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ORIGINAL ARTICLE

High ward occupancy, bedspacing, and 60 day mortality for patients with myocardial infarction, stroke, and heart failure

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Abstract

Aims To study the consequences of crowded wards among patients with cardiovascular disease.
Methods and results This is a cohort study among 201 801 patients with 258 807 admissions who were acutely admitted for myocardial infarction (*N* = 107 895), stroke (*N* = 87 336), or heart failure (*N* = 63 576) to any Norwegian hospital between 2008 and 2016. The ward admitting most patients with the given clinical condition was considered a patient's home ward. We compared patients with the same condition admitted when home ward occupancy was different, at the same hospital and during comparable time periods. Occupancy was standardized such that a one-unit difference corresponded to the interquartile range in occupancy in the given month. One interquartile increase in home ward occupancy was associated with 7% higher odds of admission to an alternate ward [odds ratio (OR) 1.07, 95% confidence interval (CI) 1.09 to 1.11], and length of stay was shorter (−0.10 days, 95% CI −0.18 to −0.09). Patients with heart failure had 15% higher odds of admission to alternate wards (OR 1.15, 95% CI 1.08 to 1.23) and increased mortality [hazard ratio (HR) 1.08, 95% CI 1.03 to 1.15]. We found no apparent effect on mortality for patients with myocardial infarction (HR 0.99, 95% CI 0.94 to 1.05) or stroke (HR 1.00, 95% CI 0.96 to 1.05).
Conclusions Patients with heart failure had higher risk of admission to alternate wards when home ward occupancy was high. These patients may be negatively affected by full wards.

Keywords Ward occupancy; Bedspacing; Stroke; Myocardial infarction; Heart failure; Mortality

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Introduction

Patients with cardiovascular diseases admitted to intensive care require close follow-up and surveillance from clinical staff. During periods of high demand, hospitals may be strained, with possible negative consequences for the clinical outcomes for certain patient groups.[1–3] Emergency department crowding is one aspect of strained hospitals that is well studied, while there is limited research on the effect of strain in other parts of hospitals.[4]

In situations where hospital wards are full, patients may suffer from suboptimal care.[5] For example, patients could be placed in wards that are not optimally suited for their condition. This practice, which is often referred to as bedspacing, may have adverse effects,[6] in particular for patients requiring highly specialized care, for example, stroke patients.[7]

Organization of care between hospitals often differs, and this complicates studies of how full wards may influence patient treatment and care, for example, length of hospital stay and being bedspaced. In this study, to overcome methodological challenges, we restricted our comparisons to patients who were admitted for the same clinical condition to the same hospital during the same month, day of the week, and time of the day. We aimed to study the effects of high ward occupancy on patients acutely admitted for myocardial infarction, stroke, or heart failure. The patients' outcomes were evaluated in terms of whether they were admitted to an alternate ward where they might receive suboptimal treatment, their length of hospital stay, and 60 day total mortality.

Methods

Data and study cohort

We used data from the Norwegian Patient Registry to acquire information about a nationwide cohort of 201 801 patients with a total of 258 807 acute admissions between 1 January 2008 and 31 December 2016. All Norwegian hospital trusts are required to submit information about their clinical activity to the national patient registry.[8] The registry provided us with information on age and sex of all treated patients, as well as their diagnoses, and time of admission and discharge. In addition, the registry contained admitting hospital and a local administrative ward identifier. Date and cause of death within 60 days of admission were collected from the Norwegian Cause of Death Registry and were therefore not limited to in-hospital deaths. Information about contacts with regular general practitioners (GPs) was obtained from the Norwegian Health Economics Administrative database (Helfo). All patients could be tracked by a unique, anonymous identification number throughout the observation period. This number was used to link different data sources. All hospital use and GP consultations, as well as date and cause of death, could therefore be followed for all patients until 31 December 2016 through data linkages.

Using the ICD10 code for main diagnosis, we selected acute admissions of adult patients (removing 528 admissions where the patient was under 18 years of age) due to three subgroups of cardiovascular disease: myocardial infarction (I21 or I22), stroke (I61, I63, or I64), or heart failure (I50). We removed 22 287 admissions that occurred within 60 days of an earlier admission for the same diagnosis. This was done to avoid that the results were influenced by repeated admissions that could be caused by conditions during a primary hospital visit.

