Modeling Health Policy with Digital Humans

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ABSTRACT

The healthcare system is the foremost human system responsible for preventing human casualty. Most of the health research and development is focused on basic science, drug development, optimizing patient experience, and electronic healthcare systems. There is less research focused on the systemic interaction of multiple entities involved in patient care. In this early research paper, we model the relationships between Payers, Providers and Patient entities and examine the effects of policy changes on these entities and their relationships.

Keywords

Healthcare, Policy, Reference Architecture, Digital Human

INTRODUCTION

In most of the world, the healthcare system is no longer epitomized by the patient-doctor relationship, dedicated to the diagnoses and treatment of disease for a nominal payment of service. Instead, it involves state of art hospitals, complicated insurance contracts and highly specialized care providers. As the complexity of the healthcare system has increased, costs have increased (now nearly 1/5th of U.S. GDP)[1], patient access has decreased (primary care doctors are leaving medicine)[2], and patient outcomes have decreased (three consecutive years of life expectancy decreases in the U.S.)[3]. Along with the problems resulting from the complexity of this system there are an increasing number of proposed solutions such as alternative payment models (which includes outcome based payments, for example), and proposed initiatives such as reducing physician burden. But how can these complex solutions be evaluated or even studied in their entirety? For example in United States, how can we evaluate Accountable Care Organizations (ACO) and Value Based Care (VBC) as an alternative for Fee-for-Service (FFS). These solutions are policy-based idealistic implementations that are complex systems themselves. Evaluating these systems, involve real people and their health, and require long time periods to evaluate whether or not they are successful [4,5]. The comprehensive evaluation and testing of proposed solutions, without the real-world implementation costs and time, is essential to save money and improve health.

In complex engineering problems, modeling and simulation are established tools to evaluate proposed solutions. Fortunately, there is a long history of modeling and simulation in healthcare. Prior work in this area has focused on various levels of abstraction, from the cellular, human, hospital, city, or nation. They also focus on various domains from modeling biologic processes [6], optimizing workflow and patient throughput [7,8,9,10,11], modeling the insurance sector [12,13], patient history [14], and health policy. It is this last area, health policy that interests us here.

MODELING HEATH CARE POLICY

One ongoing issue with trying to predict the effects of health policy on patient outcomes, access, and cost is the unpredictability of human behavior. It is extremely difficult (perhaps impossible) to predict how humans will respond to new health policies, whether they are patients, family-members, clinicians, hospital executives, insurance adjusters, etc. Even if reasonable predictions could be forecasted in the short-term, the cone of uncertainty around those predictions must widen significantly the further out in time one attempts to make a prediction.

We propose that an alternative to trying to predict human behavior is to predict a quantitative effect of a policy on the relationships between entities. For example, instead of predicting how a patient will respond to an increase in an insurance copayment accompanied by a decrease in monthly rates, we might aim to predict the impact of that policy on the relationship between the insurance company and the patient -- will the health of the relationship increase, or will it become toxic? In other words, is it possible to develop a predictable index with a range from healthy to toxic, quantifying the relationship between patient and payer? What role does the provider play in this policy change? How are the provider-patient and provider-payer relationships affected by the increase in copay? Figure 1 is a simplified representation of the relationships between patients, payers, and providers, as well as the notional effects of policy.

