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► **To cite this version:**

Ozgun Pinarer, Sultan Turhan. Web Service Solution for Adverse Drug Events and Medication Errors. 2018 IEEE International Conference on Big Data (Big Data), Dec 2018, Seattle, United States. pp.2449-2452, 10.1109/BigData.2018.8622070 . hal-02380160

**HAL Id: hal-02380160**

**<https://hal.science/hal-02380160>**

Submitted on 2 Jan 2024

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# Web Service Solution for Adverse Drug Events and Medication Errors

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**Abstract**—Investigating the incidence, type, and preventability of adverse drug events (ADE) and medication errors is crucial to improving the quality of health care service. ADEs, medication errors can be extracted from practice data, patients feedback and especially from medication order. In this study, we examine the dataset filled with medication orders and with a web service based approach, each medication order is analyzed to avoid from drug-drug interaction. Firstly, the study is performed on a training set to explore the drug-drug interactions based on the clinical drug component of each medication. Then the proposed web service approach is integrated into the actual centralized Medication Order Management System (MOMS) of the hospital. With this real time checking ADE mechanism, doctors are warned in case there is a possible ADE or a medication error between the medications.

**Keywords**—*drugbank, drug interaction, IT solution, medication order*

## I. INTRODUCTION

Health services work hard to provide safe and high quality care, but sometimes people are inadvertently harmed. Unsafe health care has been recognized as a global challenge and much has been done to understand the causes, consequences and potential solutions.

Medications are the most frequent cause of adverse drug events (ADE). An adverse drug event is an injury resulting from medical intervention related to a drug. This includes medication errors, adverse drug reactions, allergic reactions, and overdoses. ADEs can happen anywhere: in hospitals, long-term care settings, and outpatient settings. Some ADEs are caused by errors called medication errors. Depending on the setting, about a third to half of ADEs are typically associated with medication errors. Based on the surveys, relevant reports announce that the frequency of medication errors is 5.3 per 100 medication orders, much higher than the ADE rate of 0.25 per 100 orders. Another recent report from 36 hospitals which evaluated the administration stage in particular showed that 19% of medication administrations contained an error [1].

The Health Authority Abu Dhabi (HAAD) [2] revealed that it has received 616 adverse reaction reports and 1102 medication error reports during 2016. Figure 1 shows the pharmacovigilance reports for the year 2016. According to statistics presented by HAADs Pharmacovigilance program for the period 2013-2015: antibiotics class of drugs was the greatest cause of adverse reactions, with a 47% prevalence rate; followed by 19% for anti-inflammatory medications; and, 5% each for painkillers and gastrointestinal drugs (See Figure 2).

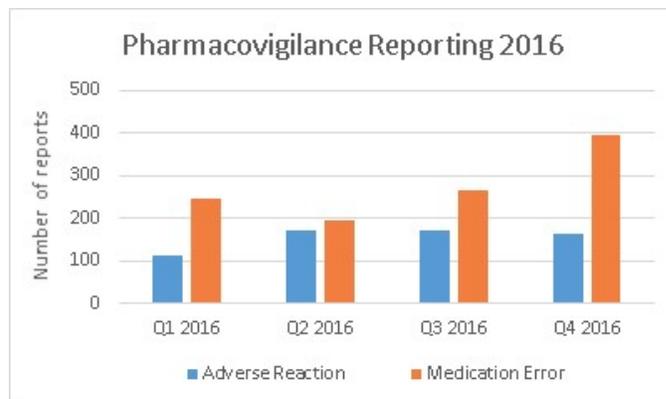


Fig. 1: Adverse Reactions and Medication Errors Reporting Trend for year 2016 [2].

Based on the reports, the main challenge in this domain is the ADE and the medication error. To avoid from having medication error, an IT solution is highly required. In this paper, a novel approach is proposed. A real-time checking mechanism based on the web service principles is proposed to prevent serious injuries even deaths. The proposed approach is performed on a training dataset containing medication orders (prescriptions) and after having concrete improvement on the medication error detection, a real-time interaction/error checking mechanism is implemented into the actual hospitals medication order management system (MOMS). The remainder of this paper is organized as follows: Related works are given in Section II. Section III presents an overview of our real-time medication order checking mechanism. Section IV gives a brief description of our experimental platform to implement our approach and describes the experiments we conducted. Finally, conclusions are presented in Section V.