Measures

The home ward for a patient group was defined as the most common hospital ward to which the patients were first admitted. This was calculated for each hospital and for each of the three specified cardiovascular diagnosis groups per year covered by the study (2008 to 2016). For example, if 80% of patients admitted with stroke were admitted to the same ward in a given year, this was the home ward for stroke patients that year. If a patient was not admitted to the home ward during the hospital stay, this patient was considered to be treated at an alternate ward. Arrival times were categorized in time slots, night (from midnight until 8 AM), day (between 8 AM and 4 PM), and evening (4 PM to midnight). The exposure variable was occupancy at the home ward at the start of the time slot, midnight for night arrivals, 8 AM for day arrivals, and 4 PM for evening arrivals. The exposure was standardized such that a difference of one unit corresponded to the interquartile range of variation in occupancy for the given month, day of the week, and time of the day (night, daytime, or evening).

The main outcomes were admission to an alternate ward, length of stay in the hospital, and 60 day total mortality. We defined being admitted to an alternate ward as never being admitted to the home ward during the hospital stay. As secondary outcomes, we analysed readmissions, the number of days in contact with GPs and outpatient units, and length of stay (days) in hospital on subsequent stays, all within 60 days of the primary admission.

Statistical analysis

We matched patients in groups of those admitted for the same condition at the same hospital, during the same month, day of the week (holidays were coded as Sundays), and time of the day (night, daytime, or evening), and patients were only compared within these groups. By basing the estimates only on within-matched-group variability, we adjusted for any confounders that were constant within each group, for example, seasonal differences and hospital-specific changes over time. For instance, this means that a stroke patient admitted on a Monday night in September 2016 was only compared with other stroke patients admitted in one of the three other Monday nights of that month and at the same hospital.

For binary outcomes, for example, admission to alternate ward, the analyses of within-matched-group variability were done using conditional logistic regression (*xtlogit, fe* in Stata). Length of stay was analysed using a within-group linear regression (*xtreg, fe* in Stata). To analyse healthcare services use within 60 days (visits to a GP, outpatient contacts, and length of stay on subsequent stays), we used a within-group Poisson estimator (*xtpoisson, fe* in Stata) with censoring at death or end of 2016, whichever occurred first. We analysed mortality and readmission as time-to-event outcomes using stratified Cox regression with the matched groups as strata and with time from admission as the time scale. For mortality, patients were followed up to 60 days after admission or until the end of 2016, whichever occurred first. For readmissions, patients were followed till readmission or death, up to 60 days, or until the end of 2016, whichever occurred first.

The within-matched-group analysis was our main design choice to avoid confounding. In addition, we adjusted for age, age squared, sex, any acute admissions during the last 60 days, and visits to a GP during the last 60 days.

Precision was evaluated with 95% confidence intervals (CIs). The analyses were performed with Stata Version 15.1 and R Version 1.1.463. We publish the codes for running the analyses on Github.[9]

Additional analyses

Given our model, we assumed that occupancy at the home ward prior to admission was not associated with the state of the patient, thereby minimizing the potential for confounding. To justify this assumption, we studied the association of home ward occupancy with known indicators of the patients' condition: age, sex, previous hospital admissions during the last 60 days, and the number of visits to a GP 60 days prior to admission to hospital.

The analyses were also performed for subgroups of the total population to assess possible heterogeneity of the results. We investigated subgroups based on patient sex (men, women) and age (older or younger than 75 years). We also considered different timing of admission in terms of time of the day (night, day, evening), holiday and work-day admissions, and admissions during summer and winter months. Finally, we investigated university hospitals and other hospitals separately.

Cause-specific mortality within 60 days was also analysed by using the ICD10 code of cause of death. We performed a separate analysis censoring at death from cardiovascular disease (ICD10 Chapter IX) and diseases of the respiratory system (ICD10 Chapter X), and other causes.

To assess whether there could be a non-linear effect of occupancy, an additional analysis was done using spline regression. Details about this analysis are presented in Supporting Information, *Figures S9–S11*.

The administrative ward identifiers were based on local, hospital-specific codes. Organization of wards may differ substantially between hospitals. For descriptive purposes, we have presented the proportion of patients at home wards and alternate wards for each of the three diagnosis groups. This proportion was plotted against the mean daily number of acute admissions at the home ward and the hospital (Supporting Information, *Figures S7* and *S8*).

