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Financial and temporal costs of patient isolation in Norwegian hospitals

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SUMMARY

Background: Isolation of patients colonized or infected by antibiotic-resistant bacteria is an established infection-control measure taken in Norway. Local reliable data on the costs of this isolation are needed.

Methods: A micro-costing study from a healthcare perspective was conducted on infectious disease wards in three general acute hospitals, utilising direct observation, staff registration, interviews and survey data.

Findings: The daily additional cost of isolation was €56.8 (95% confidence interval (CI) 42.4–72.7) for non-bedridden patients and €87.5 (95% CI 48.3–129.6) for bedridden patients. Of these sums, labour costs accounted for the largest share (71–72%), followed by the costs of personal protective equipment (21–23%) and waste management (6–8%). Overall, isolation-specific workload amounted to 65 min/day for non-bedridden patients and 95 min/day for bedridden patients, predominantly in the form of extra time used by nurses. Higher isolation costs for bedridden patients were largely attributable to resources used for personal hygiene practices. One-time isolation costs incurred for room cleaning after patient discharge averaged at €14.0 (95% CI 10.7–17.6).

Conclusions: Our study provides novel, detailed evidence on resource use attributable to patient isolation in hospitals that can be used to inform future assessments directed toward precautionary hygienic measures. Our results suggest that allocating additional nurse staffing to wards with large numbers of isolated patients should be considered.

Introduction

Antimicrobial resistance (AMR) has emerged as one of the principal challenges and economic burdens to health systems and societies worldwide. Healthcare institutions and hospitals

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with vulnerable patients and high levels of antibiotic usage are key locations for the acquisition and spread of AMR.

Norwegian hospitals have routines for single-room contact isolation of patients carrying or infected with resistant organisms. This may partly explain the low incidence of multidrug-resistant organisms (MDROs) in Norway and the infrequently documented spread of MDROs in Norwegian healthcare institutions. Such organisms include meticillin-resistant *Staphylococcus aureus* (MRSA) [1], vancomycin-resistant enterococci (VRE), and carbapenem-resistant *Enterobacteriaceae* (CRE) [2]. Infection prevention control (IPC) protocols are outlined in the isolation guidelines published by the Norwegian Institute of Public Health [3] and locally by many hospitals. The guidelines provide explicit instructions for placement of contagious patients in single-room isolates, using personal protective equipment (PPE), washing hands, transporting isolated patients, serving food, doing laundry, carrying out routine cleaning, disposing of waste, and more.

The cost effectiveness of single-room isolation of patients colonized with MDROs in Norwegian hospitals is currently under debate. There is also increasing international focus on the potential downsides of isolation, including delayed treatment, lower quality of care, and negative psychological effects on isolated patients [4]. The direct costs of the extensive isolation precautions in Norwegian hospitals have never been determined. These costs are not included in the diagnosis-related group (DRG) reimbursement that hospitals receive. International literature on isolation-related costs is scarce and difficult to interpret in a local context. Some studies focus only on patients with particular diseases, account for isolation only in combination with other measures, lack details, or utilize measures not comparable with the Norwegian setting.

This study sought to determine the additional time and resource requirements needed for patients in isolation in order to facilitate cost-effectiveness and budget impact analyses that may be used to inform policy decisions in Norway, and for use in cross-country comparison of isolation practice.

Materials

Study design

A micro-costing study was conducted from a healthcare perspective on infectious disease wards in Norwegian hospitals. Micro-costing is an approach that attempts to assign a cost to each aspect of a service as precisely as possible, through measuring resource use at the level of individuals or singular services, within an organization. Our study involved a mixed approach to data gathering, including direct observation, self-reported logging of patient contacts by staff, face-to-face interviews, and questionnaires given to select staff members. The following cost items were included: (1) additional workload (itemized by staff category), (2) additional personal protective materials, (3) additional waste, and (4) room cleaning/disinfection after discharge. The average additional cost per isolated patient per day was used as the main outcome, calculated separately for mobile and bedridden patients. Dependency assessment and classification (mobile or bedridden) was made independently for each registration based on direct observation of patients. All inpatients on the wards were eligible to be included in the study. Prior to the study, written approval was obtained from data-protection officers at each hospital. No sensitive information was collected.

