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Trends, causes and timing of 30-day readmissions after hospitalization for heart failure: 11-year population-based analysis with linked data

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ABSTRACT

Background: Reliable data are necessary if the burden of early readmissions following hospitalization for heart failure (HF) is to be addressed. We studied unplanned 30-day readmissions, their causes and timing over an 11-year period, using population-based linked data.
Methods: All hospitalizations from 2003 to 2013 were analyzed by using administrative linked data based on the Minimum Basic Set discharge registry of the Department of Health (Region of Murcia, Spain). Index hospitalizations with HF as principal diagnosis (n = 27,581) were identified. Transfers between centers were merged into one discharge. Readmissions were defined as unplanned admissions to any hospital within 30-days after discharge.
Results: In the 2003–2013 period, 30-day readmission rates had a relative mean annual growth of +1.36%, increasing from 17.6% to 22.1%, with similar trends for cardiovascular and non-cardiovascular causes. The figure of 22.1% decreased to 19.8% when only same-hospital readmissions were considered. Most readmissions were due to cardiovascular causes (60%), HF being the most common single cause (34%). The timing of readmission shows an early peak on the fourth day post discharge (+13.29%) due to causes other than HF, followed by a gradual decline (−3.32%); readmission for HF decreased steadily from the first day (−2.22%). Readmission for HF (12.7%) or non-cardiovascular causes (13.3%) had higher in-hospital mortality rates than the index hospitalization (9.2%, $p < 0.001$). Age and comorbidity burden were the main predictors of any readmission, but the performance of a predictive model was poor.
Conclusion: These findings support the need for population-based strategies to reduce the burden of early-unplanned readmissions.

1. Introduction

Heart failure (HF) is a huge issue for health systems, for which they represent the most common reason for hospitalization in patients aged over 65 years. Health system data show that hospitalization with a primary diagnosis of HF account for 1–3% of all hospital admissions [1]. The direct costs of HF represent about 2% of health care expenditure and hospitalization represents approximately 80% of this cost [1]. The use of healthcare resources and associated costs are predicted to rise markedly over the coming years, as the prevalence of HF is expected to increase with the aging population [2].

In this epidemic and costly scenario, readmissions are a very relevant event [3]. However, readmission is considered to be one of the most preventable causes of hospitalization and related health expenditure [4]. The early period after discharge is named the 'vulnerable phase', as the risk of readmission is highest at this time [5]. Indeed, after HF-related hospitalization, the early (30 days) readmission rate is taken as a relevant quality indicator and has been incorporated by health providers and payers as one of the main outcomes to measure [3]. Data from the USA show that readmissions rates at 30 days range between 22% and 27%, with an increasing trend in last years [6,7]. In Europe, 30-day readmission data are scarce and those that exist were obtained from registries or studies with a hospital basis, with no population or temporal framework [8]. This may cause bias, given that patients may be readmitted to a different hospital from that which they were discharged or be transferred between centers [9]. In order to overcome these limitations, the use of administrative data with

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linked information is an opportunity to obtain reliable information about readmissions, their characteristics and temporal trends; in particular, the analysis of timing and causes of readmissions are relevant to define preventive actions. The importance of these questions will help design health policies able to prevent the burden of HF readmissions.

This work aimed to study the temporal trend of unplanned readmission up to 30 days post-discharge during an 11-year period, their causes and timing, in a well-defined population and using administrative linked data.

2. Methods

2.1. Design and study population

This retrospective observational study is based on the Minimum Basic Set discharge (MDS) registry of the Department of Health of the Region of Murcia (Spain). The study population included all hospitalizations with a main diagnosis of HF between 2003 and 2013 (funded by the National Health System in either public hospitals of the Murcia Health Service or subsidized private hospitals). "Heart failure" was defined as indicated by the International Classification of Diseases, 9th revision Clinical Modification: 398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93 and 428.XX [10]. Planned and long-stay hospitalizations were excluded. "Health care episodes" were created by grouping together the discharges showing continuity of care (transfers between hospitals), identifying people through the code of their Individual Health Card and contrasting it with the population database PERSAN (Health Person, collects all Users of the Murcia Health Service). Of these episodes, 91.5% were assigned to single individuals, allowing their follow-up in all hospitals of the health network. In the remaining 8.5% of episodes, the individual could not be identified, thus the follow-up was conducted by the initial admitting hospital. Of all discharges, 1.5% corresponded to transfers between hospitals, and were merged into a single hospitalization event. The geographical framework of the study was the Autonomous Community of the Region (province) of Murcia (Spain), which had a population of 1,410,850 inhabitants according to the official census of 2013.

2.2. Readmissions and study variables

All administrative, clinical and demographical variables were obtained from the index hospitalization, including Elixhauser's comorbidity index. The latter is a validated score for predicting the use of hospital resources and the risk of in-hospital mortality and readmission [11]. Readmission was defined as an unplanned admission within 30 days after discharge from the index HF hospitalization, regardless of the hospital in which hospitalization occurred. When more than one readmission was identified in the 30-day period, the information of the first one was used by agreement. For each readmission, the main diagnosis for the hospitalization was obtained, as well as the in-hospital mortality. Readmission causes were grouped following the main diagnosis according to the major diagnostic category (MDC) of the AP GRD v23 [12], which classifies the diagnoses into groups by organs and systems. Within the MDCs, causes were sub-classified according to the Clinical Classifications Software (CCS) developed by the Healthcare Cost and Utilization Project-HCUP [13]. This classification strategy was chosen because it includes the complications of CDM and to make the CCS more clinically sensitive.

