

Exploring Delays in Cardiac Care Processes Through Electronic Health Records

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Abstract. Cardiovascular diseases are the leading cause of death globally. Timely health services are fundamental to the appropriate prevention, identification, care and rehabilitation of these diseases. This study aimed to explore the potential of using electronic health records as a data source to help identify health system -related delays in care processes of cardiac patients. This retrospective registry study is based on a sample of electronic health records of 200 cardiac patients admitted to one out of twenty wellbeing services counties in Finland during the years 2021–2022. A total of 426 health system -related delays were identified. All expressions were found in unstructured format and most of these (58.7%) were generated by nurses. These results show that the electronic health records contained a variety of information on health system -related patient care delays, and that most delays were associated with difficulties in finding a bed for the patient in a post-acute care facility (49.8%), but also in-hospital process delays were common (27.7%). These findings show great potential for exploring electronic health record data with natural language processing methods in the future for the development of tools to better identify and monitor different types of delays in care processes. Such tools may support leadership to respond to organisational procedures in need of improvement.

Keywords. Electronic health records, care delay, cardiac care, quality of care, secondary use

1. Introduction

Cardiovascular diseases are the leading cause of death on a global scale and timely health services are fundamental to the appropriate prevention, identification, care and

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rehabilitation of these diseases [1]. A care delay may be understood as a postponement in receiving the health services needed. Delays in care processes may be due to factors connected to the individual, such as financial barriers, but they may also be associated with the health system, such as staffing shortages and information technology issues. Reducing the health system -related factors is important, as delays in care processes can lead to adverse patient outcomes, such as increased mortality, infections and readmissions [2]. Delays can also impede healthcare professionals in progressing with care activities needed by a patient [3]. Care timeliness constitutes one of the dimensions of healthcare quality and delays are also associated with increased healthcare costs [4].

Prior research on health system -related factors have focused on delays in referrals from primary care to specialised care [5], emergency department admission delays [6], critical care discharge delays [7] and hospital discharge delays [8]. However, research exploring systematic assessment of delays related to care processes in hospitals is scarce and more work is needed to develop means to better identify and monitor different types of delays to respond to organisational procedures in need of improvement. Hence, the aim of this study was to explore the potential of using electronic health records as a data source to help identify health system -related delays in care processes of cardiac patients.

2. Methods

This retrospective registry study is based on a sample of electronic health records of 200 cardiac patients admitted to one of twenty wellbeing services counties in Finland during 2021–2022. The multimodal electronic health record data set included patients' documentation related to demographics, diagnoses, medical notes, nursing notes, radiology reports, laboratory/examination information, procedures done and medication.

2.1. Data collection and analysis

We used our custom Python script to identify delays in care from the documentation. The script took the terms “delay”, “que”, “wait”, “cancelled”, “postponed” with their synonyms as an input and consequently extracted those expressions from the health records as a new list. Each identified hit in this novel list was presented with a 10-word window before and after its occurrence together with the pseudonymised identifier from the health record. We then manually screened each hit to exclude all the individual-related hits and only included the health system -related hits in a qualitative analysis. In case the extracted text with the 10-word window left uncertainty, the original text was checked in the health record to ensure its context, so that it could be classified appropriately as a health system -related delay or not. The manual screening was done individually by two domain experts to ensure appropriate classification of each hit.

We organised the identified health system -related delays in the care processes inductively using content analysis and then screened the reasons behind reported delays.

2.2. Ethical considerations and data security

The ethical review was done by the Ethics Committee of the University of Turku (9/2020/J.Kuha) and an administrative approval was obtained from the wellbeing services county (T95/2020-1). All data were processed in a secure certified computing environment.

3. Results

3.1. Description of findings

The data set (n=200) included 48% female and 52% male patients. The mean age of the patients was 74 years, ranging from 28 to 96 years. We found altogether 1500 hits when screening the health records with the given list of terms. All hits were found in sections of unstructured documentation done by nurses and physicians. The manual screen showed that 28.4% (n=426) of the identified expressions were health system -related and 71.6% (n=1074) were associated with the patient. Five hits could not be categorised due to their vague formulation. From the health system -related hits, 58.7% (n=250) were found in the nursing documentation, 42.5% (n=181) in the medical notes and one in the radiology reports. There was overlap between the extracted expressions in the narratives where a unique hit appeared from one to twelve times within a patient's health record.