Data collection

From December 2017 to January 2018, on-site data was collected from three hospitals in South-Eastern Norway: Lovisenberg Diakonale Hospital (a ~240-bed local hospital), Akershus University Hospital (a ~950-bed teaching hospital), and Hospital Østfold Kalnes (a ~580-bed general hospital). The wards consisted largely of single-patient rooms, designed for contact/droplet precautions and without additional ventilation installed. The wards were scaled to accommodate a large share of contagious patients and did not increase staffing during periods with a high load of isolated patients.

An observer was present on weekdays during the day, recording time used by staff to perform various tasks in contact with isolated and non-isolated patients. Additionally, the observer recorded the use of PPE per patient task. The tasks were grouped into the following categories: doctor's visits; simple tests performed in the room (e.g., blood sample, urine sample); dispensing of medicine; personal hygiene (including changing bed linen); food service; diagnostic tests or treatment performed outside the room (e.g., gastroscopy); and 'other tasks', covering a heterogeneous set of interactions (e.g., particular types of care services, preparations of patients before examinations, conversations with patients at discharge, etc.). Staff registered further information about contacts with isolated patients involving PPE throughout the rest of the day.

Information about the amount of daily waste was obtained from staff interviews and by weighing a sample of waste bags. The observer also collected opportunistic data about workload, PPE, and disinfectants used to clean isolated and non-isolated rooms following patient discharge.

Data analysis

The mean time used by staff per task was calculated for isolated and non-isolated patients stratified into subgroups of bedridden and non-bedridden patients (see Supplementary Table S1). These calculations were performed separately for four staff categories: doctors; nurses; cleaning staff; and other staff groups, including nursing students, healthcare assistants, physiotherapists, and nutritionists. The average use of PPE per task was calculated in a similar way (Supplementary Table S2). We itemised staff-reported patient contacts into tasks and calculated the mean frequency of each task per time of day (day, evening, night) in the two patient categories (Table A.3). Routine costs – specifically for doctor's visits, daily cleaning and food service – were assumed to be fixed. Additionally, due to observation limitations, all mean values related to diagnostic tests were assumed based on information provided by staff.

The daily task-specific costs attributable to isolation were determined from the difference in resource use between isolated and non-isolated patients, multiplied by the corresponding unit prices and the average numbers of tasks performed during the full course of a day. In this approach, the counterfactual assumption was made that isolated patients would have received the same amount of staff care (i.e. tasks) had they not been isolated. Isolation costs incurred from waste handling were estimated from the mean daily amount of waste per bedridden and non-bedridden patient multiplied by the difference in weight-specific costs of contaminated and regular waste (Supplementary Table S4). Finally, the one-time additional costs that result from cleaning and disinfection following patient discharge were calculated by comparing the mean resource use in isolated and non-isolated rooms (Supplementary Table S5).

Cost data

Labour costs were based on average 2017 salaries of the specific staff professions considered [5], including additional payment for evening and night shifts (shift differential) [6]. All costs were converted from Norwegian Kroner (NOK) to Euros using the average exchange rate in December 2017 (1€ = 8.6464 NOK) [7]. A baseline hourly wage of NOK 445 was assumed for doctors, NOK 250 for nurses, NOK 200 for cleaning staff, and NOK 220 for other staff groups. In the last group, a salary for nursing students was included to reflect the value of their time, even though they do not receive compensation during their studies. For work performed after 18:00 h, hourly compensation of NOK 70 was added for doctors and nurses, NOK 60 for cleaning staff, and NOK 68 for other staff groups. For weekend work, NOK 40 per hour was added for all staff. An additional 25% overhead was added to all labour costs.

The unit costs of PPE and the costs per kilo of waste paid by hospitals are considered confidential information and cannot be shared publicly; they were however made available to the authors and were used in the calculations. The cost of disinfectants used in cleaning procedures after patient discharge was estimated at NOK 38, based on retail prices in 2017.

Uncertainty

Statistical uncertainty in the main cost outcomes was explored using Monte Carlo simulations. With the exception of the frequencies of routine tasks, probability distributions were incorporated into all input variables based on principles outlined by Briggs and colleagues [8]. Specifically, time use, PPE, task frequencies and daily waste weights were assumed to be gamma-distributed. Time use and the frequencies of diagnostic tests were drawn from normal and beta distributions, respectively. Due to the small number of observations, bootstrap resampling was employed to gauge uncertainty in room cleaning costs upon patient discharge. All cost results presented were based on 10,000 simulations.