## II. RELATED WORKS

A Drug-Drug Interaction (DDI) is defined as an alteration in a clinically meaningful way of the effect of a drug (object drug) as a result of administration of another drug (precipitant drug). A potential drug-drug interaction occurs when two drugs known are interacted for a patient, regardless of whether harm ensues [3]. Extracting drug-drug interaction information from text based databases like drug resources is a very popular and interesting research domain in computer science and also in the biomedical engineering

A number of studies have explored ways to improve the

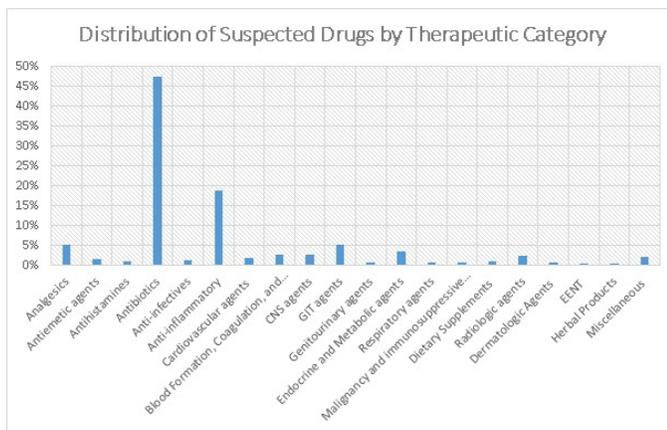


Fig. 2: Distribution of of Suspected Drugs by Therapeutic Category for 2013-2015 [2].

quality of prescribing in primary care. However, outcomes are heterogeneous and few studies have specifically focused on medication errors. Reducing medication errors and improving medication safety requires a systems approach [4].

From several proposed (computer based and non-computer based) approaches, randomized trials of computerized interventions found a reduction in medication errors in half of the studies. Computerized provider order entry (CPOE) with decision support may be effective if targeted at a limited number of potentially inappropriate medications and is designed to reduce the alert burden by focusing on clinically-relevant warnings [5]–[7].

Besides having several approaches to avoid, to reduce the medication errors, as mentioned in the annual report of World Health Organization, existing technological tools are not sufficient however, the adoption of electronic tools are critical to improving safety in many ways. Examples include the use of electronic health records for more accurate and complete patient records; timely and reliable sharing of health data; supporting the diagnosis, monitoring and management of diseases and conditions; effecting behavior change and reduction of health risk, and empowering and engaging patients and families in their own care. eHealth applications may reduce errors and improve coordination. It can reduce unnecessary consultations and hospitalizations and improve access to knowledge about health conditions and their management for both professionals and patients. However, to achieve their full potential, electronic tools need to be integrated with other parts of service delivery and adapted to the local context.

Since medication error is a crucial problem in health care services and may result with a serious injuries, there are many drug databases that can be used for detecting the interactions between the drugs written on the prescriptions. [8] presents a detail evaluation the DDI information in The National Drug File - Reference Terminology (NDF-RT) and DrugBank, besides, NDF-RT and DrugBank interactions against each other. Moreover, the paper gives more information about the DrugBank which presents the list of existing drugs in the health market and the clinic drug component for each drug. Besides National Institutes of Health, Department of Health Human

Services introduces the U.S. National Library of Medicine in which there are several useful APIs that can be used for detecting drug interactions. However, an IT solution is highly required to use this database and observe the interactions between the drugs.

Besides, in the literature there are many studies that try to explore the drug interactions by using static datasets. [9] proposes an extraction method to explore the drug-drug interaction from the biomedical literature and the paper uses a stacked generalization-based approach to achieve the detection. Similarly, [10] proposes using a shallow linguistic kernel in order to extract DDI. The paper introduces a novel extraction method: a basic information extraction (IE) techniques provides health care professionals to reduce time spent reviewing the literature for potential drug-drug interactions however the paper points that it does not exist an approach to the problem of extracting DDIs in biomedical texts. Moreover, the paper proposes that machine learning techniques (supervised) can be useful in biomedical domain. Besides the existing studies in the literature, we propose a web service based solution to avoid having drug-drug interactions and medication errors due to the doctors fault. Moreover, proposed approach analysis the drugs in real-time and warns the doctor immediately to avoid potential errors.

### III. WEB SERVICE BASED APPROACH

In this paper, our goal is to generate a mechanism, a sort of a warning system for the health care services especially for health care staff such as doctors. Since we are in a high technology era, in most of the health care organizations, medication orders are registered over an IT system (called medication order management system), a real-time checking and warning mechanism can be integrated into the actual MOMS.

RxNorm, produced by National Library of Medicine (NLM) in US, is a catalog of the standard names given to clinical drugs and drug delivery devices and a tool for supporting semantic interoperability between drug terminologies and pharmacy knowledge base systems [11]. It provides normalized names for clinical drugs and links its names to many of the drug vocabularies commonly used in pharmacy management and drug interaction software, including those of First Databank, Micromedex, MediSpan, Gold Standard Drug Database, and Multum [12]. By providing links between these vocabularies, RxNorm can mediate messages between systems which are not currently using the same software and vocabulary

The standard names of RxNorm for clinical drugs are related to the different drug names found in many controlled vocabularies in the Metathesaurus Unified Medical Language System (UMLS), including those of commercially available drug information sources. These connections are intended to facilitate interoperability between computerized systems that record or process clinical drug data. Like other vocabularies in the Metathesaurus, RxNorm is organized by concept or meaning. All RxNorm concepts are assigned to at least one semantic type of the Semantic Network. This provides a consistent categorization of all the concepts in RxNorm at the relatively general level represented in the semantic network.

