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Special Communication

Measuring the effects of computer downtime on hospital pathology processes

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ABSTRACT

Objective: To introduce and evaluate a method that uses electronic medical record (EMR) data to measure the effects of computer system downtime on clinical processes associated with pathology testing and results reporting.

Materials and methods: A matched case-control design was used to examine the effects of five downtime events over 11-months, ranging from 5 to 300 min. Four indicator tests representing different laboratory workflows were selected to measure delays and errors: potassium, haemoglobon, troponin and activated partial thromboplastin time. Tests exposed to a downtime were matched to tests during unaffected control periods by test type, time of day and day of week. Measures included clinician read time (CRT), laboratory turnaround time (LTAT), and rates of missed reads, futile searches, duplicate orders, and missing test results.

Results: The effects of downtime varied with the type of IT problem. When clinicians could not logon to a results reporting system for 17-min, the CRT for potassium and haemoglobon tests was five (10.3 vs. 2.0 days) and six times (13.4 vs. 2.1 days) longer than control ($p = 0.01–0.04$; $p = 0.0001–0.003$). Clinician follow-up of tests was also delayed by another downtime involving a power outage with a small effect. In contrast, laboratory processing of troponin tests was unaffected by network services and routing problems. Errors including missed reads, futile searches, duplicate orders and missing test results could not be examined because the sample size of affected tests was not sufficient for statistical testing.

Conclusion: This study demonstrates the feasibility of using routinely collected EMR data with a matched case-control design to measure the effects of downtime on clinical processes. Even brief system downtimes may impact patient care. The methodology has potential to be applied to other clinical processes with established workflows where tasks are pre-defined such as medications management.

1. Introduction

Information technology (IT) can enhance the safety and quality of clinical processes, but poorly designed, implemented or used systems may have unintended consequences, and even contribute to patient harm [1,2]. Technical problems are a major contributor to IT-related patient safety incidents. For example, in our analysis of incidents reported to the US Food and Drug Administration 96% of problems related to technical issues [3]. Computer system *downtime* features amongst such reports, and appears to be common in hospitals. A *downtime* is a period of time when IT is either unavailable or only partially available because of planned maintenance or an unplanned event [4]. There is no active surveillance of the frequency and scope of downtimes currently experienced by hospitals. A recent survey of US hospitals found that downtimes were common, and often lasted 8 or more hours [5]. In other industries, with more mature IT systems, organisations typically experience 25 h of downtime per year [6].

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1.1. Gaps about the effects of downtime on clinical processes and patient outcomes

There remain major gaps in evidence regarding the effects of downtime on clinical processes and patient outcomes. While the use of IT in pathology testing is well examined in the health informatics literature, little is known about disruption of these processes due to downtime [7–9]. There are case reports about some large-scale events, for instance one that affected 80 trusts in England's NHS [10]. Other examples come from the USA e.g. where it took more than 9 hours to restore services to the 17 sites in the Veterans Affairs Administration after a similar outage [10]. At Boston's Beth Israel Deaconess Medical Centre, it took 4 days to restore systems [11].

Delays due to downtime: While some downtimes may be uneventful, our previous analysis of incident reports indicates that hospitals are particularly susceptible to downtime. Information critical to treating patients could not, for example, be accessed for up to 8 h at a time [12]. This lack of access to the electronic medical record (EMR), order entry and results reporting systems disrupted multiple clinical processes simultaneously. In one case, cancer diagnosis was delayed for six patients because specimens were not analysed as ordered and cytology results were not available [13].

In one US study involving five hospitals it was reported that downtime was highly disruptive to workflow [14]. Another survey of 78 hospitals found monthly downtime for medication systems lasted up to 8 hours [15]. The only study prospectively measuring downtime, done in 2003, was restricted to an emergency department, and detected 77 events ranging from a few minutes to 16 h over 4 months [16].

Errors and patient harm due to downtime: Although the epidemiology of IT-related adverse events has not been studied, qualitative studies provide some insight into their nature. Recent surveys of US hospitals have linked downtime to medication errors, increased length of stay [15] and patient harm [5]. An observational study identified 22 new types of IT-related errors which delayed medication orders [17]. In our analyses of incidents most adverse events were associated with clinical processes [13,18]. For example, a hospital-wide system breakdown delayed post-surgery treatment leading to a permanent musculoskeletal disability. In another case, a patient died when a network problem delayed transmission of images for diagnosis.

1.2. The need for methods to measure the effects of downtime

Current approaches to examining downtime are primarily based on reports from clinicians which usually appear well after issues are resolved and are not directly actionable [3,12]. Many incidents may go undetected, or be detected only after patients have been harmed [14,19]. Moreover incident reports cannot be used to measure delays to clinical processes and quantify the effects of errors on patients because the reports do not represent a systematic sample [20].

The lack of methods to measure the effects of downtime hampers preparedness and response [2]. Without robust data it is not possible to employ surveillance methods for early detection of IT system failures before they impact care delivery and patient safety [21,22]. Nor is it possible to guide hospital administrators, policy makers and IT implementers on appropriate strategies to minimize disruptions to clinical work, safety practices to avoid patient misadventure, and the engineering approaches to improve IT system resilience [23].

1.3. Objective and hypotheses

One way to quantify the effects of downtime in hospitals is to measure the real-time effects on clinical processes which can be tracked using EMR data [2]. For example, a new record with an electronic timestamp is created in the EMR when a pathology test is ordered, the record is subsequently updated when results are available and when viewed by a clinician. These markers can be used to identify the effects of a downtime, which can occur at any time during processing of the test. EMR data can also be used to examine errors such as missed follow-up of test results and duplicate testing [24].

The objective of this study was to assess the feasibility of using routinely collected EMR data to measure the effects of downtime on clinical processes. We focus on pathology tests because laboratories provide up to 80% of the information used by clinicians to make important medical decisions and IT use directly influences patient safety in this process [25,26]. Based on the literature we hypothesize three scenarios for downtime to disrupt pathology testing [14–17,27]:

(1) Disruption at the time test orders are received by the laboratory may delay processing i.e. increasing *laboratory turn around time (LTAT)* [28]. Clinicians may find results are not available at the expected time (i.e. search for results is futile) and may generate *duplicate orders* [29].
(2) Disruption after test orders are received by the laboratory and until results are posted may mean results go missing (*missing results*) or are delayed [30]. Again, *futile searches* may lead to duplicate orders.
(3) Disruption after posting of test results may cause tests to be missed by clinicians (i.e. *missed reads*) or delay review of results (i.e. increasing *clinician read time, CRT*) [7]. For instance, a results reporting system may not be accessible for several hours following a downtime.

2. Materials and methods

2.1. Pathology tests and results

The study was conducted in a 350-bed metropolitan teaching hospital in Australia. The hospital's order entry, results reporting and EMR were integrated with the laboratory information system. Pathology tests and results for all admissions were extracted from the EMR between February 2011 and January 2012, excluding those associated with deceased patients and critical tests communicated directly to the ordering clinician. This accounted for 3,408,437 records. For each test order, timestamps were available when a test was *performed* by the laboratory, when results were posted and *available*, and when they were *reviewed* by a clinician. If a clinician attempted to review a result before it was available then this was also recorded by the system and was counted as a *futile search*. The time of initial order entry was not available in the current system.

Four indicator tests were chosen because they represent the four major workflows in the laboratory and have been widely used as indicators of laboratory performance [28,31,32]. They are also representative of a number of other tests also used for acute care. There are shared components for each pathway but they each have their own specific factors.

All four indicator tests have the same initial workflow of reception, checking tubes and forms, and data entry and tube labelling with an internal barcode.