Sensitivity analysis

Additional sensitivity analyses were performed by varying the daily frequency of diagnostic tests or procedures outside the isolation room, set at 0.25/day at baseline, uniformly between 0 and 1. As isolated patients are scheduled for diagnostic tests or treatments late in the day to limit transmission risk, test frequencies exceeding 1/day were not considered.

All simulations were performed in MS Excel 2013 and R version 3.5.2.

Results

The study included 275 observations of time and PPE use by staff in contact with patients, in addition to 674 staff-recorded registrations of contact with isolated patients (Supplementary Figure S1). The mean number of admitted patients varied between 8 and 25 on the wards, and the average proportion of isolated patients was in the range of 22%–38% during the study period (Supplementary Table S6).

Daily costs of isolation

In total, the mean daily additional cost of isolation was estimated to be €56.8 (95% CI 42.4–72.7) for non-bedridden patients and €87.5 (95% CI 48.3–129.6) for bedridden patients (Table I). The relative distribution of daily isolation costs was, however, similar in the two patient groups. Labour costs were the most expensive component, comprising 71–72% of total costs, while PPE accounted for 21–23% and waste handling 6–8%. Of the labour-related costs, nurses and doctors accounted for more than 80%. The workload contribution of doctors was largest for bedridden patients (33% vs. 16%).

The simulated distribution of isolation costs for bedridden patients exhibited greater variation than that for the costs for non-bedridden patients due to there being fewer bedridden patients overall (Figure 1; Supplementary Table S6). Only 13% (90/684) of registrations by staff were related to bedridden patients. However, there was also heterogeneity in the cost

Table I
Daily additional isolation costs based on Monte Carlo simulations (N = 10,000)

Cost item	Costs per isolated patient day (€)							
	Non-bedridden				Bedridden			
	Mean	95% CI	SD	%	Mean	95% CI	SD	%
Additional workload								
Doctors	6.48	2.13–10.88	2.21	11.4	20.69	7.23–38.86	8.08	23.7
Nurses	27.02	15.71–39.13	6.01	47.5	30.51	1.02–61.34	15.42	34.9
Cleaning staff	3.27	2.01–4.66	0.67	5.8	3.27	2.01–4.66	0.67	3.7
Other staff groups	3.74	0.03–9.38	2.38	6.6	8.21	-12.28–28.30	10.01	9.4
Additional materials								
PPE	12.95	10.71–22.07	2.77	22.8	18.07	14.81–26.37	2.73	20.6
Waste	3.36	0.93–7.39	1.69	6.0	6.73	1.94–14.70	3.30	7.7
Total	56.82	42.38–72.70	7.64	100.0	87.48	48.27–129.56	20.57	100.0

CI, confidence interval; PPE, personal protective equipment; SD, standard deviation.

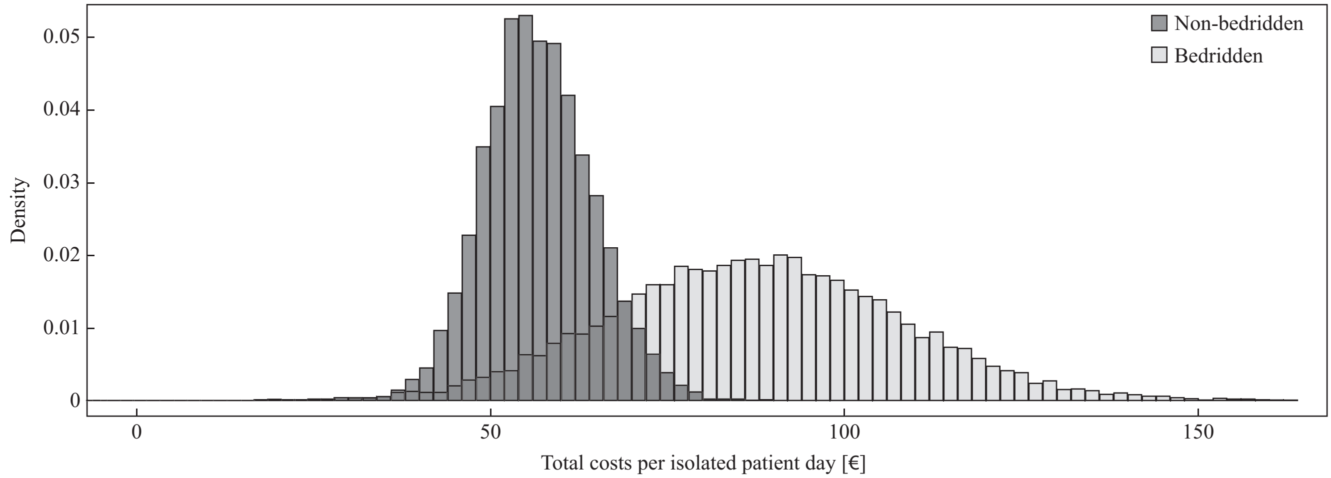

Figure 1. Density plots of total isolation costs per patient per day (N = 10,000 simulations).

