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Missed infection prevention and control activities and their predictors: insights from a pre- and post-pandemic study

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SUMMARY

Aim: The primary aim of this study was to compare differences, if any, in missed infection prevention and control (IPC) activities before and after the pandemic, along with the related predictors. The secondary aim was to identify relationships between missed IPC activities and unfinished nursing care.

Methods: A repeated cross-sectional design was conducted in 2019 (pre-pandemic, 184 nurses) and 2024 (post-pandemic, 240 nurses) in a large academic hospital following the Checklist for Reporting of Survey Studies guidelines. The Missed Nursing Care in Infection Prevention and Control Survey (MNC-IPC) (Part A: missed activities, Part B: reasons), the Unfinished Nursing Care Survey (UNCS), and professional data were collected homogeneously across both periods.

Findings: Self-reported missed IPC activities decreased from 2.15 out of 5 (95% confidence interval (CI), 2.05–2.25) to 1.51 (95% CI, 1.45–1.58) ($P<0.0005$), as did the related reasons, which decreased from 2.35 out of 4 (95% CI, 2.24–2.46) to 2.20 (95% CI, 2.11–2.30) ($P=0.046$). The total variance in the MNC-IPC overall scores was explained by 22.8% (pre-) and 20.7% (post-pandemic) by different predictors: system-level issues (estimated value 0.409, $P=0.008$) and nurses' intention to leave (0.107, $P=0.023$) in the pre-pandemic and by the number of patients admitted in the last shift (0.015, $P=0.053$), organizational issues (0.186, $P<0.0005$) and priority-setting issues (0.092, $P=0.053$) in the post-pandemic period. MNC-IPC and UNCS scores have reported significant correlations in both periods.

Conclusions: Missed IPC activities were less likely in the post-pandemic period possibly due to system efforts and lessons learned during the pandemic, which may have routinized IPC practices among nurses. Overall, predictors of missed IPC care changed after the pandemic, suggesting new patterns and the need for innovative interventions, particularly at the unit level and targeting younger nurses. The correlations between UNCS and MNC-IPC suggest

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that targeted improvements in one area are likely to yield positive outcomes in the other. However, despite their commonalities, these represent two distinct phenomena.

Introduction

The coronavirus disease 2019 (COVID-19) pandemic has intensified efforts to implement infection prevention and control (IPC) strategies as crucial components of hospital control measures. Previous outbreaks have also been reported to increase awareness among healthcare workers (HCWs) [1]. However, outside of known outbreaks, compliance with IPC strategies remains suboptimal [1]. Hospital-acquired infections (HAIs) continue to be a significant concern for patient safety, leading to increased morbidity and mortality. Nurses, along with other HCWs, play a key role in preventing and controlling these infections by ensuring adherence to available guidelines [2]. The persistently high incidence of HAIs, as a consequence of poor compliance [3], suggests that continuous efforts are needed to understand the factors promoting compliant professional behaviour. Proxy measures, such as those considering self-reported perceptions regarding lapses in behaviour compliance with best practices, are still important, despite their possible limitations leading to under- or overestimations of the phenomenon (e.g., Dolega *et al.* [4]); however, given the increased concerns regarding HAIs worldwide, the perceived compliance may provide information on interventions needed in advance (e.g., Dalziel *et al.* [5]).

Despite their importance, non-compliant behaviours have been primarily investigated in the pre-pandemic era (e.g., Issa *et al.* [6]) or during outbreaks (e.g., Lee *et al.* [7]), with limited evidence produced in the post-pandemic period. During outbreaks, anxiety and concern regarding the risk of infection may improve compliance and generate learning [8]. Thus, investigating the behaviours that are retained after a pandemic may reveal changes in the level of awareness, the learning that has been acquired, as well as new patterns in the degree of compliance.

Several instruments have been established to measure the self-reported degree of compliance among HCWs, although they have generally reported low to moderate quality in their methodologies [9]. This suggests that strong evidence for measures capable of detecting HAIs in advance is still lacking. Additionally, gaps in the chain of infection, contributing to cascade iatrogenesis, have been documented by Bail *et al.* [10]. This implies that not only singular non-compliant behaviours, but also several interconnected unconscious and conscious behaviours may affect overall compliance.

In this context, immediately before the pandemic, a new line of research was introduced that shifted the perspective by considering non-compliant IPC activities as missed care. This conceptualization, which originated approximately 30 years ago in the USA, describes care activities that are necessary but, for various reasons, left unfinished, omitted or delayed. Tools for measuring unfinished nursing care (UNC) as those activities expected by nurses at the bedside, quantifying the amount of care left undone (e.g., helping patients eat or walk) and the reasons behind it, have been well validated and widely used [11]. Starting from this research line, non-compliant IPC behaviours have started to be considered as a type of missed or unfinished care; as a consequence, tools measuring their occurrence and underlying reasons have been established on the basis of the documented relationship between lapses in care (e.g., neglecting handwashing) and HAIs [12]. Thus, measuring missed care in practices such as hand hygiene, personal protective equipment use, environmental cleanliness, isolation precautions, adherence to protocols, and staff training [13] has been considered a proxy for HAIs. Furthermore, the underlying reasons for missed care as perceived by nurses have been considered essential in tailoring interventions capable of minimizing or preventing its occurrence [14]. However, the limited data available on missed IPC care activities were collected only before the pandemic [15] or during the pandemic [16]. Additionally, despite their conceptual similarities, the correlations between UNC measures and IPC measures have not been explored [17]. Continuing to investigate missed nursing care as a whole and in the specific context of IPC is crucial, as unfinished or delayed care can have serious implications for patient outcomes, including higher rates of HAIs [18].

