INTERNATIONAL JOURNAL OF MEDICAL INFORMATICS 78 (2009) 745–756

journal homepage: www.intl.elsevierhealth.com/journals/ijmi

A computational framework to identify patients with poor adherence to blood pressure lowering medication

Thusitha Mabotuwana[a], *Jim Warren*[a,b,*], *John Kennelly*[c]

[a] *Department of Computer Science – Tamaki Campus, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*
[b] *Section for Epidemiology and Biostatistics, School of Population Health, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*
[c] *Department of General Practice, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand*

ARTICLE INFO

Article history:
Received 6 January 2009
Received in revised form
30 May 2009
Accepted 23 June 2009

Keywords:
Ambulatory care information systems
Clinical audit
Long-term care
Patient non-adherence
Patient outcome assessment
Quality indicators

ABSTRACT

Background: Blood pressure (BP) lowering medications have impressive efficacy in reducing cardiovascular and renal events; but low adherence threatens their effectiveness. Analysis of patterns in electronic prescribing from electronic medical records (EMRs) may have the potential to reveal cohorts of patients with significant adherence problems.
Methods: We developed a computational framework to identify patient cohorts with poor adherence to long-term medication through analysis of electronic prescribing patterns. A range of quality reporting criteria can be specified (as an XML document). We illustrate the framework by application to the EMRs of a New Zealand general practice with a focus on adherence to angiotensin-converting enzyme inhibitors (ACE-inhibitors) and/or angiotensin II receptor blockers (ARBs) in patients classified with hypertension and diabetes. We analyse medication supply based on Medication Possession Ratio (MPR) and duration of lapse in ACE-inhibitors/ARBs over a 12-month evaluation period. We describe graphical tools to assist visualisation of prescribing patterns and relationship of the analysis outputs to controlled blood pressure.
Results: Out of a cohort of 16,504 patient EMRs, 192 patients were found classified with both hypertension and diabetes and under active ACE-inhibitor and/or ARB management. Of these, 107 (56%) patients had an ACE-inhibitor/ARB MPR less than 80% together with a lapse in ACE-inhibitors/ARBs for greater than 30 days. We find non-adherent patients (i.e. MPR <80% or lapse >30 days) are three times more likely to have poor BP than adherent patients (odds ratio = 3.055; $p = 0.012$).
Conclusions: We have developed a generic computational framework that can be used to formulate and query criteria around issues of adherence to long-term medication based on practice EMRs. Within the context of the example we have used, the observed adherence levels indicate that a substantial proportion of patients classified with hypertension and diabetes have poor adherence, associated with poorer rates of blood pressure control, that can be detected through analysis of electronic prescribing. Further work is required to identify effective interventions using the reporting information to reduce non-adherence and improve patient outcomes.

* *Corresponding author*. Tel.: +64 9 373 7599x86422; fax: +64 9 303 5932.
E-mail addresses: thusitha@cs.auckland.ac.nz (T. Mabotuwana), jim@cs.auckland.ac.nz (J. Warren), j.kennelly@auckland.ac.nz (J. Kennelly).
1386-5056/$ – see front matter © 2009 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ijmedinf.2009.06.006

1. Introduction

Research has shown impressive efficacy rates of blood pressure (BP) lowering medications for reduction in cardiovascular and renal events. These antihypertensive medications come in a variety of classes and subclasses, with varying indications, as well as used in combination, depending on other characteristics of the patient, such as presence of diabetes or heart failure. For this paper, the reader is referred to the categories of blood pressure lowering medications and their use as per the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC7) [1], as well as New Zealand Heart Foundation guidelines [2]. Notably, we will refer to the medication categories of angiotensin-converting enzyme inhibitors (ACE-inhibitors) and angiotensin II receptor blockers (ARBs), which are indicated for patients with concurrent ('comorbid') diabetes and hypertension.