estimates within that group of patients, in particular in the time used by nurses and other staff groups.

A breakdown of daily isolation costs into task-specific components showed that uncategorized tasks were the largest cost driver, amounting to €22.1/day for bedridden patients and €17.8/day for non-bedridden patients (Figure 2). Diagnostic tests or treatments outside the isolation room and food services were also substantial, exceeding €10/day in both patient groups. Cost estimates for personal hygiene were significantly larger for bedridden than non-bedridden patients (€20.02 vs. €0.63 per day), and this was the main reason for the higher isolation costs associated with immobile patients. Noticeably, a negative daily isolation cost was estimated due to doctor's visits in the group of non-bedridden patients. Further comparison of staff personnel present for daily rounds of visits showed that nurses were less likely to participate in visits involving non-bedridden isolated patients (mean 0.08 vs. 0.67, Mann–Whitney test, P=0.031; Supplementary Table S7).

Daily time use by staff

It was estimated that, in a 24-h period, staff spent approximately 65 more minutes in contact with isolated than non-isolated patients in the non-bedridden group (Table II). In the bedridden group, the mean additional time used by staff with isolated patients was approximately 95 min. Nurses

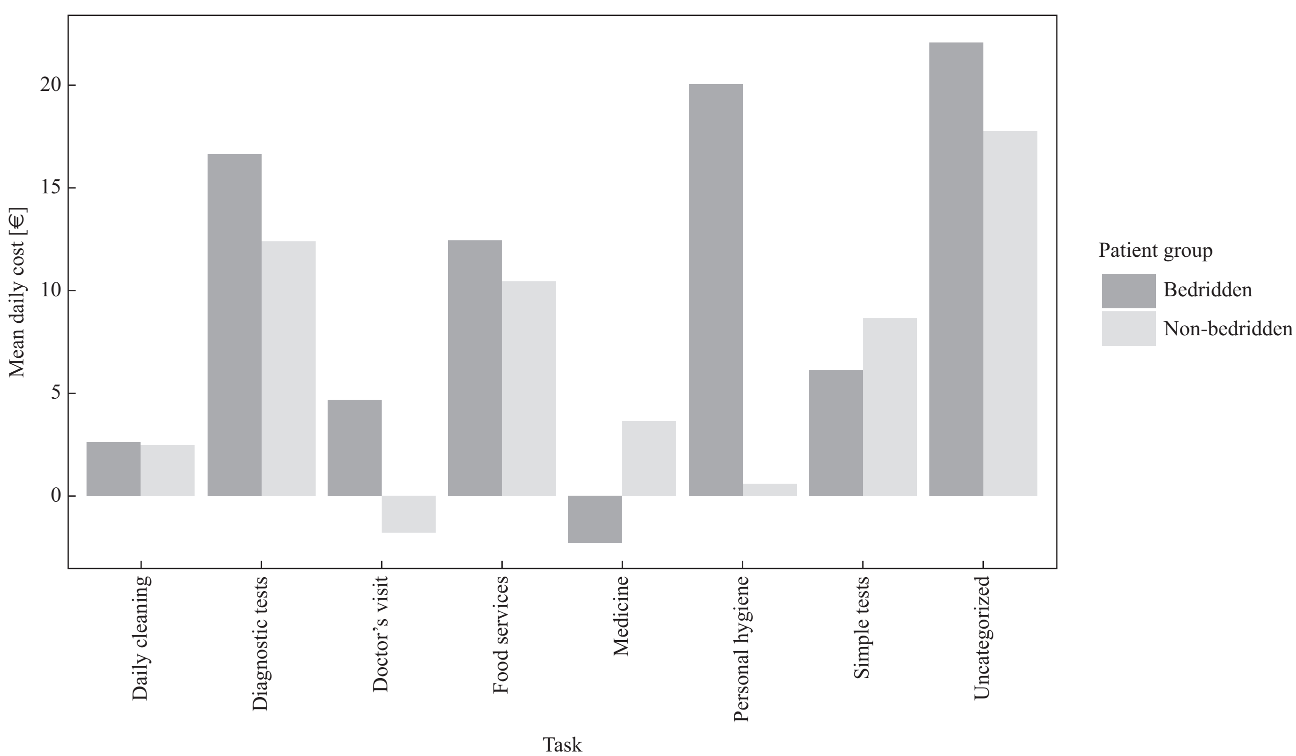

Figure 2. Bar plot of task-specific isolation costs per day.