Therefore, the primary aim of this study was to compare differences, if any, in missed IPC activities before and after the pandemic, along with the related predictors. The secondary aim was to identify any relationship between missed IPC activities and UNC.

Methods

A repeated cross-sectional survey was conducted in 2019 (pre-pandemic) and 2024 (post-pandemic) following the Checklist for Reporting of Survey Studies guidelines [19] (Supplementary Table S1).

Setting and participants

The study was conducted in a large academic hospital with more than 1700 beds and five acute-care centres. The hospital employs approximately 8800 HCWs (with around 3500 nurses). Nurses were considered the target of our study given that: (i) they are the largest group of HCWs directly involved in IPC activities, and are thus capable of providing a crucial perspective on the compliance of these practices [20]; and (ii) validated tools with good psychometric properties have been specifically designed to assess missed IPC activities and their predictors within the nursing role [11] whereas those considering all HCWs have been documented with low/moderate quality in their methodologies. Thus, a convenience sample of registered nurses working in all medical and surgical units (11 and 10 units, respectively) who were willing to participate was included in the study. To ensure comparability, eligible participants were recruited from the same wards, located in the same buildings, and exposed to the same rules of the hospital, during both the pre-pandemic and post-pandemic periods.

Nurses working in other settings (e.g., emergency room), in managerial roles, or in short-term positions were excluded.

Data collection process and measures

Nurses were recruited through their ward managers, who were provided with detailed information about the study's aims and procedures. Data were collected via paper-and-pencil surveys in the pre-pandemic period and through the EUSurvey platform in the post-pandemic period. Participants were given one month to complete the survey, with two reminders sent during each survey period to encourage participation. The same comprehensive data collection tool was used for both surveys as follows:

- The Missed Nursing Care in Infection Prevention and Control Survey (MNC-IPC), developed and validated in 2017 [21] and subsequently extensively validated [13,22,23]. The tool comprises two parts: (i) Part A consists of 37 items listing various IPC activities. Participants are asked to indicate the frequency with which they believe these activities were missed during their last shift, using a scale from 1 (never) to 5 (always); and (ii) Part B includes 24 items in which participants ranked the reasons for missed activities on a scale from 1 (not important) to 4 (very important). These reasons are categorized into four factors: systemic (seven items), organizational (eight items), environmental (six items), and personal (three items). In this study, the internal consistency (Cronbach's alpha) for Part A was 0.873 (pre-pandemic) and 0.948 (post-pandemic); for Part B, it was 0.926 and 0.939, respectively.
- The Unfinished Nursing Care Survey (UNCS), which has been extensively validated [24—26] and is composed of two parts: (i) Part A includes 37 items listing an inventory of nursing activities, where nurses are asked to indicate their perceptions of these activities during their last shift using a scale from 1 (never) to 5 (always unfinished); and (ii) Part B comprises 18 items that explore potential reasons for unfinished care activities, categorized into six factors: communication (expressing tensions among healthcare professionals, five items), priority setting (inadequate work care processes and prioritization, three items), nurse aides supervision (lack of supervision in basic care, three items), material resources (shortages in medications, diagnostic functions, and materials available at the bedside; three items), human resources (insufficient nurses and nursing aides, two items), and workflow predictability (unexpected admissions, urgencies, and discharges; two items). Nurses are required to score each item from 1 (not significant) to 5 (very significant), resulting in average scores ranging from 1 to 5. In this study, the internal consistency (Cronbach's alpha) for Part A was 0.874 (pre-pandemic) and 0.959 (post-pandemic); for Part B, it was 0.922 and 0.941, respectively.
- The sociodemographic and professional data collection form included items such as age, education, experience as a nurse, shift profile, missed shifts (e.g., due to health issues), changes in planned shifts due to organizational issues, and overtime hours in the last three months. Additionally, data were collected on workloads (e.g., number of patients cared for during the last shift, perceived appropriateness of human resources), nurses' satisfaction with their profession, role, and teamwork (rated from 1 (very dissatisfied) to 5 (very satisfied)), intention to leave, and perceived involvement in roles and programmes related to infection control.

Rigour

To address potential bias due to lack of control in contextual factors over the periods investigated [27], several strategies were used: firstly, to ensure consistency in the data collection, the same validated instruments were adopted over the periods; secondly, participants were recruited from the same hospital units, located in the same buildings (e.g., layouts) and under homogeneous hospital rules before, during and after the pandemic, thus preventing variations in the clinical settings and procedures; the staff were also exposed to the same continuing education strategies and contents; thirdly, the research team was the same to ensure consistency in the research protocol and the Checklist for Reporting of Survey Studies guidelines [17] was followed to provide a reliable comparison of IPC practices over time.

Data analysis

The quality of the dataset was checked, revealing some missing data, particularly in the pre-pandemic survey. Nevertheless, the entire dataset was used in the preliminary descriptive analysis, with these findings guiding the data cleansing necessary for proceeding with the regression analysis. Explanatory variables with more than 10% missing data were excluded from the regression model [28] (e.g., overtime hours in the last three months). The descriptive analysis presented averages with 95% confidence intervals (CIs) for quantitative variables and frequencies and percentages for qualitative variables. To compare differences between the pre- and post-pandemic groups, the chi-square (χ^2) test was used for categorical variables, and the Mann—Whitney U-test was applied to non-normally distributed continuous variables. The relationship between the MNC-IPC and UNCS, Part A and Part B scores was assessed using Pearson's correlation, with correlations considered weak if <0.30, moderate if <0.70, and strong if >0.70 [29].