The electronic prescription system used in our country is a prescription made by health professionals who have the power to prescribe in the electronic environment after the diagnosis they have posed to their patients. In order to establish a smart system, the person writing the prescription should be checked if the prescription drugs interact independently with each other. The determinants of this effect among the drugs are the parts of the active ingredient. No native web service is open to anyone to indicate the interactions between these essential parts of the drugs. Being a domestic service because of the system used in Turkey is important. However, based on DrugBank, the largest database of drugs, the study was created by the US National Library of Medicine and it returns the results we require. The project is intended to benefit from this service. The problem we have is that the `RxNorm` API takes the input of the `RxCui` code and gives the drug interaction. Electronic prescription system in Turkey uses the anatomical therapeutic chemical (ATC) code. By performing a similarity analysis between the datasets with the target ATC codes, the name of the drug and the name of the active substance, etc., for the scope of the project, and the datasets containing the `RxCui` codes obtained by the functions of the `RxNorm` API. It aims to convert ATC codes into `RxCui` codes.

#### IV. EXPERIMENTAL SETUP AND DATASET

In the literature, there are many studies targeting medication error to prevent drug interactions. Thus, many health care organizations publish drug bank databases publicly. For instance, [?]. combines all the publicly available sources of PDDI information using a common data model after conducting a comprehensive and broad search. The merged dataset consists of the synthesis of 14 different sources including 5 sources obtained from clinically-oriented information sources, 4 sources from Natural Language Processing Corpora, and 5 sources from Bioinformatics/Pharmacovigilance information sources.

In this study, as a reference, we use U.S. National Library of Medicine of National Institutes of Health, Department of Health Human Services and their APIs for detecting the drug interactions. The primary task in this study is to find the relevant `RxNorm` and the `RxCui` in order to use the proposed API and to detect the potential drug interactions. `RxNorm`, a standard nomenclature for clinical drugs, is produced by the National Library of Medicine. In this context, a clinical drug is a given pharmaceutical product (or taken) by a patient with a therapeutic or diagnostic intent. In `RxNorm`, the name of a clinical drug combines its ingredients, strengths and form. In `RxNorm`, form is the physical form in which the drug is administered or is specified to be administered in a prescription or order. The name of the clinical drug `RxNorm` does not indicate the form in which the product was manufactured or its shape upon arrival at the clinic. With few exceptions (for packaging), the name of the clinical drug `RxNorm` does not indicate the size of a set of drug units.

##### A. Database Structure

As a training dataset we have all the medication orders written in a local hospital in Istanbul/Turkey for the years 2015 and 2016. This dataset contains 16 million medication orders and each medication order may have multiple medications. At

total we have in this dataset 37 million medications. Our aim in this study is to analyze these 16 millions of medication orders and if there are multiple medications and detect if there exists a medication error, a drug interaction between these drugs. Detection of DDI will be realized via the `RxNorm` and `RxCui` API provided by the US National Library of Medicine.

Once our IT based solution works with the training dataset (analyzed all the existing medication orders and detect if there is a DDI or not), a web service can be launched to realize this detection mechanism in real-time (while the doctor is writing the medication order by using the `MOMS`).

Since the system used in Turkey is different from the international ones, firstly a database should be constructed with the existing medication orders and the drugs for each medication order.

Afterwards, to be able to use the existing API, the drug substance (active ingredient of that drug) should be known and as mentioned in the previous section, each drug substance has an unique code (universal ID). Since turkish drug system mechanism has its own identification system, they use ATC codes to differentiate the drugs. Thus, for each drug, we should do a mapping from ATC system to `RxCui` system before using the existing API.

#### V. CONCLUSION

In this paper, we point one of the crucial health care problem: adverse drug events. To prevent from medication errors and to improve the quality of health care service, we propose a real-time web service based solution by examining the dataset filled with medication orders. To detect the drug-drug interactions within the prescriptions, each medication order is analyzed. With this real time checking ADE mechanism, doctors are warned in case there is a possible ADE or a medication error between the medications. As a dataset, we analyzed 7046207 prescriptions and our web service based drug-drug interaction system detected 1881080 interactions including high and low warning detection (26.6% DDI ratio).

#### ACKNOWLEDGEMENT

This work is supported by Galatasaray University Research Foundation under the Grant No. 18.401.005.

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