Results

In total, 258 807 admissions among 201 801 patients satisfied the inclusion criteria. *Table 1* shows characteristics of the three diagnostic groups. Within 60 days of admission, 11% of patients with myocardial infarction, 16% of patients with stroke, and 15% of patients with heart failure died. Overall, 13% of the patients were admitted at an alternate ward, and median length of hospitalization was 5 days.

For patients admitted when occupancy at the home ward was on the 75th percentile, the odds ratio (OR) for being admitted to an alternate ward was 1.07 (95% CI 1.04 to 1.11) when comparing with patients admitted when occupancy was on the 25th percentile (*Figure 1A*). Considering the diagnosis groups separately, patients with heart failure had an OR of 1.15 (95% CI 1.08 to 1.23), patients with myocardial infarction 1.07 (95% CI 1.02 to 1.12), while stroke patients had an OR of 1.02 (95% CI 0.97 to 1.07) of being admitted to an alternate ward. Hospital stays were estimated to be shorter for patients admitted at high occupancy, with an overall estimated difference of −0.10 days (95% CI −0.18 to −0.03) (*Figure 1B*). Being admitted at high home ward occupancy had no apparent effect on 60 day mortality for patients with stroke or myocardial infarction. In contrast, for patients with heart failure, the hazard ratio (HR) was 1.08 (95% CI 1.03 to 1.15) (*Figure 1C*).

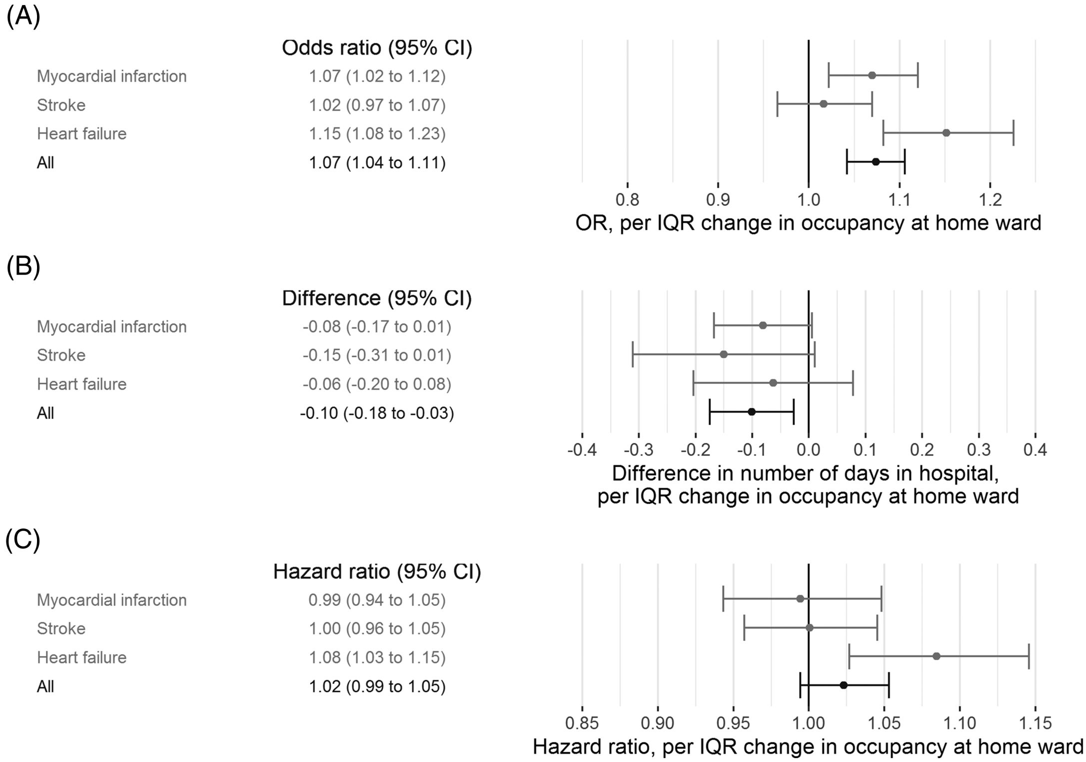
There were few or no substantial associations between occupancy at the home ward and different patient characteristics (age, sex, admitted previous 60 days, and GP visits previous 60 days) within matched groups (Supporting Information, *Figure S1*).