The regression analysis, aimed at identifying predictors of the MNC-IPC Part A total score, was designed based on theoretical knowledge [13,22,23] and the significant associations found in the descriptive analysis. A stepwise selection method was applied using the Akaike information criterion. A parallel selection using the Bayesian information criterion retained only the significant variables. Some predictors were kept in the model despite not being statistically significant, because they exhibited a non-negligible effect on the model's predictive capability. Variance inflation factors were considered to check for multicollinearity, ensuring that the model results were not affected by multicollinearities.

Ethical issues

The Institutional Review Board of the Department of Medicine, University of Udine, Italy (no. 62/2024, 5th March 2024) approved the study. Participation was anonymous and voluntary, both for individuals and units, allowing nurses to withdraw from the study at any time without consequences. No

rewards were offered, apart from the opportunity to complete the questionnaire during working hours.

Results

Participants

A total of 184 nurses participated in the pre-pandemic (184/437, 42%) and 240 in the post-pandemic survey (240/483, 59%) (Table I). Most demographic and professional variables were homogeneous between the groups, except for gender (female: pre-, 85.33% vs post-pandemic, 82.08%; $P=0.044$), post-graduate education (1.09% vs 16.67%, respectively; $P<0.0005$), and shift type (rotating: 72.28% vs 81.67%; $P<0.0005$).

A significant decline in satisfaction as a nurse was observed from the pre- to post-pandemic group (average, 4.02 (95% CI, 3.90—4.14) vs average, 3.80 (95% CI, 3.67—3.93), $P=0.018$) and in satisfaction with the current role (average, 3.66 (95% CI, 3.53—3.78) vs average, 3.39 (95% CI, 3.26—3.52), $P=0.009$). Similar percentages of participants in both the pre- and post-pandemic groups reported being involved in infection control programmes (41.30% vs 45.42%, $P=0.397$), and approximately 8% of participants in each group were appointed as link professionals ($P=0.191$).

Missed IPC occurrence and reasons

In the MNC-IPC Part A, the average scores decreased from 2.15 out of 5 (95% CI, 2.05—2.25) to 1.51 (95% CI, 1.45—1.58) ($P<0.001$) (Table II). Except for 'patients are showered pre-operatively', which showed homogeneous average scores (1.93 (95% CI, 1.65—2.22) vs 1.99 (95% CI, 1.77—2.21), $P=0.744$), significant differences emerged in the remaining items measuring IPC missed care activities, with higher average scores in the pre-pandemic than in the post-pandemic group.

In the MNC-IPC Part B, the total average scores significantly decreased from 2.35 out of 4 (95% CI, 2.24—2.46) to 2.20 (95% CI, 2.11—2.30) ($P=0.046$). A significant decrease was observed in all items, whereas at the factor level, only the systemic and personal factors showed statistically significant differences between the pre- and post-pandemic groups (from 2.87 (95% CI, 2.78—2.96) to 2.70 (95% CI, 2.61—2.79) ($P=0.010$) and from 2.48 (95% CI, 2.34—2.62) to 2.21 (95% CI, 2.10—2.32) ($P=0.002$), respectively) (Table III).

UNC occurrence and reasons

In the UNCS Part A, a significant decrease in total scores was observed, from 2.71 out of 5 (95% CI, 2.60—2.82) to 1.89 (95% CI, 1.81—1.98) ($P<0.0005$) (Table IV), as was the case for all items comprising the tool (Supplementary Table S2). Scores were significantly correlated with those from the MNC-IPC tool Part A, with coefficients of 0.610 in the pre-pandemic group and 0.705 in the post-pandemic group (both $P=0.001$).

The perceived importance of the reasons listed in UNCS Part B also decreased significantly, from 3.30 out of 4 (95% CI, 3.22—3.38) in the pre-pandemic group to 2.79 (95% CI, 2.71—2.87) in the post-pandemic group ($P<0.0005$). Human resources and workflow predictability were the most important factors contributing to UNC in both groups (Table IV). UNCS Part B factors were significantly correlated with MNC-IPC Part B factors, ranging from 0.220 to 0.518 ($P=0.001$) in the pre-pandemic data and from 0.241 to 0.659 ($P=0.001$) in the post-pandemic data.

Predictors of missed IPC

The MNC-IPC Part A overall scores in the pre- and post-pandemic groups were explained by 22.8% and 20.7% of their total variance, respectively (Table V). Pre-pandemic missed IPC activities were predicted by MNC-IPC systemic factors (estimated value 0.409, $P=0.008$) and nurses' intention to leave (0.107, $P=0.023$). By contrast, the number of patients admitted (-0.084, $P=0.011$), the satisfaction as a nurse (-0.150, $P=0.054$), the UNCS Factor 4 'Material resources' (-0.269, $P=0.008$), and the UNCS Factor 5 'Human resources' (-0.258, $P=0.048$) all reduced the likelihood of missed care in the IPC practices. In the post-pandemic group, MNC-IPC Part A scores were predicted by the number of patients admitted during the last shift (0.015, $P=0.053$), the MNC-IPC Factor 2 'Organizational' (0.186, $P<0.0005$), and by the UNCS Factor 2 'Priority setting' (0.092, $P=0.053$), whereas the age of nurses (-0.008, $P=0.010$) played a protective role.