2.3. Statistical analysis

SPSS® software version 21.0 was used for the analysis (IBM Corp., Armonk, NY, USA). Patients who died in the initial hospitalization were not taken into account for the calculation of the rate of readmissions. The trends of readmissions were standardized by age and sex using the direct method, taking as reference the distribution of the total index cases and using the Joinpoint regression model, version 4.2.0.2 [14], which estimates the presence of changes in standardized annual rates and the mean annual percentage change (APC). An APC value was considered statistically significant if it differed from 0 with a p-value of <0.05. The temporal trends for readmissions for any cause, MDC5 (diseases and disorders of the circulatory system) and any other causes were calculated. The distribution of readmissions during the 30-day period was also studied. The chi-square test was used in the univariate analysis. For the logistic regression models, variables with a p < 0.20 (in the univariate analysis) were introduced, while those with a high correlation were not introduced in the same model. First-level interactions were studied. A p-value of <0.05 was considered statistically significant.

3. Results

3.1. 30-day readmissions, causes and trends 2003–2013

In the period 2003–2013, there were 27,581 index hospitalizations with a principal diagnosis of HF (76.9 ± 10.5 years, 57% females). After considering in-hospital mortality (9.2%), the final number of index hospitalizations was 24,654. After discharge, the overall 30-day readmission rate was 20.0% (n = 4938). Readmission to a different hospital occurred in 8.3% of readmissions ranging from 4.2% to 33.7% depending on the individual hospital for the overall study period; considering only readmissions to the same hospital, the overall rate was 18.1% (n = 4528). Table 1 shows the year-by-year data. During the 11-year period (Fig. 1), the 30-day readmission rates showed a significant trend to increase, with a relative annual increase of +1.36% (APC), increasing from 17.8% in 2003 to 22.1% in 2013. The last figure was 19.8% when only admissions to the same hospital were considered.

Regarding the causes of readmission, 12.0% (60%) were cardiovascular-related and 8.0% (40%) were non-cardiovascular related. The 11-year trend was similar for readmissions due to cardiovascular (APC = +1.30%) and non-cardiovascular causes (APC = +1.40%), although the latter trend did not reach statistical significance (Fig. 1). HF was the main individual cause, representing 59.9% among cardiovascular causes and 35.9% among total causes. Respiratory pathologies were the most prevalent among non-cardiovascular causes, representing 15.8% of the total. In addition, 3.5% of all readmissions were due to complications directly related to procedures or medical care during the index-hospitalization.

3.2. Timing of readmissions in the 30-day period

Fig. 2 shows the distribution of readmissions within the 30-day period. All-cause unplanned readmissions exhibited a steep initial rise (APC = +13.29%) with a peak on the fourth day, followed by a steady decrease during the rest of period (APC = −3.32%). The same pattern was observed for cardiovascular causes other than HF and for non-cardiovascular causes, whereas readmission for HF followed a different pattern, with a gradual decrease from the day following discharge (APC = −2.22%). At least one quarter (27.4%) of readmissions occurred within the first 6 days, and half within the first 12 days. The relative contribution of the different causes was similar in each quartile for readmissions within the 30-day period (Table 1S in Supplementary material). The Joinpoint analysis identified days 2, 5, 9, 14 and 22 as time points associated with a significant reduction in the slope (Supplementary material, Fig. 1S).

3.3. In-hospital mortality of readmissions

As shown in Fig. 3, the mortality of readmissions was significantly higher than that of the index hospitalization (12.5% vs 9.2%, p < 0.001). As regard the cause of readmission, mortality was significantly higher in those readmitted for HF (12.7%) and non-cardiovascular causes (13.3%), whereas cardiovascular causes other than HF had similar mortality (9.7%) to the index hospitalization.

3.4. Variables associated with readmission

The administrative variables of the index hospitalization were analyzed according to the readmission status at 30 days and the cause categorized as cardiovascular or non-cardiovascular (Table 2S in Supplementary material). The group aged 45–64 years showed the lowest frequency of non-cardiovascular readmissions, whereas those older than 84 years showed higher non-cardiovascular readmissions. Non-cardiovascular readmissions were fewer for short hospital stays (<6 days), but were more frequent for long stays (>9 days). As regard comorbidity, an Elixhauser index lower than <4 was associated with a lower readmission rate, whereas values above 5 points were associated with higher rates, regardless the cause. After adjustment in a multivariable logistic regression model, the variables associated with a higher risk of readmission, whether cardiovascular or non-cardiovascular, were sex (female was protective for both types of cause), age (increased risk with aging for both), length of stay (preventive effect of shorter stays only for cardiovascular readmissions), Elixhauser score (increased risk with a higher score for both causes). The description of individual