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Real-World Applications of Artificial Intelligence to Improve Medication Management Across the Care Continuum

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Abstract

Discussions about the application of artificial intelligence (AI) in healthcare often span multiple areas, most commonly about making more accurate diagnoses, identifying at-risk populations, and better understanding how individual patients will respond to medicines and treatment protocols.

To date, there has been relatively little discussion about practical applications of AI to improve medication management across the care continuum, an area this article will address.

Keywords: Artificial Intelligence, Healthcare, drug delivery system.

The Significance of Medications

What's the first thing that comes to mind when someone mentions prescription drugs in the United States? In poll after poll, the high and rising costs of medications are American voters' top healthcare-related issue.1

This concern is well founded. The U.S. spends almost $400 billion a year on medications--$325 billion on a retail basis and about $75 billion for inpatient and outpatient use.2, 3, 4

To put the $400 billion in perspective, it is equal to about 11% of total U.S. healthcare expenditures, and it's one of the top reasons why the U.S. spends much more on healthcare than other industrialized countries.

Medication Management Shortcomings

Unfortunately, there are a lot of issues with the medication management system, broadly defined.

It's estimated that 20-30% of prescriptions are not even filled, not even picked up at the retail pharmacy.5 Each year, adverse drug events result in 1.3 million visits to the emergency department, and of those ED visits, over a fourth, 350,000, result in hospitalizations, which result in significant costs.6

Over the past 50 years, much legislation has been passed to regulate and reform the U.S. healthcare system, and this has significantly increased the administrative burden on healthcare provider organizations. As a result, the number of administrators has grown by 3,200% since 1970, while over the same period, the number of physicians has been relatively flat, in line with population growth.7 It is estimated that the average physician and/or his or her staff spends 785 hours per year on quality reporting.8

The administrative burden also falls heavily on pharmacists. According to a national survey by the American Society of Health-System Pharmacists (ASHP), pharmacists spend over three-fourths of their time on non-clinical activities—mostly manual, administrative processes.9

In spite of the massive amount of spending on medications, the medication management system is fraught with errors at multiple steps in the medication-use process, prescriptions are often not filled, and over one-fourth of all hospital readmissions are potentially preventable and medication related.10

The Autonomous Pharmacy

Visual observation

Recognizing both the need to significantly improve medication management and the potential impact of advanced technologies, a group of pharmacy leaders from several leading hospitals and health systems from across the U.S. have formed an organization, the Autonomous Pharmacy Advisory Board. This group's mission is to transform the pharmacy care delivery model thru the application of technology—automation, robotics, data analytics, machine learning and AI.

The advisory board's vision is the realization of what it calls a fully autonomous pharmacy, which will apply automation, such as robots, and intelligence to the different areas of medication management to improve operational and clinical outcomes, ensure regulatory compliance, and advance population health.

Real-World Use Cases

Drug Shortages

What is a drug shortage? The U.S. Food and Drug Administration has a simple, basic-economics definition: when demand for a drug is greater than the supply of that drug.11 ASHP's definition has a higher bar. It says a shortage must be verified by the drug manufacturer, and it must impact pharmacy operations or patient care.12

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According to Erin Fox of the University of Utah Drug Information Service, arguably the foremost expert on drug shortages in the U.S., the average number of new drug shortages has been increasing for the past 15 years.13

As indicated by ASHP's definition, drug shortages adversely impact both pharmacy operations and patient care. Operationally, there are hard-dollar costs for buying more expensive substitutes, and there are numerous soft-dollar labor costs for investigation, developing remediation plans, managing pharmacy automation systems, and changing the electronic medical record (EMR).

In addition, there are patient safety issues. Patient treatment can be delayed if suitable alternative product cannot be obtained, and medication errors can occur as healthcare workers diverge from standard protocols.

So how can data science help with drug shortages? Machine learning is being applied to drug shortages in two ways. First is proactive identification of drugs at risk of shortage. Using various factors, shortage risk scores for individual drugs can be generated. Equipped with a list of drugs at risk of shortage, hospitals can first shift stock between departments and facilities. Second, machine learning is being used to help deal with a drug shortage while it is occurring. Algorithms identify therapeutic alternatives, either substitute drugs or different delivery methods. Currently, this is a heavily manual, reactive process requiring informaticists; in the future, this prescriptive guidance will be automatically integrated in the EMR and electronic prescribing system.

The Opioid Crisis

The U.S. Centers for Disease Control and Prevention estimates that more than 67,000 Americans died of drug overdoses in 2018, and almost 70% of these involved opioids.14 The President's Council of Economic Advisors estimated in 2015 that the opioid crisis cost the U.S. over $500 billion, almost 3% of the nation's gross domestic product.15 What kind of data-oriented approaches can help deal with the opioid crisis?

