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The ability of triggers to retrospectively predict potentially preventable adverse events in a sample of deceased patients

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ABSTRACT

Several trigger systems have been developed to screen medical records of hospitalized patients for adverse events (AEs). Because it's too labor-intensive to screen the records of all patients, usually a sample is screened. Our sample consists of patients who died during their stay because chances of finding preventable AEs in this subset are highest.

Records were reviewed for fifteen triggers (n = 2182). When a trigger was present, the records were scrutinized by specialized medical doctors who searched for AEs. The positive predictive value (PPV) of the total trigger system and of the individual triggers was calculated. Additional analyses were performed to identify a possible optimization of the trigger system.

In our sample, the trigger system had an overall PPV for AEs of 47%, 17% for potentially preventable AEs. More triggers present in a record increased the probability of detecting an AE. Adjustments to the trigger system slightly increased the positive predictive value but missed about 10% of the AEs detected with the original system.

In our sample of deceased patients the trigger system has a PPV comparable to other samples. However still, an enormous amount of time and resources are spent on cases without AEs or with non-preventable AEs. Possibly, the performance could be further improved by combining triggers with clinical scores and laboratory results. This could be promising in reducing the costly and labor-intensive work of screening medical records.

1. Introduction

Unintentional medical harm received increased attention during the past years (Rutberg et al., 2014; Najjar et al., 2013; Kennerly et al., 2013; Zegers et al., 2009; Mull et al., 2015; Kurutkan et al., 2015; Farup, 2015; Doupi et al., 2013; Goodman et al., 2011; Baines et al., 2015).

Several years have passed since the report "to err is human" was published, in which the need for a safer health care system was emphasized. Fifteen years after this initial report, a recent update stressed the importance of continuing efforts to improve patient safety (Anon., 2015). Also, a recent Dutch paper (2013) showed that an average of 12% of patients who died in the hospital still experienced care related injury, which sometimes even contributed to the death of the patient (Langelaan et al., 2013a). It is, therefore, important to identify AEs and to determine the risk factors related to their occurrence, in order to reduce harm to patients and improve the quality of care (Hwang et al., 2014).

It is time-consuming to screen all records for the presence of AEs. Therefore, "triggers" that can be easily identified in the medical records by well-trained nurses in a relatively short time, have been developed. Several trigger systems were created to screen medical records of hospitalized patients for AEs. These triggers are indicators or characteristics of the disease course, known to be often associated with AEs (Resar et al., 2003). The fact that cases can be missed, is generally accepted because investigating all records would be too time and cost-consuming in relation to the positive effect of screening. A well-known trigger system is the Global Trigger Tool (GTT), developed by the Institute for Healthcare improvement (IHI). Also, the system from the Harvard medical practice study (HMPS), with a smaller set of triggers, is often used (Griffin and Resar, 2009; Brennan and Leape, 1991). For the aforementioned trigger systems, the positive predictive value has been determined in several studies (Kennerly et al., 2013; Unbeck et al., 2013). However, the part of the quality cycle where medical records are scrutinized is still time-consuming and costly. Therefore, it is important to minimize the number of false positive results without increasing the

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number of false negative results. Because it is too labor-intensive to screen the records of all patients, usually the screening is performed in a sample.

Our sample consists of records of all patients who died during their stay. Therefore, in this study, we used a slightly adapted list of triggers. Examples of cases are illustrated in appendix I, to explain some of the most used triggers and the ones which needed extra explanation.

It closely resembles the trigger list from the HMPS, but adjusted to be applicable to medical records of deceased patients. Admittedly, AEs in diseases with negligible mortality but with an unfavorable outcome or hospitalization in departments with low mortality (e.g. ENT, ophthalmology, obstetrics, pediatrics etc.) would escape the opportunity for improvement of care using this sample. Although there are conflicting reports, the most recent and largest study concerning detection of preventable AEs showed that this is particularly effective in deceased patients (Baines et al., 2015; Hogan et al., 2012; Dunn et al., 2006). However, patients who die in hospitals are usually older with more comorbidities and therefore studies in these patients are not generalizable to the average hospital patient. In this study, we assumed that the probability of detecting (serious) AEs was highest in this subset of patients. This would then result in a manageable number of cases to be scrutinized by the committee, but still acquiring a fair overall estimation of the quality of treatment and causes of treatment failure. We wondered whether the positive predictive value (PPV) of the trigger system in deceased patients was acceptable compared to other study samples. Therefore, we analyzed our database with information on triggers and AEs of all in-hospital deaths in the past years. In addition to this, we performed supplementary analyses in an attempt to optimize the current trigger system.