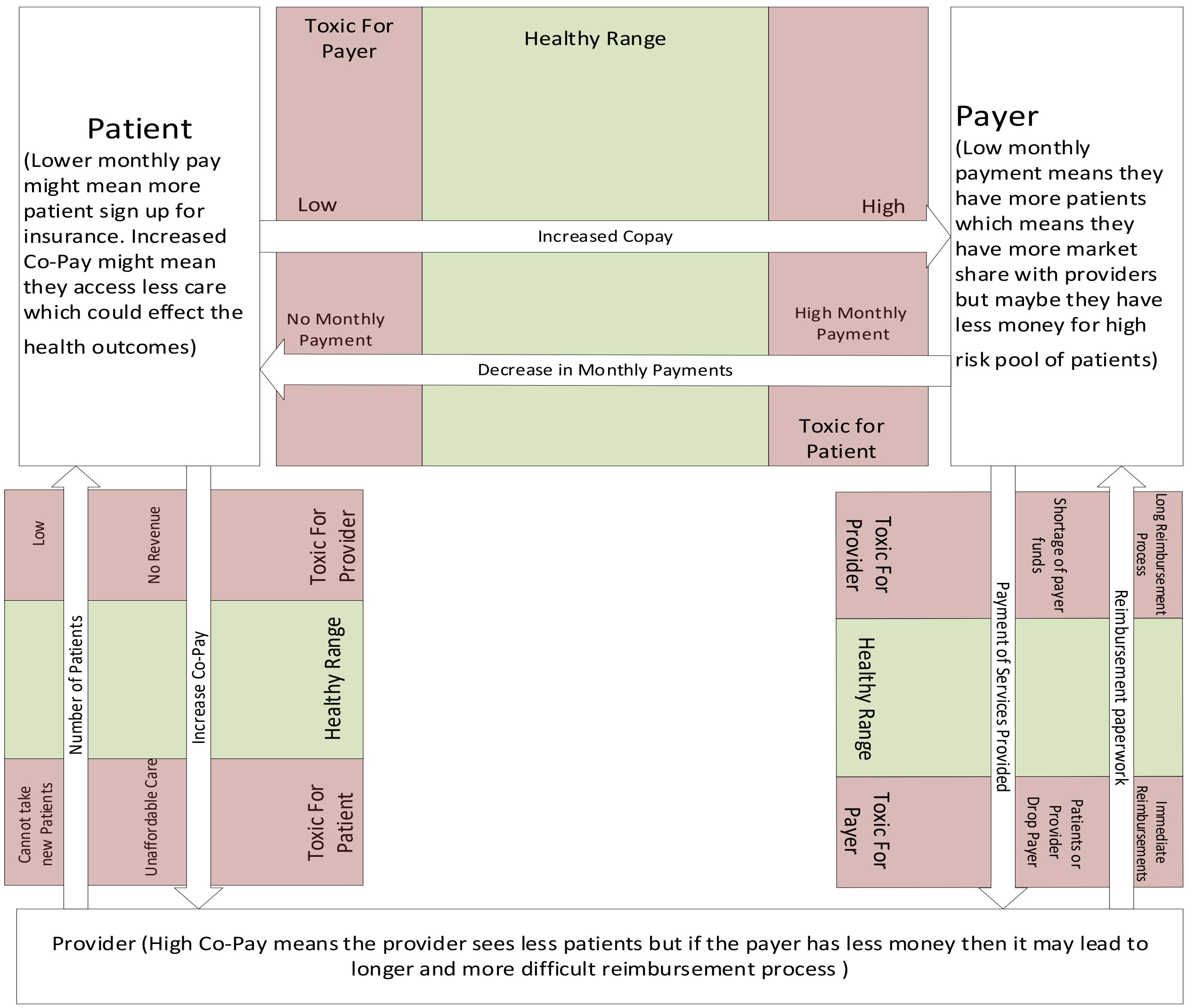

Figure 1: Policy Model for an Increase in Copayment

The three corner boxes (top left, top right, bottom) represent the three main players in the healthcare system, the patient, payer (insurance companies, government entities etc) and provider (doctor, hospital, medical device companies etc). The arrows between these players model the relationships between these entities. The scenario modeled is a hypothetical scenario based on the commonly occurring events experienced by most Americans for illustration purposes and is not based on evidence.

As illustrated, the patient-payer relationship is toxic for the patient if the copayments and monthly payments are both high. Conversely, the relationship is toxic for the payer, if there are no monthly payments and low copayments. From the patient-provider perspective, the policy may be toxic for the patient if the provider is not taking any new patients (perhaps because there has been an increase in the number of patients due to low copayments) or the care may be unaffordable if the copayment is very high. This policy may be toxic for the payer if they lose patients (e.g. if the copayment is too high) or providers (e.g. the reimbursement time is too long given the low copayment) or other problems emerge such as low cash reserves (for either the payer or provider depending on the reimbursements). Each dyad in this policy model represents a toxicity range (at each extreme) with a simplistic healthy medium. The healthy and toxic range for each relationship may be a function of the economic, demographic, geographic and disease specific conditions.

