Estimation of Asthma Severity from Electronic Prescription Records using British Thoracic Society and Scottish Intercollegiate Guidelines Network Treatment Steps

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Abstract

Asthma is a common chronic lung disease. National guidelines encourage a stepwise approach to pharmacotherapy, and as such, an individual's current treatment step can be considered as a severity categorization proxy. BTS/SIGN steps can be estimated from electronic prescription records, however substantial data processing is required including extracting information from free-text drug descriptions and dose instructions.

Almost 4.5 million asthma controller inhalers were prescribed for people in the Asthma Learning Health System (ALHS) Scottish cohort between 2009 and 2017. Asthma treatment regimens were identified and categorized by the combination of medications prescribed in the 120 days preceding prescribing events.

26% of prescriptions had no primary controller (inhaled corticosteroid) prescriptions in the previous 120 days and were thus assigned Step 0. 16% of prescriptions were assigned to BTS/SIGN Step 1, 7% to Step 2, 21% to Step 3, and 30% to Step 4.

We developed a robust methodology enabling researchers to easily replicate BTS/SIGN asthma treatment step estimates, to both describe the severity of asthma in a population and to demonstrate changes over time. This can provide valuable insights into population and patient-specific trajectories, to improve understanding and management of symptoms.

Keywords—asthma, treatment, severity, prescribing, electronic health records

I. Introduction

Asthma is a chronic long-term lung disease characterized by inflammation of the airways and sensitivity of the nerve endings in the airways so they become easily irritated (known as hyper-responsiveness) [1]. Asthma treatment progression is typically considered a linear process, progressively recommending more advanced treatments (known as a step up) if adequate control is not reached at a previous step. Asthma severity can be dictated by the minimum treatment required to achieve control at a specific time [2]–[4].

Electronic Health Records (EHRs) can be used in pragmatic observational and intervention studies of asthma. National guidelines produced by the British Thoracic Society (BTS) and the Scottish Intercollegiate Guidelines Network (SIGN) encourage a stepwise approach to pharmacotherapy, and as such, an individual's current treatment step can be considered as a severity categorization proxy. The aim of this study was to introduce a robust methodology towards deriving asthma severity by identifying asthma prescribed medications, conducting free-text analysis on practitioners' clinical records, and operationalizing the BTS/SIGN steps from extracted data.

II. Methods

A. Data

The Asthma Learning Healthcare System (ALHS) dataset was created to develop and validate a prototype *learning healthcare system* for asthma patients in Scotland, in which patient data are used to generate a continuous loop of knowledge-generation, evidence based clinical practice change, and change assessment/validation [5]. Over half a million patients from 75 general practices in Scotland were recruited [6].

B. Asthma Prescription Processing

As corticosteroids are also used in other dosages and formulations for conditions such as rhinitis [7] and Crohn's disease [8], Inhaled Corticosteroids (ICS) or combination ICS and Long-Acting Beta-2 Agonist (ICS+LABA) medications with spray, drop, foam enema, rectal suppository, or cream formulations were excluded.

The BTS/SIGN treatment steps are a categorization based on the type and dosage of medications a person has been prescribed. The daily medication usage was estimated based on the number of daily dose times (e.g. *twice daily*), the number of puffs per dose (*e.g. two puffs*), and the strength of each puff (e.g. *100mcg*), extracted from the dose directions and full medication name.

C. British Thoracic Society Treatment Steps

The 2019 BTS/SIGN Guidelines [9] present a single value for each level of dosage: low, medium, or high. These values were converted into ranges, using the recommended values for low- and medium-dose as the upper boundary of each category, and four times the medium-dose category as the upper limit of the high-dose category.

Treatment step was calculated on any day on which an individual had a prescription for at least one asthma medication (a *prescription day)*, based on any

medications which had been prescribed in the last 120 days. A run-in period of 120 days (January 31st to June 1st, 2009) allowed refills of different medications to be accumulated for the first regimen estimate in the study period. The 2019 BTS/SIGN guidelines recommended treating everyone with a minimum of as-needed low dose ICS (Step 1), and thus we have categorized regimens without any ICS component as being at treatment Step 0, as shown in the decision tree in **Error! Reference source not found.**.

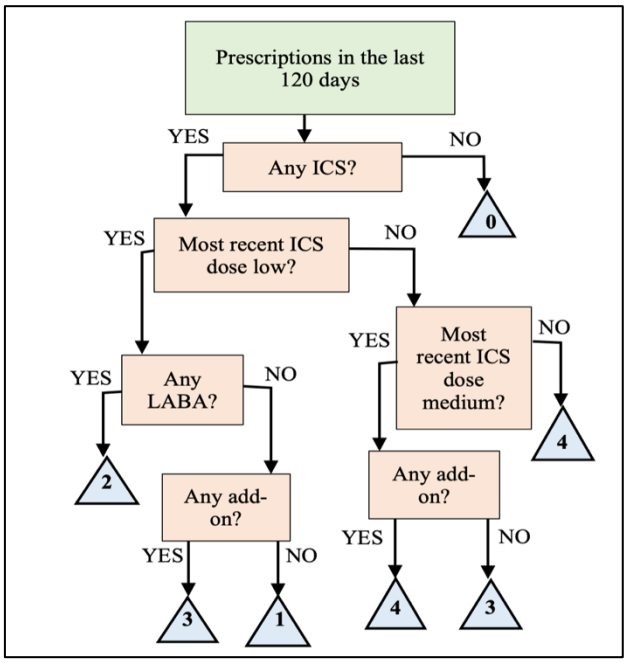

Fig. 1. Decision tree demonstrating the implementation of the BTS/SIGN treatment steps

III. Results

There were 110 unique regimens observed, and 19% of prescription events corresponded to the regimen high-dose ICS+LABA (either standalone or combination inhalers). There were 2,772,818 prescription events, each with one final BTS/SIGN Step assigned based on the prescriptions written in the preceding 120 days. 26% of prescription events were for non-ICS prescriptions with no ICS prescriptions in the previous 120 days and were thus assigned Step 0. Of these, 69% had only been prescribed only short-acting reliever inhalers for the last 120 days. 16% of prescription events were Step 1, 7% were Step 2, 21% were Step 3, and 30% were Step 4.

IV. Discussion

A. Results in Context

Previous studies which have categorized individuals according to their BTS/SIGN steps have interpreted and implemented the guidelines in different ways, and indeed the guidelines have also been updated over time making direct comparisons challenging.

The use of a grace period (the look-back window for prescriptions prior to the current one to classify the treatment regimen) allows prescriptions for different components to be collected on different dates without the treatment step being incorrectly estimated. The use of a 120-day period facilitates rapid detection of regimen changes, which can be used to evaluate rates of clinical outcomes by treatment step, unlike the year-long observation period used in such studies as Bloom *et al*. [10]. The grace period is also long enough, however, to capture reasonable as-needed ICS use, which is encouraged at Step 1 of the 2019 guidelines [9]. Most ICS are prescribed in 30-day supplies [11], [12], and thus up to 25% usage would still be captured as continuation.

B. Limitations and Future Work

Data extraction from the free-text fields of the drug description and instruction was handled using easy to implement approaches: the guiding principle was to develop something which should be straightforward to operationalize. Future work could integrate more advanced Natural Language Processing techniques to investigate this aspect further.

C. Conclusion

The novel robust methodology presented herein enable researchers to easily replicate BTS/SIGN asthma treatment steps, which can be used both to describe the severity of asthma in a population, and to demonstrate changes over time.

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