Discussion

To our best knowledge, this is the first study investigating missed IPC care in both pre- and post-pandemic periods, comparing differences in patterns within the context of HAI control and the nursing care as a whole. The same university hospital and units were involved, with nurses being homogeneous in their main personal and professional characteristics over time, reflecting those documented at the national level [26]. The nurses reported having more than 10 years of experience in their units, suggesting that the post-pandemic group was probably working in the same wards before the pandemic and may have participated in the first data collection.

Despite increased dissatisfaction with their current roles and nursing careers in the post-pandemic period, nurses reported the same intention to stay in their units, suggesting a continued willingness to invest and engage in delivering quality care [30]. Additionally, the consistent involvement in infection control programmes across both groups suggests similar empowerment levels to apply policies and support peers in adhering to those policies [31]. Conversely, the high workloads (more than 17 patients cared for in the last shift) and the perceived inadequacy of healthcare assistants and nursing resources reported by both groups suggest ongoing challenges in ensuring the highest quality of care.

Fewer missed IPC care activities were reported on the MNC-IPC tool, with scores of rarely/sometimes (averages of >2) in the pre-pandemic group and never/rarely (averages of 1—2) in the post-pandemic group. At the item level, only the pre-operative shower was consistently not missed before and after the pandemic, in line with the strong recommendations in international guidelines mandating its execution before surgery [32]. In the pre-pandemic group, seven items were reported as sometimes to always missed, with average scores of >3 out of 5 (e.g., 'intravenous cannulas are swabbed with alcohol for 15 s and allowed to dry for 15 s before flushing or administering medications'). By contrast, all items in the post-pandemic group had lower average scores, indicating that

Table I
Participants

	Pre-pandemic N = 184	Post-pandemic N = 240	P
Age (mean, 95% CI)	38.56 (37.06–40.07)	40.06 (38.66–41.46)	0.157
Gender (*n*, %)			0.044
Female	157 (85.33)	197 (82.08)	
Male	27 (14.67)	35 (14.58)	
Not indicated	0 (0.00)	8 (3.33)	
Country of graduation (*n*, %)			0.105
Italy	181 (98.37)	227 (95.78)	
Other	3 (1.63)	13 (4.22)	
Highest education (*n*, %)			<0.0005
RN	65 (35.52)	60 (25.00)	
BNS	116 (63.38)	140 (58.33)	
Postgraduate	2 (1.09)	40 (16.67)	
Working as a nurse, years (mean, 95% CI)	14.24 (12.60–15.88)	15.87 (14.40–17.34)	0.144
In the current unit, years (mean, 95% CI)	9.94 (8.53–11.34)	10.01 (8.84–11.19)	0.934
Shift profile (*n*, %)			<0.0005
Only day shift	51 (27.72)	44 (18.33)	
Rotating shift, including nights and weeks ends	133 (72.28)	196 (81.67)	
Weekly working hours (*n*, %)			0.513
Full time	163 (88.59)	220 (91.67)	
Part time	21 (11.41)	20 (8.33)	
Overtime hours in the last 3 months (mean, 95% CI)	30.73 (23.11–38.35)	32.27 (26.08–38.47)	0.762
Shifts missed due to health issues in the last 3 months (*n*, %)			0.289
0 (none)	135 (73.37)	159 (66.25)	
1–6	36 (19.57)	64 (26.67)	
>6	13 (7.07)	17 (7.08)	
Shift changes for organizational reasons in the last 3 months (n, %)			0.353
<3	159 (86.89)	199 (82.92)	
3–5	19 (10.38)	36 (15.00)	
>5	5 (2.73)	5 (2.08)	
Patients cared in the last shift (mean, 95% CI)	17.64 (16.39–18.89)	16.97 (15.98–17.96)	0.403
Patients admitted in the last shift (mean, 95% CI)	1.87 (1.61–2.13)	2.31 (1.72–2.90)	0.224
Patients discharged in the last shift (mean, 95% CI)	1.62 (1.31–1.92)	1.53 (1.19–1.88)	0.731
Perceived appropriateness of nurses in the units (mean, 95% CI)[a]	2.14 (2.02–2.26)	1.99 (1.87–2.11)	0.097
Perceived appropriateness of healthcare assistants in the unit (mean, 95% CI)[a]	2.03 (1.91–2.15)	2.14 (2.02–2.25)	0.195
Satisfaction as a nurse (mean, 95% CI)[b]	4.02 (3.90–4.14)	3.80 (3.67–3.93)	0.018
Satisfaction with the current role (mean, 95% CI)[b]	3.66 (3.53–3.78)	3.42 (3.29–3.54)	0.009
Satisfaction with the working group (mean, 95% CI)[b]	3.34 (3.20–3.49)	3.39 (3.26–3.52)	0.623
Intention to leave the unit (*n*, %)			0.880
No	138 (75.41)	177 (73.75)	
Yes, in the last 6 months	20 (10.93)	30 (12.50)	
Yes, in the last 12 months	25 (13.66)	33 (13.75)	
I am involved in the IPC in my unit (*n*, %)	76 (41.30)	109 (45.42)	0.397
I am appointed in a specific role in IPC (*n*, %)			0.191
Link professional	15 (8.15)	21 (8.75)	
Member of an IPC study/working group	0 (0.00)	5 (2.08)	
Other (e.g., teacher on courses)	0 (0.00)	1 (0.42)	

BNS, bachelor nurse science; CI confidence interval; IPC, infection prevention and control; *n*, number; RN, registered nurse.
[a] 5-point Likert scale, from Likert scale from 1, 'never', 0% of the time, to 5, 'always', 100% of the time.
[b] 5-point Likert scale, from 1 'very dissatisfied' to 5 'very satisfied'.

