International Journal of Medical Informatics 95 (2016) 49–59

Contents lists available at ScienceDirect

International Journal of Medical Informatics

journal homepage: www.ijmijournal.com

The development and use of a new methodology to reconstruct courses of admission and ambulatory care based on the Danish National Patient Registry

Sophie Gubbels[a,*], Kenn Schultz Nielsen[b], Jakob Sandegaard[c], Kåre Mølbak[a], Jens Nielsen[a]

[a] Department of Infectious Disease Epidemiology, Statens Serum Institut, Artillerivej 5, 2300 Copenhagen S, Denmark
[b] Department of IT-Projects and Development, Danish Health Data Authority, Artillerivej 5, 2300 Copenhagen S, Denmark
[c] Department of Data Quality and Content, Danish Health Data Authority, Artillerivej 5, 2300 Copenhagen S, Denmark

ARTICLE INFO

Article history:
Received 28 October 2015
Received in revised form 6 August 2016
Accepted 17 August 2016

Keywords:
Re-construction algorithm
Electronic health records
Hospital admissions
Ambulatory care
Denmark

ABSTRACT

Introduction: The Danish National Patient Registry (DNPR) contains clinical and administrative data on all patients treated in Danish hospitals. The data model used for reporting is based on standardized coding of contacts rather than courses of admissions and ambulatory care.
Methods: To reconstruct a coherent picture of courses of admission and ambulatory care, we designed an algorithm with 28 rules that manages transfers between departments, between hospitals and inconsistencies in the data, e.g., missing time stamps, overlaps and gaps. We used data from patients admitted between 1 January 2010 and 31 December 2014.
Results: After application of the DNPR algorithm, we estimated an average of 1,149,616 courses of admission per year or 205 hospitalizations per 1000 inhabitants per year. The median length of stay decreased from 1.58 days in 2010 to 1.29 days in 2014. The number of transfers between departments within a hospital increased from 111,576 to 176,134 while the number of transfers between hospitals decreased from 68,522 to 61,203.
Conclusions: We standardized a 28-rule algorithm to relate registrations in the DNPR to each other in a coherent way. With the algorithm, we estimated 1.15 million courses of admissions per year, which probably reflects a more accurate estimate than the estimates that have been published previously. Courses of admission became shorter between 2010 and 2014 and outpatient contacts longer. These figures are compatible with a cost-conscious secondary healthcare system undertaking specialized treatment within a hospital and limiting referral to advanced services at other hospitals.

1. Introduction

The secondary and tertiary healthcare provision in Denmark is predominantly public and management and policy making occurs primarily on a national level and in the five Danish Regions [1]. The development and use of common standards for information and communication technology plays a large role in the organization of the Danish healthcare sector.

Administrative and clinical data on patient contacts with the Danish secondary and tertiary healthcare system are recorded locally and gathered daily in the Danish National Patient Registry (DNPR) [2]. This registry was established in 1977. Originally, it only covered somatic inpatients, but over the years, the registry expanded. Since 1995, also outpatient activities, Accident & Emergency Room (A&E) contacts and psychiatric departments have gradually been included. In 2003, notification of inpatient and outpatient contacts from private hospitals became compulsory [3]. Before 2014, A&E patients were recorded as a separate category. From 1 January 2014, these have been recorded as acute outpatients. In addition, since 1 January 2014 the Capital Region of Denmark reorganized its on-call service, after which patients, who would previously have been seen by a general practitioner, were seen in the A&E. The consequence is that, for this region, primary sector patients are now recorded as acute outpatients in the DNPR. Initially, the DNPR was a discharge registry, meaning that data were first sent to the DNPR after discharge. Since 1996, open outpatient

* Corresponding author.
E-mail addresses: gub@ssi.dk (S. Gubbels), ksn@ssi.dk (K.S. Nielsen), sandegaard@live.dk (J. Sandegaard), krm@ssi.dk (K. Mølbak), nls@ssi.dk (J. Nielsen).

http://dx.doi.org/10.1016/j.ijmedinf.2016.08.003

contacts have been registered and since June 2015, hospitals could voluntarily register inpatients that were still admitted. The latter became obligatory from 1 January 2016. Data are entered in the DNPR in accordance with specifications made by Danish Health Data Authority to secure a certain level of standardization and data quality.

Due to the contact based design of the DNPR, in which each inpatient contact with a new department is registered as a new event, and sometimes even several (overlapping) contacts are recorded for the same department, courses of admission cannot directly be deducted. DNPR does for example not disentangle contacts representing transfers within the same course of admission from records that represent a new admission. Outpatient contacts are registered as the period in which the patient was in ambulatory care at a specific department, with visits/consultations related to them. Registration practice of outpatient contact varies between hospitals: where some hospitals record new outpatient contacts regularly, other hospitals keep an outpatient contact open for years. All registrations of inpatients and outpatients are manually entered and may therefore contain inaccuracies, for example in the exact time of admission and discharge, leading to overlaps and gaps in the course of an admission and course of ambulatory care.