2. Methods

This study was performed at the Maastricht University Medical Centre (MUMC+), a teaching hospital in the south of the Netherlands. The medical records used in this study included all inpatient wards including children's. The study protocol was approved by the Ethics Committee of our hospital. We also checked whether patients ever expressed objections against the use of their data for research (this is recorded in a special database in the hospital). If so, their data were excluded. However, none of the patients that were in this sample, did so.

The medical records of all patients who died in our hospital between January 1st, 2012 and January 1st, 2015 were explored by a team of trained nurses for the presence of triggers. Subsequently, a committee consisting of medical specialists from all major disciplines analyzed the records to search for AEs. Both the screeners and the specialists were not time restricted. All results were saved using software provided by Medirede®, Clinical File Search version 3 (Mediround BV, 2015). This software was designed to store these data in a clear and easily accessible way. An AE was defined as an unintended outcome arising from the (non)-action of a caregiver and/or the health care system with damage to the patient resulting in temporary or permanent disability or death of the patient (Wagner, 2007). If a potentially preventable AE was suspected, this was discussed with the involved medical department. Finally, the committee decided on the definite presence of an AE and its potential preventability. For the purpose of this study, we used the committee result as a gold standard for AEs. We did not evaluate the effect of hindsight bias, inter- and intrarater reliability.

The starting point of our trigger system was the HPMS list, and we hypothesized that this list would be redundant in deceased patients (Brennan and Leape, 1991). Trigger 1 (patient was admitted before (< 12 months) for a reason related to the current admission) was adapted to a shorter period (< 3 months) because analysis of previous years showed this trigger was not discriminative for potentially preventable AEs. The 12-month cut-off contained a large number of patients with planned chemotherapy or planned second stage operations. Two other triggers were not applicable in a deceased population.

To create a simplified method of triggering, we calculated the positive predictive value (PPV) for the combination of triggers that can be detected by a computer search of the medical records (trigger 1, 4 and 5) and a combination of three triggers that generate the highest number of potentially preventable AEs (trigger 4, 7 and 8). Here, we only looked at the PPV for potentially preventable AEs as the outcome. The PPV of individual triggers was calculated as the rate at which a trigger was associated with an AE, both potentially preventable and not preventable (Naessens et al., 2010). Furthermore, we calculated risk scores for an AE in patients with a trigger taking the patient characteristics into account. These risk scores could then be used, to generate cut-off points leading to a smaller selection of records with a varying number of AEs depending on the chosen cut-off point.

3. Statistical analysis

Descriptive statistics are used to describe the general characteristics of the screened medical records and the triggers used in this retrospective analysis.

Chi-square tests and independent *t*-tests were performed to determine the differences between the groups of patients who experienced an AE during their stay, compared to the group of patients who did not develop an AE.

Furthermore, multivariable backward logistic regression analyses (with classification cut-off 0,5) were performed for three scenarios, the first one to detect only computer detectable triggers. The second model contains all 15 triggers to identify the trigger with the highest odds for AEs and potentially preventable AEs. The last model was used to determine the contribution of patient characteristics to the occurrence of AEs to identify possible additional factors that could improve the selection of cases with AEs.

The presence of an AE was used as the dependent variable. Independent variables were: origin (coming from another hospital yes/no), emergency admission, age, gender, admission specialism, and length of stay (in days). Referred by emergency admission was applicable when the patient was admitted via the emergency ward. Admission specialties were divided into surgical (e.g. urology, vascular surgery, gynecology etc.) and medical departments (e.g. internal medicine, gastroenterology, cardiology, pulmonology, rheumatology, pediatrics etc.). For evaluating the additional value of including the patient characteristics in this last logistic regression model (model 3), we have calculated the probability of every individual of having an AE, given the fact, one or more triggers would be positive. In this model, the following patient characteristics were included: urgent admission, origin, age, gender, length of stay and admission specialism. The logistic regression model yields a continuous outcome, i.e. the predicted probability ranging from 0.0 to 1.0. However, the model will likely be used to classify patients into high risk versus low risk, or positive versus negative. To aid in choosing the right cut-off point for classification, we evaluated 6 different cut-off points. By computing test characteristics for each cut-off point, one cut-off point can be chosen that fits the need for either ruling in or ruling out an adverse event.

Analyses were executed using IBM SPSS Statistics version 23 (IBM Corporation, 2015), a $p < 0.05$ was considered statistically significant.

4. Results

The medical records of 2182 patients were investigated (shown in Fig. 1). The general characteristics of these patients are shown in Table 1. Men were significantly younger than women ($p = 0.004$) and they had a significantly higher chance of experiencing an AE ($p = 0.021$). The length of stay is significantly longer in patients with an AE compared to patients without an AE ($p < 0.001$), whereas preventable and non-preventable AEs don't differ concerning the length of stay ($p = 0.911$).