Table II
Daily additional time use, stratified by hospital staff group

Additional time use (min)				
Staff group	Day shift	Evening shift	Night shift	24 h
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Non-bedridden				
Doctors	6.9 (2.3)	-0.2 (0.2)	—	6.8 (2.3)
Nurses	18.1 (4.9)	18.0 (3.8)	7.8 (2.3)	44.0 (9.9)
Cleaning staff	7.5 (1.5)	0.0 (-)	—	3.5 (1.5)
Other staff groups	3.2 (1.8)	2.3 (1.6)	1.4 (1.1)	6.9 (4.3)
Total	35.7	20.1	9.2	65.2
Bedridden				
Doctors	15.5 (6.0)	5.1 (3.2)	0.1 (0.1)	20.8 (8.1)
Nurses	29.8 (12.6)	22.5 (13.1)	-1.0 (2.2)	51.3 (25.3)
Cleaning staff	7.5 (1.5)	—	—	3.5 (1.5)
Other staff groups	6.3 (9.0)	7.5 (9.7)	1.2 (0.9)	15.0 (18.5)
Total	59.1	35.2	0.3	94.6

SD, standard deviation.

accounted for the majority of the extra workload: 72% for non-bedridden patients and 57% for bedridden patients. Doctors' workload was the second-largest contributor, with the corresponding estimates for non-bedridden and bedridden patients being 11% and 23%, respectively.

Sensitivity analysis

Sensitivity analysis was performed on daily costs by varying the frequencies of diagnostic tests and treatments outside the isolation room (Figure 3). For non-bedridden patients, the