3.2. Reasons for delay

The health system -related factors were categorised into awaiting bed in secondary or primary care; awaiting care assessment, surgery, procedure, lab/test results or bed on hospital inpatient ward; awaiting time for appointment for follow-up planning; and other factors. Most of all identified factors associated with the delays were related to situations where patients were waiting in the tertiary hospitals to be transferred into primary care (49.8%), while a smaller portion waited for a bed in a secondary care hospital (12.2%). The 'awaiting care assessment, surgery, procedure or lab/test results' -category covered a variety of factors associated with a delay in the care process. Specific examples included patients awaiting to meet a clinician for assessment, such as a specialist nurse or a physician, and patients awaiting to have an MRI, a CT scan or lab test taken or have the results for further care planning. This category also included ample examples of patients awaiting surgery or a postponement of a planned operation due to more urgent cases that needed to be prioritised in the operating department. A further category was associated with patients queuing for an appointment time for an outpatient follow-up visit after being discharged from the hospital, for example to the cardiac care center (7.1%). There were also other factors, which were less conventional, such as mentions where patients' appointments had been rescheduled due to strike action within the workforce. The reasons identified to cause delays included limited facilities and malfunctioning equipment, staff workload and allocation issues, other reasons (e.g. delayed, missing or cancelled tasks, missed requests and communication issues), and unclear reasons. The identified factors associated with delays are presented in Table 1 with frequencies and percentages.

Table 1. Factors associated with health system -related delay presented with frequencies and percentages

Factor	n (%)
Awaiting bed in primary care	212 (49.8)
Awaiting care assessment, surgery, procedure or lab/test results or bed in the hospital	118 (27.7)
Awaiting bed in secondary care	52 (12.2)
Awaiting time for follow-up visit	30 (7.1)
Other	14 (3.3)

4. Discussion

The main findings of this study are that 1) the electronic health records contained a variety of information about health system -related delays that had occurred in the care processes of cardiac patients, 2) most delays identified were associated with difficulties in finding a patient bed at a post-acute care facility, but also in-hospital process delays were common, and 3) health system -related delay information was found in unstructured format in both nursing and medical documentation within the health records.

Although the primary purpose of electronic health records is to digitally manage health information of individual patients to support care delivery and ensure communication amongst all actors involved, these systems have a great deal of untapped potential to serve in secondary use purposes as well, such as performance monitoring and quality improvement of health services [9]. The results of this study add to the growing body of evidence supporting the acknowledgement of patient health data in performance monitoring, as a variety of information on health system -related delays that occurred in the care processes of cardiac patients could be found in professionals' documentation. However, challenges that need to be addressed in secondary use of such data include data quality, preprocessing [10,11], privacy and limited generalisability issues [11] as well as professionals' support for such applications [12].

More than a quarter of the hits in the data set regarded health system -related delays, which indicates opportunities to improve care processes. This aligns with prior work on organisational reasons of admission and discharge delays in the critical care setting [7]. About half of the identified health system -related delays were associated with difficulties in finding a bed at post-acute care facility, which seems to correspond to a growing body of literature exploring interventions targeted at hospital discharge delays [13,14]. However, less work exists on reducing delays within the hospital. Although timeliness is one key perspective of high-quality care [1], there is yet no consensus on quality indicators that should be measured in the care processes of patients with cardiovascular diseases. Thus far, such indicators have mainly focused on procedural factors, while less attention has been on structural and outcome factors [15]. Hence, exploring the elements associated with delays in care processes become important, and can form the basis for the development of efficient solutions to support the monitoring of health system -related delays within and beyond the hospital. Monitoring the delays can guide developmental work to improve care processes and patient outcomes.

The information on health system -related delays in care processes was only found in unstructured format in both nursing and medical documentation. This highlights the value of exploring natural language processing technologies for future development of systems that automatically identify delays in patient care processes. A further important point raised is the value of interdisciplinary documentation: It seems important to include both nurses' and physicians' documentation in such secondary use of electronic health record data, as the mentions of delay were presented in both sets of notes, with a higher representation in the data generated by nurses.

Study limitations regard the data set, which was collected from only one county and the simple approach used to capture the delays from the electronic health records. Further limitations concern the nature of electronic health record data and its implications for secondary use, e.g. not all delays are documented into electronic health records. Future work is needed to explore more effective natural language processing methods that may be used to automatise the identification process of delays in care of cardiac patients beyond the limited terms used in this study.

5. Conclusions

The results of this study indicate that electronic health records show great potential as a data source for the monitoring of health system -related delays in care processes of cardiac patients in hospitals. The results showed that interdisciplinary unstructured data, documented by nurses and physicians, seem to bring high value to work aiming at identifying these delays. Future work is needed for a more in-depth analysis of delay processes and their underlying reasons, and to develop and test natural language processing methods that better identify the health system -related delays and may be used in the development of automatised monitoring systems to support in systematically identifying structures, practices and procedures in need of improvement.