Using a large registry for scientific studies and surveillance systems poses many challenges, particularly when data are primarily recorded for administrative and economic purposes. A system that is driven by reimbursements has certain forces driving the coding practice [4–6]. Variations in content, completeness and validity of data between different groups and over time create an additional challenge as these may make adjustments for co-morbidity problematic or even useless [7–9]. A recent review article compiled validation studies performed on the DNPR, showing varying levels of completeness and validity of diagnosis codes [10]. So far, no validation studies were published assessing the accuracy of registrations of admission and discharge dates in the DNPR, although many scientific studies and policy documents use these data to calculate length of stay and numbers of (re-)admissions in relation to specific diseases and for the healthcare system as a whole. In 2014 alone, 12 articles were published using the DNPR to calculate numbers of admissions and/or length of stay (PubMed search with search terms '*National Patient Register Denmark hospitalization*' and '*National Patient Registry Denmark hospitalization*'; limited to English original articles and publication date in 2014. Full text articles were screened for length of stay calculations or analyses of numbers of (re-)admissions). These studies were either done using the DNPR as it is, with the contacts as equivalents to admissions and courses of ambulatory care [11–19], or with a loosely specified algorithm to create courses of admission [20–22]. This variety of practices makes interpretation of results and comparison with other studies difficult.

In this article, we present a method, which can standardize the way DNPR data are used for epidemiological studies, surveillance and policymaking. We describe how registrations can be related to each other using an algorithm ("DNPR algorithm") to reconstruct a complete and coherent picture from inpatient contacts to admissions within the same department, to courses of admission across departments and hospitals as well as from outpatient contacts to courses of ambulatory care within the same department. Using this algorithm, we describe and discuss trends in hospital admissions and ambulatory care and identify areas for further research.

This work was done as a prerequisite for the development of a national automated surveillance system to monitor hospital-acquired infections: the Danish Hospital-Acquired Infections Database (HAIBA) [23]. However, the DNPR algorithm will also be relevant when using DNPR for other surveillance, research and planning purposes. It also gives insight in data quality, as well as dynamics and trends in the utilization of the Danish secondary and tertiary healthcare system. The experiences with this algorithm will be of value for other countries planning to develop an administrative patient system or applying data from existing patient registries.

2. Methods

2.1. Definitions

Inpatient: A patient who occupies a hospital bed for medical care or treatment

Outpatient: A patient who receives medical care or treatment at a hospital, but is not admitted

Ambulatory Care: medical care or treatment an outpatient receives

Inpatient contact: A single registration in the DNPR for an inpatient

Outpatient contact: A single registration in the DNPR for an outpatient

Admission: A coherent hospital stay within the same hospital department as identified with the DNPR algorithm (can include more than one inpatient contact)

Course of admission: A coherent hospital stay across departments and hospitals as identified with the DNPR algorithm (can include more than one admission)

Course of ambulatory care: A coherent period of ambulatory care within the same hospital department as identified with the DNPR algorithm (can include more than one outpatient contact)

2.2. Study population and period

We used data of inpatients admitted between 1 January 2010 and 31 December 2014, and outpatients with contacts starting in that same period. Data included somatic inpatients and outpatients from all private and public hospitals in Denmark, but not A&E contacts before 1 January 2014. Data were extracted on 1 October 2015.

2.3. Data flow and output data model

Data flow and the output data model are shown in Fig. 1. DNPR retrieves data from the five Danish regions. Data from public and private hospitals are collected in separate databases each containing both administrative and clinical information (diagnosis and procedure codes). National classification tables were used to allow translating codes for hospitals, departments as well as diagnosis and procedure codes [24]. The codes also include information on whether data are from the public or private sector and from which Danish region.

Patients were identified by their CPR number, a civil registration number that each person in Denmark receives upon birth or immigration [25].

Data on inpatient and outpatient contacts from both public and private hospitals contained the patients' CPR numbers, dates and times of admission and discharge (with hours being the lowest level of detail) and hospitals and departments where the patients were admitted or received ambulatory care. Each contact has a unique contact identifier, which is the key to linking the contacts to data on diagnosis, procedures and visits.

Diagnosis codes are entered upon discharge according to the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD10) [26], and adapted for use in the Danish healthcare system [24]. Additional information to the diagnosis codes may also be entered, here referred to as additional diagnosis codes. Diagnosis codes and additional diagnosis codes do not have a date and time of diagnosis, but can be related to the period between the start and end date and time of the corresponding inpatient or outpatient contacts.