As a start, the National Association of Boards of Pharmacy (NABP) and Appriss Health, a company based in Louisville, Ky., have done work in the areas of data collection and data sharing. Each state has what's called a prescription drug monitoring program (PDMP), an electronic database that tracks controlled substance prescriptions. NABP and Appriss have developed a solution called PMP Gateway to facilitate PDMP data sharing within electronic health records (EHRs), retail pharmacy management systems, and health information exchanges (HIEs).

Using the data, Appriss has a robust analytics tool and care management platform called NarxCare which automatically analyzes PDMP data and a patient's health history. It generates patient risk scores and an interactive visualization of usage patterns to help identify potential risks of drug misuse or abuse.

With the patient risk scores, both prescribers and dispensers can provide the patient with access to needed drug addiction treatment, patient education, and appropriate care coordination.

Drug Diversion

Drug diversion refers to healthcare workers stealing medications meant for patients. It is a significant problem that is getting worse. Protenus, a Baltimore, Md.-based software company, estimates that 47.2 million doses of drugs were diverted in 2018, up 126% from the prior year, and the vast majority of diverted drugs were opioids.16

Who's stealing these drugs? It is overwhelmingly people with the most access to them. It is estimated that 15% of pharmacists, 10% of nurses, and 8% of physicians struggle with alcohol and/or drug dependency,17 and as many as 10% of clinicians in general are involved in diverting medications.18

Moreover, there is a direct connection between drug diversion and the opioid crisis. U.S. Attorney John Huber of Utah explained. "Under the law, healthcare networks… have a responsibility to ensure that controlled substances are used for patient care and are not diverted for non-medical purposes. Diversion of these drugs feeds addiction, contributes to potential illicit drug sales, and fuels the opioid epidemic."19

There are many healthcare IT vendors that are endeavoring to prevent drug diversion. They all rely on tapping data sources: automated medication dispensing cabinets, EMRs, time and attendance systems, and building security systems. These systems have information about the medications inventoried, dispensed and administered in healthcare facilities, as well as information about healthcare worker behaviors.

These data sources often provide detailed information about the dispensing, administration, wasting and return of drugs, as well as the actions and movements of healthcare workers who have access to them.

With such data, pharmacy and compliance departments, as well as drug diversion solution vendors, can find clues that may indicate drug diversion activity. This general approach is used in two ways to combat drug diversion: for diversion monitoring and detection—catching people stealing drugs; and for diversion prevention, by assigning individual risk identification scores and educating, monitoring and counseling the highest-risk individuals.

Medication Adherence

Former U.S. Surgeon General C. Everett Koop famously said, "Drugs don't work in patients who don't take them."

Medication non-adherence is a huge problem. A majority of Americans who have been prescribed medications are non-adherent, and this behavior results in emergency department visits, accounts for a tenth of all hospital admissions, and causes 125,000 deaths per year, as well as an economic cost to American society of nearly $300 billion.20

As with drug diversion, there are several healthcare IT vendors working to address the problem of medication non-adherence, using different combinations of health insurance claims, EHR, census, and social determinants of health data.

After applying algorithms and rules to the data, various risk stratification outputs are generated, identifying:

- Individuals who are at high risk or emerging risk of non-adherence;
- Individuals who would likely respond well to interventions; and
- Individuals for which there would be a positive return on investment on the interventions.

These risk stratifications aim to allocate intervention resources most effectively, get patients to pick up their prescriptions and take their medications, and, as a result, avoid unnecessary utilization and cost.

Using longitudinal outcomes data—primarily EHR and claims data—enables assessment of the effectiveness of the risk-stratification and predictive models. It also allows for refining the rules and algorithms, a difficult, yet critical, step. Loopback Analytics, a software company in Dallas, Texas, refers to this as "rapid cycle learning in support of continuous improvement."21

AI and ML also are used address medication non-adherence by figuring out what are the optimal interventions to carry out for a very specific cohort or subpopulation. Jvion, a company based in a suburb of Atlanta, Ga., takes member populations of millions of people and divides them up into relatively small cohorts.

These cohorts can be defined by multiple characteristics, such as gender, age, race or ethnicity, caregiver availability, socioeconomic status, medical conditions, number and type of medications, access to retail pharmacies, etc.

For each cohort, the AI engine generates a rank-ordered list of prescribed interventions that are proven to be most effective in driving medication adherence.

These interventions can be carried out in the hospital as part of discharge planning, through various medication adherence activities—such as medication reconciliation, medication synchronization, medication therapy management, and patient messaging—through care coordination, outreach, and patient education.

Conclusion

TThe medication management system in the United States suffers from shortages, opioid abuse, diversion, and non-adherence. All of these problems are currently being addressed by various healthcare IT vendors. They are using data, applying AI, machine learning, and other advanced technologies, and refining their algorithms and models by measuring and analyzing outcomes—the real test of value. The ultimate vision is the achievement of the fully autonomous pharmacy, a smarter, more efficient, less error-prone, and more insightful medication management system.

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