In order to more fully understand these healthy and toxic ranges we need representative healthcare metrics and supporting data. The goal is not to quantify these ranges for one scenario, but to build a digital architecture that would support modeling and analysis of multiple scenarios within a diverse healthcare system.

The first step towards modeling is to select a modeling environment that supports the complexity and diversity of healthcare systems. The modeling environment should be able to support healthcare data, relationship data, census data, as well as geographic, economic, and policy parameters, among other things. Some factual data are readily accessible such as geographic census data, but other information such as healthcare records are not readily available and hence, we require either data sets, or suitable statistics sufficient to proxy access to that data. This healthcare record data includes data about Patients (census demographics), Disease Progression and Treatment data (or models), Providers (healthcare organizations, individual clinicians with their specialties), Payers (insurance companies, insurance policies, payment models), Prices (reimbursement rates, charge masters), and Relationships (which providers are in/out of network for which payers, which patients see which clinicians, what insurance coverage does each patient have). Once all of the above are modeled or mined, we can start the process of analyzing and defining healthy ranges for policies.

Prior Health Care Modeling

There is a long history of modeling and simulation in healthcare. Simulation techniques range from microsimulation, system dynamics, econometrics, agent-based models, to discrete event simulations.[7,8] Domain focus has ranged from patient access[9], hospital modeling[10], patient flow[11], patient outcomes[12], insurance[14], fraud[13], and payment models[12].

Rather than a specific use-case (e.g. patient flow), we would like to model the entire healthcare system to include patients, providers, and payers, from the individual level to the organizational level and system levels. In this research we proposed to expand the open-source Synthea [15] simulation which models synthetic patients, to include the either an individual toxicity metric (how toxic is the healthcare system with respect to each patient or provider or payer), or how policies might affect patients individually or in aggregate.

Synthea

Synthea is an open-source, synthetic patient generator that models the disease progression and treatment of synthetic patients. But Synthea also models access to care, health outcomes, and financial metrics. For access to care, Synthea models healthcare facilities and utilization, recording each visit and the associated activities. For health outcomes, Synthea calculates Quality Adjusted Life Years (QALYs) and Disability Adjusted Life Years (DALYs) for each year of each patient's life. For financial metrics, Synthea models claims, insurance, and costs (which are configurable). Synthea has been previously described in the literature [15]. Synthea data sets are publicly available and the software is available under the Apache 2.0 open-source license [16]. Synthea will help model and quantify the relationship toxicity based on the breath of healthcare information available in the system.

SUMMARY

The synthetic health record digitizes the healthcare records simulating an important human experience. The desire to optimize health likely depends on healthy relationships between payers, providers, and patients. The complexities potentially arising in the system from something like monthly premiums and copayments, is just one example.

Metrics are a means to understand the complexity in the system, in this case the relationship toxicity can be a metric that indicates what is a healthy situation and what is not. Metrics need to be unbiased, responsive to change and accurate indicators of what they are measuring. In our case the toxicity metrics might be a ratio such as service complexity versus cost or treatment received versus treatment reported, that likely need to be balanced for a healthy relationships. In a sense we are exploring developing a healthcare health/toxicity dashboard that is responsive to policy changes and representative of the diversity existing in the healthcare realm.