post-pandemic nurses perceived themselves as more effective in applying measures to prevent and control infections, possibly reflecting the tangible outcomes of the extensive training received during the pandemic on the importance of IPC practices [33]. The statistically significant differences emerged may also have practical implications; for example, the item 'patients are invited or assisted to perform hand hygiene following use of a bedpan or urinal in bed' showed an average decrease of 1 point out of 5 (from 3.12 to 2.19), indicating concrete improvements in care delivered. Overall, the pre-pandemic findings align with those documented in other countries before the COVID-19 pandemic (e.g., Henderson

Table II
Missed nursing care infection prevention and control activities, Part A

Items	Pre-pandemic Mean score[a] (95% CI)	Post-pandemic Mean score[a] (95% CI)	*P*
1. Hand hygiene is performed before touching a patient	2.70 (2.44–2.95)	1.69 (1.58–1.79)	<0.0005
2. Hand hygiene is performed before a procedure is undertaken	1.97 (1.73–2.20)	1.41 (1.32–1.49)	<0.0005
3. Hand hygiene is performed after a procedure has been performed	1.97 (1.73–2.20)	1.29 (1.22–1.36)	<0.0005
4. Hand hygiene is performed after touching a patient	2.47 (2.21–2.72)	1.47 (1.38–1.57)	<0.0005
5. Hand hygiene is completed before drug administration	2.98 (2.71–3.23)	1.74 (1.62–1.85)	<0.0005
6. Equipment is cleaned before it touches each patient	3.63 (3.45–3.80)	2.20 (2.06–2.35)	<0.0005
7. Appropriate PPE (such as gloves and gowns) are used when providing direct care to patients/residents who have a transmissible disease including MROs	1.79 (1.57–2.01)	1.27 (1.19–1.35)	<0.0005
8. PPE is donned in the correct order, for example putting on gown first and then gloves to ensure that they are pulled over the cuff of the gown so that no skin is exposed	2.55 (2.29–2.82)	1.42 (1.33–1.51)	<0.0005
9. Gloves are changed when moving from a contaminated/dirty site to a clean site	1.70 (1.49–1.92)	1.26 (1.19–1.34)	<0.0005
10. Touch contamination is avoided, for example, not scratching your nose or adjusting your glasses	2.38 (2.12–2.65)	1.31 (1.23–1.38)	<0.0005
11. Gloves are removed before taking off the gown	2.17 (1.93–2.41)	1.66 (1.51–1.80)	<0.0005
12. Hand hygiene is undertaken following gown removal	1.80 (1.58–2.03)	1.20 (1.14–1.27)	<0.0005
13. Facial equipment is removed before hands are washed	1.95 (1.71–2.19)	1.24 (1.16–1.32)	<0.0005
14. Goggles and mask or mask face shield are worn when caring for patients on respiratory/droplet precautions	2.21 (1.96–2.47)	1.58 (1.47–1.69)	<0.0005
15. All new admissions are screened for MRO	3.32 (3.08–3.55)	2.86 (2.67–3.06)	0.005
16. Appropriate signage informing staff and visitors of the need for transmission-based precautions is displayed when managing a patient with a MRO	1.51 (1.32–1.70)	1.24 (1.17–1.32)	0.004
17. Patients are invited or assisted to perform hand hygiene following use of a bedpan or urinal in bed	3.12 (2.88–3.35)	2.19 (2.04–2.34)	<0.0005
18. Patients are showered preoperatively	1.93 (1.65–2.22)	1.99 (1.77–2.21)	0.744
19. Catheter toilet care is performed each shift	1.40 (1.23–1.58)	1.18 (1.11–1.25)	0.011
20. Oral care/teeth are cleaned at least daily	3.17 (2.94–3.41)	2.15 (2.00–2.29)	<0.0005
21. Intravenous cannulas are swabbed with alcohol for 15 s and allowed to dry for 15 s before flushing or administering medications	3.37 (3.19–3.60)	1.97 (1.85–2.10)	<0.0005
22. Gloves are worn and/or hand hygiene performed for preparing and administration of antibiotics	3.27 (3.07–3.45)	2.09 (1.95–2.24)	<0.0005
23. The nurse/midwife follows up with a medical officer/senior nurse if a patient has indications of an infection, for example, temperature increase, presence of new swelling or pus	1.94 (1.69–2.18)	1.37 (1.29–1.46)	<0.0005
24. Healthcare organization documentation specifies the MRO status of patients on admission	2.98 (2.71–3.25)	1.76 (1.64–1.89)	<0.0005
25. Documentation of patient's MRO status is completed when the patient is discharged	2.29 (2.03–2.56)	1.47 (1.37–1.58)	<0.0005
26. Nurses/midwives document follow up of pathology tests/results, for example, wound swabs, MRO status	2.44 (2.17–2.70)	1.53 (1.44–1.63)	<0.0005
27. Nurse/midwives communicate patient's MRO status at handover	1.44 (1.26–1.62)	1.24 (1.17–1.31)	0.023
28. Nurses/midwives communicate patient's MRO status on transfer to other wards or to new department, for example, X-ray	1.74 (1.53–1.96)	1.31 (1.23–1.39)	<0.0005
29. Cleaners/support staff wear appropriate PPE	2.01 (1.76–2.25)	1.50 (1.40–1.60)	<0.0005
30. Cleaners/support staff adhere to signage related to transmission-related precautions	1.75 (1.53–1.97)	1.40 (1.31–1.49)	0.001
31. Cleaners/support staff fully clean rooms between patients	2.27 (2.03–2.51)	1.82 (1.69–1.95)	0.001
32. Cleaners/support staff fully clean rooms when an infected patient is discharged or transferred	1.79 (1.56–2.01)	1.40 (1.30–1.49)	0.001
33. Patient's over-way table is cleaned prior to food delivery	3.37 (3.17–3.56)	2.43 (2.27–2.58)	<0.0005
34. Staff decontaminate spills of blood and other body substances/fluids	1.88 (1.65–2.11)	1.29 (1.21–1.36)	<0.0005
35. Instruments and equipment are stored to ensure sterility prior to use	1.65 (1.44–1.36)	1.15 (1.10–1.21)	<0.0005
36. Hand hygiene is performed after exposure to body fluids	1.28 (1.14–1.42)	1.13 (1.08–1.18)	0.030
37. Hand hygiene is completed after drug administration	2.75 (2.50–3.01)	1.54 (1.44–1.64)	<0.0005
Overall item scores[a]	2.15 (2.05–2.25)	1.51 (1.45–1.58)	<0.0005