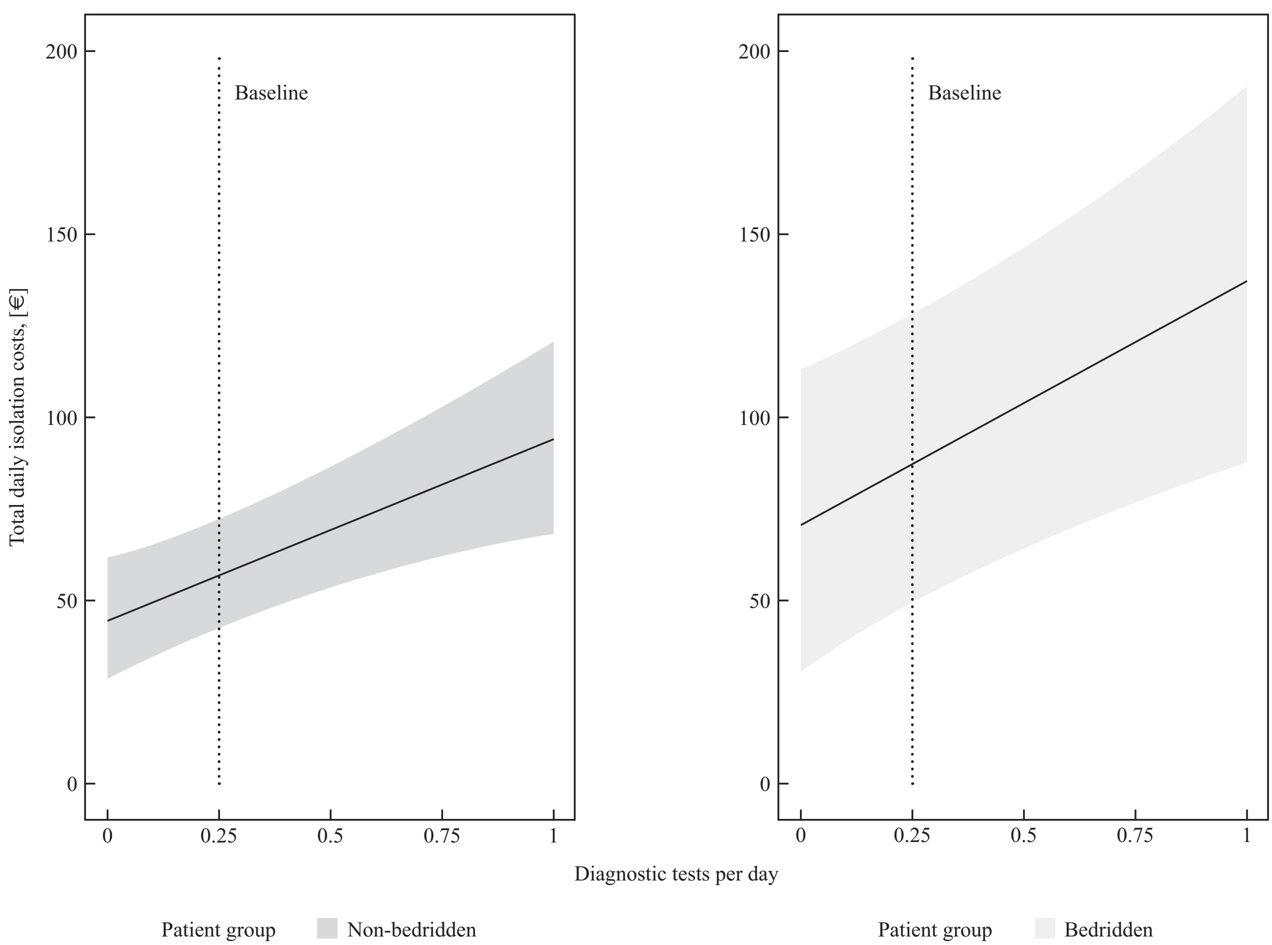

Figure 3. Total daily isolation costs dependent on frequency of diagnostic tests and treatments outside room; mean value and 95% confidence intervals visible ($N = 10,000$; step size = 0.05).

mean daily isolation costs were €44.4 in the absence of diagnostic tests or procedures plus €49.6 per time they had to do tests or treatments outside the room. For bedridden patients, mean costs were €70.8 without diagnostic tests or treatments plus €66.6 per daily test or procedures.

Room cleaning costs

The cost of additional resource use for cleaning and disinfection of rooms after patient discharge was estimated at €14.0 (95% CI 10.7–17.6; Table III). This figure corresponds to 25% and 16% of the daily isolation costs for non-bedridden and bedridden patients, respectively. Labour costs accounted for the majority of room cleaning costs (60%).

Discussion

This study documented in detail the additional cost of isolating patients in three Norwegian hospitals. The underlying data on workload and resource use are presented systematically in the Appendix in a way meant to facilitate their reuse, allowing for comparison with similar data from other countries, or in combination with updated unit cost data in future, local cost studies. Our on-site approach to data collection revealed considerable resource variation within specific tasks, especially in the case of bedridden patients. Extra staff workload was a leading cost driver, in terms of both daily costs and room cleaning costs upon patient discharge. New disinfectants with a shorter time to efficacy (2 min vs. 10–30 min) are soon to be introduced to hospitals, which will decrease cleaning time and hence the associated cost of this task.

Cost estimates for isolation precautions in the literature are scarce, and studies vary in their methodologies and levels of detail [9–11]. Only two studies with a similar design to ours were found. Roth *et al.* [12] estimated the direct isolation costs per day at a Swiss hospital (at 2017 rates) to be €121.5, when excluding one-off costs. The study was conducted in intensive care units, hence among immobile patients, and their results are consistent with ours for bedridden patients, though somewhat larger. Herr *et al.* [13] estimated the costs of preventing the spread of MRSA in German hospitals. Without MRSA-specific costs and the costs of blocked beds, their estimated additional costs/day amounted to €38 at 2000 rates, which is equivalent to €51 at 2017 rates, and thus these findings are also comparable to ours. One Norwegian study on the use of supplementary MRSA testing in hospitals reported costs of isolating patients [14]. The study included an additional hourly wage for nurses during the full course of isolation. A Swedish study [15] included a daily cost parameter for isolation of €484 at 2011 rates, which converts to €514 at 2017 rates. However, the paper does not state what was included in the parameter or how it was calculated.

