urinary tract infections and urinary catheter use in hospitalized patients. Clin Infect Dis 2010;51:550—60.