CI, confidence interval; MRO, multi-resistant organism; PPE, personal protective equipment.
[a] 5-point Likert scale, from 1 'never' to 5 'always' missed.

Table III
Reasons for missed nursing care infection prevention and control, Part B

Factors, items	Pre-pandemic Mean score[a] (95% CI)	Post-pandemic Mean score[a] (95% CI)	*P*
Factor 1. Systemic	2.87 (2.78–2.96)	2.70 (2.61–2.79)	0.010
1. Inadequate number of medical staff	2.85 (2.72–2.98)	2.46 (2.32–2.59)	<0.0005
2. Inadequate number of clerical staff	2.65 (2.52–2.79)	2.13 (2.00–2.26)	<0.0005
3. Inadequate number of nursing/midwifery staff on the unit	2.95 (2.83–3.07)	2.48 (2.35–2.61)	<0.0005
4. Inadequate skill mix of nursing/midwifery staff allocated for patient care	2.89 (2.77–3.01)	2.26 (2.14–2.38)	<0.0005
5. Inadequate number of cleaning/support staff	3.60 (3.51–3.69)	3.36 (3.26–3.47)	0.001
6. Unexpected rise in patient volume and/or acuity on the unit	3.68 (3.60–3.76)	3.34 (3.23–3.45)	<0.0005
7. Urgent patient situation (e.g., a patient's condition worsening)	3.39 (3.28–3.50)	2.87 (2.74–3.00)	<0.0005
Factor 2. Organizational	2.15 (2.00–2.29)	2.07 (1.97–2.17)	0.365
1. Lack of prompts in patient records to check for signs of infection	2.57 (2.45–2.70)	1.90 (1.78–2.03)	<0.0005
2. Patient room allocation made without consideration to principles of IC	3.02 (2.87–3.16)	2.23 (2.09–2.38)	<0.0005
3. Lack of cleaning schedule for environmental cleaning in clinical areas	2.69 (2.54–2.84)	1.88 (1.75–2.01)	<0.0005
4. Unbalanced assignment/allocation to nursing/midwifery staff	3.23 (3.11–3.35)	2.70 (2.57–2.83)	<0.0005
5. Ward culture does not support IC activities	2.76 (2.64–2.89)	2.13 (2.00–2.26)	<0.0005
6. Lack of nursing/midwifery control over IC activities	2.73 (2.60–2.86)	2.11 (1.97–2.24)	<0.0005
7. Lack of support from hospital management for committees governing IC activities	2.71 (2.58–2.84)	2.14 (2.00–2.27)	<0.0005
8. Lack of support from hospital management for resources to undertake IC activities	2.65 (2.52–2.78)	2.11 (1.98–2.25)	<0.0005
Factor 3. Environmental	2.07 (1.94–2.20)	2.03 (1.93–2.14)	0.656
1. Patient rooms/bays lack sinks for handwashing	2.93 (2.75–3.11)	1.91 (1.76–2.06)	<0.0005
2. Inadequate places to store belongings (e.g., blankets, patient personal belongings)	2.92 (2.79–3.05)	2.26 (2.12–2.40)	<0.0005
3. Insufficient plastic puncture proof containers for sharps/used needles	2.59 (2.38–2.80)	1.50 (1.39–1.61)	<0.0005
4. Sterile supplies/equipment not available when needed	2.59 (2.38–2.80)	1.50 (1.39–1.61)	<0.0005
5. Patients have to share bathrooms	3.30 (3.18–3.41)	2.71 (2.57–2.86)	<0.0005
6. Patients' rooms overcrowded/cluttered with equipment/supplies	3.43 (3.31–3.55)	2.53 (2.38–2.69)	<0.0005
Factor 4. Personal	2.48 (2.34–2.62)	2.21 (2.10–2.32)	0.002
1. Nurses/midwives have inadequate education/knowledge of IC practices	2.90 (2.77–3.02)	2.18 (2.05–2.30)	<0.0005
2. Nurses/midwives have inadequate understanding of transmission-based precautions	2.76 (2.63–2.89)	2.08 (1.95–2.21)	<0.0005
3. Inadequate handover from previous shift, unit, health or aged care facility	2.99 (2.88–3.11)	2.48 (2.36–2.61)	<0.0005
Overall item score[a]	2.35 (2.24–2.46)	2.20 (2.11–2.30)	0.046

CI, confidence interval; IC infection control.
[a] From 1 'not important' to 4 'very important' reason.

et al. [34]) suggesting that nurses were previously unable to ensure all activities required to fully prevent and control infections.