Table 1 Descriptive statistics on the patient population

	Myocardial infarction	Stroke	Heart failure	Total
Number of admissions	107 895	87 336	63 576	258 807
Hospitalization length (days)	4 [3–7]	6 [3–11]	5 [2–8]	5 [3–8]
Age (years)	71 ± 14	75 ± 13	79 ± 12	74 ± 14
Woman	39 085 (36%)	41 684 (48%)	29 472 (46%)	110 241 (43%)
Dead within 60 days of admission	11 889 (11%)	13 726 (16%)	9765 (15%)	35 380 (14%)
… by cardiovascular disease	8966 (75%)	9651 (70%)	5144 (53%)	23 761 (67%)
… by diseases of the respiratory system	1208 (10%)	1793 (13%)	2212 (23%)	5213 (15%)
… by other causes	1715 (14%)	2282 (17%)	2409 (25%)	6406 (18%)
Admitted to alternate ward	14 987 (14%)	9572 (11%)	9635 (15%)	34 194 (13%)
Hospital admission previous 60 days	67 005 (62%)	51 810 (59%)	31 258 (49%)	150 073 (58%)
Had a GP consultation previous 60 days	93 573 (87%)	75 609 (87%)	60 157 (95%)	229 339 (89%)

GP, general practitioner.
Data are presented as median [interquartile range of variation], mean ± standard deviation, and *n* of patients (%).

Figure 1 Associations between home ward occupancy and main outcomes. Associations were computed within groups of similar admissions (diagnosis, same hospital, month, day of the week, and time of the day). (A) Admitted to an alternate ward; (B) number of days in hospital; (C) 60 day mortality. CI, confidence interval; IQR, interquartile range; OR, odds ratio.



The analysis of secondary outcomes indicates that being admitted at high home ward occupancy had a minor association with readmission within 60 days, but there was some evidence for shorter length of stay on readmissions and less contact with outpatient units (Supporting Information, *Figure S2*). We estimated 3% fewer days in hospital on readmissions within 60 days for patients with myocardial infarction (Supporting Information, *Figure S2b*) admitted at high occupancy [incidence rate ratio (IRR) 0.97, 95% CI 0.96 to 0.99]. For patients with stroke, higher home ward occupancy was associated with fewer outpatient visits (IRR 0.98, 95% CI 0.97 to 0.99) and more visits to a GP (IRR 1.01, 95% CI 1.00 to 1.02) (Supporting Information, *Figure S2c* and *S2d*). There was no effect on outpatient and GP visits within 60 days for patients with myocardial infarction or heart failure.

Analyses of cause-specific 60 day mortality (Supporting Information, *Figure S3*) indicate that patients with heart failure admitted at high home ward occupancy had increased 60 day mortality caused by cardiovascular diseases (HR 1.09, 95% CI 1.01 to 1.18) and respiratory diseases (HR 1.13, 95% CI 1.01 to 1.28), whereas death from other causes was unchanged (HR 1.02, 95% CI 0.96 to 1.08).

The subgroup analyses showed that the results were stable across subgroups (Supporting Information, *Figures S4–S6*).

There were large differences in how administrative ward codes were used at different hospitals. Larger hospitals had more specialized wards, that is, had a higher proportion of patients from the same diagnosis group (Supporting Information, *Figure S7*) with lower volumes of patients per ward (Supporting Information, *Figure S8*).

Figures and details on the analysis of the main outcomes using splines are shown in Supporting Information, *Figures S9–S11*. The results for the association between home ward occupancy and 60 day mortality for patients with heart failure indicated that the observed increase in mortality was predominantly seen at higher levels of occupancy. Apart from this, there were no clear non-linear effects of home ward occupancy.

Discussion

In this study, we found that high occupancy at the home ward increased the risk of being admitted to another ward than the home ward for patients with myocardial infarction and heart failure. Patients with heart failure had a somewhat increased mortality within 60 days if they were admitted at a time where occupancy at the home ward was high. This in-

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crease in mortality appeared to be driven by increase in death from both cardiovascular diseases and diseases in the respiratory system. We found no substantial effect of home ward occupancy on mortality for patients with myocardial infarction or stroke.