Our finding that each isolated patient requires roughly 1–1.5 h of additional staff labour per day suggests that it may be warranted to schedule extra personnel during periods with many patients in these isolation beds. The results are also relevant to budget planning for upgrading healthcare premises or new builds with more single-bed rooms, suggesting that provision for extra staffing should be considered. Some Norwegian hospital wards, in particular general wards, routinely hire additional personnel when patients are isolated. Our study was conducted in infectious disease wards, where staff are specially trained and are accustomed to taking additional precautions when coming into contact with patients. As such, our results may be an underestimation of the costs of isolation in general wards, where this practice occurs less frequently. Note that during our study, staffing remained unaltered, thus no financial transactions occurred in relation to additional labour time.

Noticeably, our results show that fewer nurses were present at doctor's visits involving isolated, non-bedridden patients, which is indicative of lower-quality patient care. This is because nurses have a role as coordinators of patient care, and they translate and interpret information between doctors and patients. This finding is corroborated by studies showing that isolated patients receive less attention from healthcare workers overall, in terms of both the frequency and the duration of visits, and that isolation is associated with lower quality of care and higher risk of adverse events [16].

Isolation is associated with longer hospital stays [17–20]. Contact precautions are a plausible contributing factor to this. Examination and treatment of isolated patients outside their rooms are typically delayed until the end of the day shift. Therefore, isolated patients rarely have more than one scheduled examination per day, and their stays tend to be prolonged. Andreassen *et al.* [21] conducted a Norwegian-based registry study and found that patients with MRSA stay in the hospital for 13.71 days on average, which is 7.66 days longer than the average for patients without MRSA. This estimate suggests that the cost of keeping beds occupied longer may be substantial.

Isolation costs induced for terminal room cleaning averaged at 16% and 24% of the daily additional isolation costs for bedridden and non-bedridden patients, respectively. Unlike some European countries, ultraviolet light and hydrogen perioxide are not generally part of current discharge cleaning and disinfection practices in Norwegian hospitals. These supplementary techniques substantially increase the costs associated with terminal room cleaning. The main strength of our study is that it relies on data from real-world settings, showing resource use as it is in practice – not as what it would theoretically be if guidelines were followed to perfection. Because data was gathered from several hospitals varying in size and specialization, our results are generalizable to the Norwegian setting, rather than location specific.

Our study nevertheless has several weaknesses. A micro-costing study is time-intensive and restricts the amount of

Table III
Additional one-off isolation costs due to room cleaning on patient discharge based on bootstrap resampling ($N = 10,000$)

Cost item	Discharge cleaning costs (€)			
	Mean	95% CI	SD	%
Additional workload				
Nurses	1.83	(-0.55–4.41)	1.65	13.1
Cleaning staff	6.69	(5.97–7.68)	0.73	47.7
Additional materials				
PPE	1.53	(0.73–2.27)	0.53	11.0
Disinfectants	3.95	—	—	28.2
Total	14.00	(10.69–17.58)	1.88	100.0

CI, confidence interval; PPE, personal protective equipment; SD, standard deviation.

data that can be gathered. In some cases, task-specific costs were based on fewer than five observations (generally in the case of bedridden patients), which makes baseline results uncertain. The same is true of observations related to waste handling and room cleaning on patient discharge. The frequencies of tasks were assumed to be independent of isolation status, while prior studies indicate that isolated patients receive less frequent visits by healthcare workers [15]. Furthermore, observations of time and PPE usage were assumed to be unaffected by time of day, but data were collected exclusively during day shifts. The frequencies of non-routine tasks were based on self-reported staff activity logs, which enabled data to be gathered at low cost. In this analysis, the data was used at face value and multiplied all task frequencies by the proportions of shifts with registrations (Supplementary Table S3, bottom section). However, the logs have poor reliability, as it was not possible to confirm consistency in reporting. For example, staff registrations were only received from 30 out of a total of 48 night shifts.

Our study was conducted during the 2017–18 flu season, which may have affected the patient population and influenced the proportion of patients isolated in the wards. Finally, laundry costs were not considered, as it was not possible to obtain cost estimates for this task. Herr *et al.* [13] used a daily cost estimate of €7.41 for the laundering of coats, linens, etc. Our on-site observations suggested that the daily load of laundry was comparable between isolated and non-isolated patients. Because the laundry of both populations undergoes similar washing procedures, any discrepancy in laundry costs would be negligible.

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Conflict of interest statement

The authors have no conflicts of interest to declare.

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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.2019.11.012.

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