References

- [1] World Health Organization. Cardiovascular diseases (CVDs). Fact sheet. 2021. Available from: [https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-\(cvds\)](https://www.who.int/news-room/fact-sheets/detail/cardiovascular-diseases-(cvds))
- [2] Al-Omary MS, Williams T, Briennes SC, Khan A, Graffen S, Sheehan A, Collins N. Impact of Delay in Surgery on Outcome in Patients Undergoing Cardiac Revascularisation Surgery. *Heart Lung Circ.* 2021;30(6):888-95. <https://doi.org/10.1016/j.hlc.2020.09.935>
- [3] Institute of Medicine. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington (DC): National Academy Press; 2001.
- [4] National Healthcare Quality Report. Agency for Healthcare Research and Quality. Chapter 5: timeliness. 2013. Available from: <https://archive.ahrq.gov/research/findings/nhqrdr/nhqr13/chap5.html>
- [5] Mansell G, Shapley M, Jordan JL, Jordan K. Interventions to reduce primary care delay in cancer referral: a systematic review. *Br J Gen Pract.* 2011;61(593). <https://doi.org/10.3399/bjgp11X613160>
- [6] Lee EEM, Kwok ESH, Vaillancourt C. Using emergency physicians' abilities to predict patient admission to decrease admission delay time. *Emerg Med J.* 2020;37(7):417-22. <https://doi.org/10.1136/emered-2019-208859>
- [7] Peltonen LM, McCallum L, Siirala E, Haataja M, Lundgrén-Laine H, Salanterä S, Lin F. An Integrative Literature Review of Organisational Factors Associated with Admission and Discharge Delays in Critical Care. *Biomed Res Int.* 2015;2015:868653. <https://doi.org/10.1155/2015/868653>
- [8] Cadel L, Guilcher SJT, Kokorelias KM, Sutherland J, Glasby J, Kiran T, Kuluski K. Initiatives for improving delayed discharge from a hospital setting: a scoping review. *BMJ Open.* 2021;11(2). <https://doi.org/10.1136/bmjopen-2020-044291>
- [9] Danciu I, Cowan JD, Basford M, Wang X, Saip A, Osgood S, Shirey-Rice J, Kirby J, Harris PA. Secondary use of clinical data: the Vanderbilt approach. *J Biomed Inform.* 2014;52:28-35. <https://doi.org/10.1016/j.jbi.2014.02.003>
- [10] Edmondson ME, Reimer AP. Challenges Frequently Encountered in the Secondary Use of Electronic Medical Record Data for Research. *Comput Inform Nurs.* 2020;38(7):338-48. <https://doi.org/10.1097/CIN.0000000000000609>
- [11] McGuckin T, Crick K, Myroniuk TW, Setchell B, Yeung RO, Campbell-Scherer D. Understanding challenges of using routinely collected health data to address clinical care gaps: a case study in Alberta, Canada. *BMJ Open Qual.* 2022;11(1). <https://doi.org/10.1136/bmjopen-2021-001491>
- [12] Neves AL, Poovendran D, Freise L, Ghafur S, Flott K, Darzi A, Mayer EK. Health Care Professionals' Perspectives on the Secondary Use of Health Records to Improve Quality and Safety of Care in England: Qualitative Study. *J Med Internet Res.* 2019;21(9). <https://doi.org/10.2196/14135>
- [13] Marcinow M, Cadel L, Birze A, Sandercock J, Baek J, Wodchis W, Guilcher SJT, Kuluski K. "I think we did the best that we could in the space." A qualitative study exploring individuals' experiences with three unconventional environments for patients with a delayed hospital discharge. *PLoS One.* 2024;19(2). <https://doi.org/10.1371/journal.pone.0297542>
- [14] Cadel L, Sandercock J, Marcinow M, Guilcher SJT, Kuluski K. A qualitative study exploring hospital-based team dynamics in discharge planning for patients experiencing delayed care transitions in Ontario, Canada. *BMC Health Serv Res.* 2022;22(1):1472. <https://doi.org/10.1186/s12913-022-08807-4>
- [15] Kanaoka K, Iwanaga Y, Tsujimoto Y, Shiroshita A, Suzuki T, Nakai M, Miyamoto Y. Quality indicators for acute cardiovascular diseases: a scoping review. *BMC Health Serv Res.* 2022;22(1):862. <https://doi.org/10.1186/s12913-022-08239-0>