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REFERENCES

1. National Healthcare Expenditure Data. Centers for Medicare and Medicaid Services (CMS). 2018. https://www.cms.gov/research-statistics-data-and-systems/statistics-trends-and-reports/nationalhealthexpenddata/nationalhealthaccountshistorical.html
2. "1 in 3 Physicians Plans to Quit within 10 Years", NEJM Career Center. 2012. https://www.nejmcareercenter.org/minisites/rpt/1-in-3-physicians-plans-to-quit-within-10-years/
3. Solly, Meilan. U.S. Life Expectancy Drops for Third Year in a Row, Reflecting Rising Drug Overdoses, Suicides. Smithsonian Magazine. December 2018. https://www.smithsonianmag.com/smart-news/us-life-expectancy-drops-third-year-row-reflecting-rising-drug-overdose-suicide-rates-180970942/#wCOQgR8xHglQ1ugt.99
4. David Fone, Sandra Hollinghurst, Mark Temple, Alison Round, Nathan Lester, Alison Weightman, Katherine Roberts, Edward Coyle, Gwyn Bevan, Stephen Palmer; Systematic review of the use and value of computer simulation modelling in population health and health care delivery, Journal of Public Health, Volume 25, Issue 4, 1 December 2003, Pages 325–335,
5. Elliott S. Fisher, Stephen M. Shortell, Sara A. Kreindler, Aricca D. Van Citters, and Bridget K. Larson. A Framework For Evaluating The Formation,

Implementation, And Performance Of Accountable Care Organizations Health Affairs 2012 31:11, 2368-2378

6. Deborah A. Marshall,Lina Burgos-Liz,Maarten J. IJzerman,Nathaniel D. Osgood,William V. Padula,Mitchell K. Higashi,Peter K. Wong,Kalyan S. Pasupathy,William Crown. Applying Dynamic Simulation Modeling Methods in Health Care Delivery Research—The SIMULATE Checklist: Report of the ISPOR Simulation Modeling Emerging Good Practices Task Force. Value in Health. Elsevier. 2015. https://doi.org/10.1016/j.jval.2014.12.001
7. Alvarado, Michelle; Lawley, Mark; Li, Yan. HEALTHCARE SIMULATION TUTORIAL: METHODS, CHALLENGES, AND OPPORTUNITIES. Proceedings of the 2016 Winter Simulation Conference. TMK Roeder, PI Frazer, R Szechtman, E Zhou, T Huschka, SE Chick, eds.
8. Balasubramanian, Hari; Banerjee, Ritesh; Gregg, Melissa; Denton, Brian T. IMPROVING PRIMARY CARE ACCESS USING SIMULATION OPTIMIZATION. Proceedings of the 2007 Winter Simulation Conference. S. G. Henderson, B. Biller, M.-H. Hsieh, J. Shortle, J. D. Tew, and R. R. Barton, eds.
9. Brent R. Asplin; David J. Magid; Karin V. Rhodes; Leif I. Solberg; Nicole Lurie; Carlos A. Camargo, Jr. A Conceptual Model of Emergency Department Crowding. Ann Emerg Med. 2003;42:173-180.
10. Bhattacharjee, Papiya; Ray, Pradip Kumar. Patient flow modelling and performance analysis of healthcare delivery processes in hospitals: A review and reflections. Computers & Industrial Engineering 78 (2014) 299–312
11. Stern M, Williams K, Eddy D, Kahn R. Validation of prediction of diabetes by the Archimedes model and comparison with other predicting models. Diabetes Care. 2008;31(8):1670-1.
12. Congressional Budget Office. CBO’s Health Insurance Simulation Model: A Technical Description (October 2007).
13. Parente, Stephen and Fortel Analytics LLC, 2012, “Assessment of Predictive Modeling for Identifying Fraud within the Medicare Program”, Health Management, Policy and Innovation, 1 (2):8-37
14. White, Chapin, et al. The RAND Health Care Payment and Delivery Simulation Model (PADSIM): Concepts, Methods, and Examples. RAND Corporation, 2016.
15. [Synthea-JAMIA] Walonoski, J., Kramer, M., Nichols, J., Quina, A., Moesel, C., Hall, D., Duffett, C., Dube, K., Gallagher, T., McLachlan, S., 2018. Synthea: An approach, method, and software mechanism for generating synthetic patients and the synthetic electronic health care record. Journal of the American Medical Informatics Association 25, 230–238. https://doi.org/10.1093/jamia/ocx079
16. [Synthea-github] Synthea Source Code. GitHub. https://github.com/synthetichealth/synthea