The reasons for missed IPC care also declined across all items between the pre- and post-pandemic groups. While the pre-pandemic findings align with data from other countries at similar times [34], the practical relevance of the observed statistical differences (from 2.35 pre- to 2.20 post-pandemic) may be limited. At the factor level, only those representing systemic efforts to provide the required resources and support in work processes, as well as personal education/understanding of infection control practices, significantly decreased in importance in the post-pandemic period, suggesting that they were less critical in determining missed IPC care. However, these factors were perceived as the most important reasons for missed care in both groups, indicating that strategies at these levels are crucial in minimizing failures in infection control.

A decline in overall UNCS scores suggests that nurses perceived that they performed better care in all activities, not just those related to IPC, after the pandemic. The perceived importance of UNC reasons also significantly declined between the pre- and post-pandemic periods. However, these findings are inconsistent with available studies comparing pre- and post-pandemic periods, which report homogeneity in the occurrence of UNC and only slight changes in the reasons [35]. Moreover, the moderate correlations between the MNC-IPC and UNCS scores suggest that when nursing care activities are rationed, those related to infection control are also likely to be missed, without prioritizing some (such as those strictly related to nursing) over others (such as infection control) or vice versa. Missed IPC activities and UNC, as measured by the MNC-IPC and UNCS tools, represent two interconnected but distinct conceptualizations that do not completely overlap. In other words, non-compliance can be seen as an element of UNC [36] and as a proxy for all UNC, but it is not the same issue. The weak to moderate correlations between UNCS and MNC-IPC reason factors suggest that different elements play a role in triggering these two phenomena. Therefore, while the UNCS may provide overall insights into failures in IPC, the MNC-IPC is not capable of predicting the entirety of UNC and its underlying reasons.

Table IV
Unfinished nursing care overall occurrence and reasons

Unfinished Nursing Care Survey parts A and B	Pre-pandemic Mean score (95% CI)	Post-pandemic Mean score (95% CI)	*P*
Part A UNC Occurrence, total score[a]	2.71 (2.60—2.82)	1.89 (1.81—1.98)	<0.0005
Part B UNC Reasons, total score[b]	3.30 (3.22—3.38)	2.79 (2.71—2.87)	<0.0005
Factor 1. Communication[b]	3.11 (2.99—3.22)	2.58 (2.46—2.69)	<0.0005
Factor 2. Priority setting[b]	2.97 (2.86—3.07)	2.46 (2.36—2.57)	<0.0005
Factor 3. Nurse aides supervision[b]	2.92 (2.81—3.03)	2.48 (2.37—2.59)	<0.0005
Factor 4. Material resources[b]	2.93 (2.82—3.03)	2.59 (2.47—2.70)	<0.0005
Factor 5. Human resources[b]	3.58 (3.50—3.66)	3.41 (3.32—3.51)	0.013
Factor 6. Workflow predictability[b]	3.65 (3.58—3.73)	3.29 (3.19—3.39)	<0.0005

CI, confidence interval; UNC, unfinished nursing care.
Factor 1: communication (tension/conflicts within the nursing staff, incomplete or interrupted communication among nursing staff, tension/conflicts between nursing and medical staff, incomplete or interrupted communication between nursing and medical staff, lack of support/collaboration among team members). Factor 2: priority setting (inadequate nursing care model (e.g,. functional task-oriented model of care), inaccurate initial priority setting, inadequate priority re-assessment during the shift). Factor 3: nurse aides supervision (nurse aides missed or delayed to report the tasks left undone, inadequate supervision of the tasks assigned to the nurse aides, incomplete or interrupted communication between nursing staff and nurse aides/assistive personnel). Factor 4: material resources (medications prescribed not available, equipment not available/not functioning properly when needed, other departments did not provide the service expected (e.g., delay in diagnostic processes). Factor 5: human resources (inadequate number of nurses, inadequate number of nurse aides). Factor 6: workflow predictability (unexpected rise in patient acuity, heavy admission/discharge activity during the shift).
[a] From 1 'never' to 5 'always unfinished'.
[b] From 1 'not significant' to 4 'very significant' reason.

Table V
Predictors of missed care activities in the infection control and prevention: regression analysis

Variables	Pre-pandemic			Post-pandemic		
	Estimated values	*P*	VIF	Estimated values	*P*	VIF
Intercept	3.050	0.000		1.249	<0.0005	
Age				-0.008	0.010	1.053
Shift changes for organizational reasons in the last 3 months	0.240	0.110	1.058			
Intention to leave	0.107	0.023	1.042			
MNC-IPC Factor 1. Systemic	0.409	0.008	1.927			
MNC-IPC Factor 2. Organizational	0.119	0.110	1.397	0.186	<0.0005	1.584
Patients admitted in the last shift	-0.084	0.011	1.121	0.015	0.053	1.111
Patients discharged in the last shift				-0.018	0.161	1.126
Satisfaction as a nurse	-0.150	0.054	1.297			
Satisfaction with the working group	-0.106	0.074	1.261			
UNC Factor 2. Priority setting issues				0.092	0.053	1.577
UNC Factor 4. Material resource	-0.269	0.008	1.329			
UNC Factor 5. Human resources	-0.258	0.048	1.688			
Explained variance, %	22.8			20.7		
Sample size	142			213		

MNC-IPC, missed nursing care infection prevention and control; UNC, unfinished nursing care; VIF, variance inflation factor.
Variables excluded from the model: 'education'; working in the current unit for mostly time', 'years of experience as a nurse', 'shifts/days missed in the last three months', 'i am appointed with a specific role in infection control program', 'overtime hours in the last three months', 'perceived appropriateness of nurses at the unit level', 'perceived appropriateness of healthcare assistants at the unit level', 'patients cared for in the last shift', 'satisfaction in the role', 'MNC-IPC Factor 3 Environmental', 'MNC-IPC Factor 4 Material resources', MNC-IPC Factor 4 Environmental', 'MNC-IPC Factor 5 Human resources', 'MNC-IPC Factor 6 Workflow predictability', 'UNC Factor 1 Nurse aides supervision', 'UNC Factor 6 Workflow predictability'. Variables not included in the model because of missed items: overtime hours in the last three months.