Although these drugs are effective when taken as directed, low adherence (also sometimes called 'non-compliance') to prescribed regimens threatens their effectiveness in real-world use. Long-term adherence with medications for chronic diseases is low in general, particularly among lower socio-economic groups [3]. Based on the international literature, it is thought that poor adherence to antihypertensive medication contributes to inadequate BP control in more than two-thirds of hypertensive patients [4]. A Swedish study found satisfactory refill adherence for thiazide diuretics at 55%, ACE-inhibitors at 59% and selective beta-blocking agents at 66% [5]. The level of adherence has been positively correlated with good BP control and reduction in the complications of hypertension [6]. Low adherence has been cited in the international literature as the primary cause of unsatisfactory control of BP [1], however, studies that are focussed on identifying specific cohorts of patients who are non-adherent are limited.

The reasons for non-adherence are poorly understood and vary with psychosocial factors [7]. Efforts to improve adherence to antihypertensive medication can be divided into behavioural (e.g. phone reminders, packaging, dosing changes, social assistance), educational interventions (written or verbal) or combined approaches. One meta-analysis found no one approach was superior to any other but there was a trend to improved adherence with a combined approach [8]. Reminder packaging for improving adherence to long-term medication was the subject of a Cochrane review where the authors found that this intervention improved the percentage of medications taken [9]. Interventions for improving medical adherence in primary care (specifically) found patient education alone was insufficient and the evidence for complex interventions involving social support, education and reminders was inconclusive [10]. It is difficult to judge the independent effects of individual components (e.g., nurse phone call reminders) of complex interventions. An organised system of recall and regular review may be the most successful and sustainable intervention [11].

In light of the large magnitude of long-term medication adherence issues, and the on-going need to formulate successful adherence improvement strategies, we set forth to develop a computational framework with the aim of successfully identifying patients with poor adherence to their medication, focussing mainly on antihypertensive prescribing. We hypothesise that there is an opportunity for carefully formulated automated analysis of electronic prescribing records to identify medication adherence problems in the context of blood pressure control. We utilise the concepts of Medication Possession Ratio (MPR) and duration of lapse of medication supply as key criteria in the computational framework presented in this paper. Our framework enables analysis of patterns in electronic prescribing from electronic medical records (EMRs). In previous work we have identified that moderately sensitive and specific identification of suboptimal management of hypertension can be derived from the EMRs of Australian [12] and New Zealand [13] general practice EMRs. Moreover, we have found that analysis of electronic prescribing indicates particularly large cohorts of hypertensive patients exhibiting gaps in continuity of therapy suggestive of poor adherence and correlated to poor blood pressure control [14]. The framework presented herein is flexible in terms of the specific criteria of interest with respect to medications, adherence thresholds, time periods of interest and defining characteristics of cohorts of interest. We illustrate the framework in terms of adherence to ACE-inhibitors and ARBs in patients classified with comorbid hypertension and diabetes through analysis of the EMRs of a New Zealand general medical practice.

In this paper we present a novel computational framework that can be used to identify specific patients with medication adherence issues in terms of MPR and medication lapses, as relevant to BP lowering medication. In the following sections we outline our methodology and discuss details related to the framework implementation and demonstrate how our framework has been used to identify patients with the adherence issues using production EMR data. Furthermore, we demonstrate that this cohort has significantly lower odds of having successful controlled BP compared to adherent patients. We introduce a prescription timeline visualisation scheme we have developed to aid clinicians to visualise a selected patient's antihypertensive prescribing patterns. We conclude with discussion of how our framework can be used in an active patient intervention and/or management effort and possible future directions.

2. Methodology

2.1. *Adherence to medication*

Andrade et al. in their systematic literature review that investigated different adherence measures concluded that identification, aptness and selection of measures for adherence should be determined by the objectives of the study, and limitations and benefits of the measures should be considered [15]. *Adherence* refers to the extent to which a patient's behaviour to take the prescribed medications aligns with the instructions and recommendations from the prescriber [16]. A widely used measure of adherence is defined in terms of a proportion-of-days-covered model, which calculates the proportion of days within a fixed interval that the patient has an available supply of medication [17].