Our finding that patients are placed at alternate wards when the home ward is full is likely due to the practice of bedspacing. Bedspacing entails admitting patients to other wards when the clinically appropriate ward is full. Concerns have been raised regarding the safety of these patients.[10–12] For example, difficulties in communication arising from the physical separation can lead to reduced access to clinical expertise required for appropriate care,[6,13] as well as increased staff workload.[14] Studies comparing bedspaced patients with other patients have found increased mortality,[11] lower mortality,[15] or no association.[16,17] Interpreting such results is challenging because these patients may differ substantially in ways that are not registered in data. Also, because bedspacing is used in situations with capacity problems, the alternative may be admission to an overfull home ward, which is likely harmful in itself.[4]

This study is set in the Norwegian healthcare system, where 30 day survival after stroke and myocardial infarction is among the best in Europe.[18,19] Much effort has been put into optimizing treatment for these conditions. In 2016, 92% of patients with stroke were treated at a specialized stroke unit.[20] An optimized system for managing patients with stroke or myocardial infarction may explain the difference in results we found between these patients and patients with heart failure. Patients with heart failure tend to be older and more frail and may have several comorbidities. Treatment of heart failure may be more subject to clinicians' discretion, which is harder to optimize. A recent paper by Papanicolas *et al*.[21] studied different healthcare systems in high-income countries and found substantial variation in mortality after hospital treatment for patients with heart failure and diabetes. Such differences may be an indication that treatment for this patient group is generally less optimized.

Strengths and limitations

The study was designed to minimize risk of bias in several ways. Because a patient demanding much treatment may influence the admission and treatment of concurrent patients, we measured home ward occupancy before admission of the index patient. Therefore, the index patient would not affect the measure of occupancy, not even indirectly. To avoid bias due to selection of patients to wards, we measured occupancy at an assumed home ward, whether the patient was admitted there or not.

To avoid confounding, patients were only compared if they were admitted at the same hospital during similar time periods. This approach, which is commonly used in family studies to study differentially exposed siblings,[22] effectively controls for all shared and constant confounding factors. Therefore, the results would not be affected by differences between hospitals, or hospital-specific changes over time. Organizational changes, including changes in how data were registered, would likewise not bias the results. We did not expect any associations between home ward occupancy and potential confounding factors given our analytical design, which was also supported by the additional analyses. Because this is an observational study, residual confounding cannot be ruled out.

We had access to complete national register data that made it possible to provide precise estimates. The information that was used is considered to be of good quality for such studies.[8] A weakness in the data was that administrative ward identifiers may not correspond to clinical wards. There were differences in how different hospital's wards were reported in the data, where larger hospitals generally had smaller units. However, because comparisons were only done within matched groups, this would not introduce any systematic errors. If a hospital reported several wards under one common ward identifier, this may have resulted in an underestimated effect on admission to an alternate ward. The analyses were designed not to rely on knowing which ward was the clinically appropriate one but considered changes in odds of ward admission associated with ward occupancy, while assuring that this occupancy was not associated with the condition of the patient.

Our relatively precise estimates indicated that there was no population-wide effect of high ward occupancy on 60 day mortality for patients with stroke and myocardial infarction. This does not preclude that certain subgroups were harmed in strained situations. Due to data limitations, we could not assess effects on patient treatment, for example, time to treatment, or long-term patient outcomes, like receiving institutionalized care. Also, data on clinical presentation and risk factors were limited. Such data could have given more information on which patients are at risk when home wards are full.

Conclusions

This study indicates that surges in patient inflow resulting in full wards negatively impact patients with acute heart failure. This may be a result of a compromised care regime for a vulnerable patient group and highlights the need to organize care with flexibility to accommodate for surges.

Conflict of interest

None declared.

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Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Figure S1. Exposure balance.
Figure S2. Secondary outcomes.
Figure S3. 60-day cause specific mortality.
Figure S4. Admission to alternate ward, subgroup analysis.
Figure S5. Length of hospital stay, subgroup analysis.
Figure S6. 60-day mortality, subgroup analysis.
Figure S7. The proportion of patients at the home ward and alternate wards belonging to the respective diagnosis group. Ordered by hospital size.
Figure S8. The proportion of patients at the home ward and alternate wards belonging to the respective diagnosis group. Ordered by home ward size.
Figure S9. Spline analysis of association between occupancy at home ward and probability of being placed at alternate ward.
Figure S10. Spline analysis of association between occupancy at home ward and length of hospital stay.
Figure S11. Spline analysis of association between occupancy at home ward and 60-day mortality.

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