The regression analysis revealed that the proportion of missed IPC variance explained in the pre- and post-pandemic periods remained largely the same at approximately 23% pre-pandemic and 21% post-pandemic, suggesting that other factors have played a role. However, the predictors have changed over time, as documented by UNC [35,37]. In the pre-pandemic period, both systemic issues (such as inadequacy in human resources and unexpected rises in patient volume and urgency) and nurses' intention to leave the unit increased the perceived missed IPC care, possibly due to time constraints and disaffection among nurses. In the post-pandemic period, the number of patients admitted (indicating a lack of human resources), organizational issues, and priority-setting issues (indicating both a

lack of support and clarity in workflow processes at the unit level) emerged as predictors. This suggests that while systemic-level issues were critical in the pre-pandemic period, unit-level support became more influential in the post-pandemic period. During the pandemic, increased hospital-wide support, including extensive training and continuous assistance for nurses in implementing expected behaviours to protect patients and healthcare professionals [38] may have routinized IPC practices.

Changes in protective factors were also observed: in the pre-pandemic period, increased satisfaction as a nurse, which may reflect the perceived effectiveness of safely delivered care, contributed to the reduction in MNC-IPC scores, while older age acted as a protective factor in the post-pandemic period. This suggests that senior nurses were more likely to implement expected IPC care activities [39]. Interestingly, in the pre-pandemic period, both increased issues with material resources (such as medications and diagnostic department availability) and human resources (such as lack of nurses and nursing aides), as measured by the UNCS, decreased missed IPC activities. This suggests that when nurses experience a lack of resources in delivering nursing care, they may prioritize safety by increasing their efforts to ensure all IPC care activities are completed.

This study has several limitations. Firstly, the participation rates were limited, thus potentially leading to a large margin of error that may affect the reliability and generalizability of the conclusions. However, these rates were higher than those documented in the literature for survey studies [40] and in the context of UNC studies [14,18,32]. The study targeted only bedside nurses working in medical and surgical units to gain specific insights of the practices in these units; however, any estimation of the sample size was provided *a priori*, suggesting a large and more representative sample is needed to ensure the robustness of the findings in the future. In addition, the sample was predominantly composed of nurses with at least 10 years of experience in both surveys: because experience plays a key role in hospital-related infections, a more varied sample would allow for better assessment of whether the observed differences in IPC activities were solely attributable to the pandemic or influenced by other factors, such as the experience level. Secondly, the different data collection strategies (paper and pencil versus online survey) may have affected the participation and findings. Although confidentiality was protected using boxes to collect anonymous questionnaires at the unit level, the fear of speaking up about patient safety concerns may have influenced pre-pandemic responses, whereas this fear may have been attenuated post-pandemic [41]. Thirdly, according to the self-reported nature of the data, post-pandemic survey responses may have reflected the increased knowledge rather than changes in the actual clinical practice. The extensive training and heightened emphasis on IPC during the pandemic may have led respondents to report answers aligned with expected best practices, thus expressing the increased awareness of correct procedures rather than actual improvements of the practice. Moreover, the reported reduction in missed IPC activities may reflect social desirability bias [42]: nevertheless, this may have affected both surveys. Fourthly, there were involved only bedside nurses; however, several IPC activities (e.g., hand hygiene, PPE use, isolation precautions) are not the sole responsibility of nurses, but shared responsibilities of all HCWs.

In conclusion, missed IPC care activities decreased in occurrence during the post-pandemic period. This was likely due to the efforts made by the system and the lessons learned during the pandemic, which may have routinized IPC practices among nurses. However, while self-reported data do not necessarily document changes in the actual behaviour, it may suggest a shift in attitudes towards the importance of IPC in healthcare settings. Moreover, nurses reported a decreased importance of the underlying reasons triggering missed IPC care, confirming better support provided by the hospital system.

Similar findings emerged for UNC, reflecting the complex nursing care activities left undone or delayed. Both the self-reported occurrence of unfinished care and the importance of the related reasons decreased between the pre- and post-pandemic periods. Moreover, the correlations between missed IPC care activities and UNC occurrence suggest that targeted improvements in one area are likely to yield positive outcomes in the other. However, despite their commonalities, these represent two distinct phenomena. When nurses perceive a lack of resources in providing nursing care, they may prioritize IPC care activities, probably prioritizing safety.

Overall, the factors associated with missed IPC care changed after the pandemic. After the strong investment at the system level changed the underlying factors of missed IPC, more efforts became necessary at the unit level, especially towards younger nurses. However, accumulating evidence in this field, also considering other HCWs, is strongly recommended to update interventions to promote compliance with IPC practices, providing a more comprehensive understanding of compliance across the broader healthcare team. Additionally, refining the reasons estimated by the tools used to measure missed IPC care will be essential to capture evolving patterns in the post-pandemic landscape.

Conflict of interest statement

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhin.2024.10.015.

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