Proceedings of the 2013 Winter Simulation Conference
R. Pasupathy, S.-H. Kim, A. Tolk, R. Hill, and M. E. Kuhl, eds

A SYSTEMS DYNAMICS APPROACH TO SUPPORT PROSPECTIVE PLANNING OF INTERVENTIONS TO IMPROVE CHRONIC KIDNEY DISEASE CARE

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ABSTRACT

Chronic kidney disease (CKD) is a growing health problem in the United States. Patients with CKD have had critical care gaps that have perhaps led to a more rapid progression of CKD toward end stage renal disease. To improve CKD outcomes, an interdisciplinary project has been initiated. This article describes how system dynamics supported the planning of the project. We developed a causal loop diagram through discussions with a panel advisory group and health providers. The model is particularly effective because it can demonstrate the interrelationships among patients, providers, and policies, and predict the effects of the interventions. This preliminary work may overcome the common linear approaches to care and helped design sustainable interventions through an understanding of system complexities. Future work on the project will develop a stock-flow diagram with empirical data to support the effective implementation of proposed interventions.

1 INTRODUCTION

CKD is a costly health problem in the United States, with increasing incidence and prevalence. More than 20 million U.S. adults have CKD with over $32 billion spent annually to treat end stage renal disease (ESRD). Poor education as well as inconsistent treatment practices have aggravated the problem. Limited understanding – of both patients and their healthcare providers – about the severity of renal dysfunction contributes to the progression of disease and hampers the provision of optimal care for CKD. Additionally, variations in practice for CKD treatment worsen health outcomes of patients with CKD, decrease satisfaction of patients and care providers, and increase the burden of complications associated with CKD. The need to improve CKD outcomes motivated us to develop an interdisciplinary project that aims to design and implement a healthcare system and patient-centered intervention strategies that reduce CKD progression and the gaps in care for patients with CKD.

2 MODELING APPROACH AND PRELIMINARY RESULTS

Many studies indicate that approaches to healthcare delivery have largely been siloed. A systems thinking approach can overcome the limitations of the perspectives that look at relationships between variables in a linear fashion. For our project, systems dynamics was adopted to support prospective planning and analysis of system-level interventions. Conceptual and quantitative models built upon system dynamics can enhance our ability to understand dynamic interactions among patients, care providers, processes, and policies in the system.

We developed a causal loop diagram (CLD) to analyze the interconnected relationships among key variables and promote a high-level understanding of behaviors of a system in response to changes. The first step of the modeling was to articulate problems and define variables associated with the problems. A patient advisory group illuminated several challenges to the patient journey for those with CKD. Problems in a CKD care delivery were addressed by a group of experts, including physicians, public science researchers, and social workers. The discussions led to determining a scope of the project and designing interventions.

A high-level CLD including more than 50 variables and multiple-segments was developed in Vensim®. This modeling enabled the team to quickly understand the complexity of a system and validate hyhypotheses about the effectiveness of interventions. Figure 1 shows the model of one of the segments. It depicts how care managers can help slow the disease progression in patients with CKD from stage 3 to 4 through coaching. The policy on care manager roles (underlined in the diagram) determines the variable for the number of hours the care managers have available for coaching. If the available number of hours of coaching increases, more patients with CKD stage 3 can receive coaching on the guidelines from care mangers. Active education can encourage more patients to be engaged in self-management. Patients with improved knowledge and self-management will meet their goals, and they will remain in their current stage for a longer time. That is, the disease progression from stage 3 to 4 becomes slower. The reduced disease progression rate leaves more patients with CKD in stage 3 than there would otherwise have been. For all that, the reduced disease progression rate leaves fewer patients with CKD in stage 4 than would otherwise have been present. Therefore, Figure 1 indeed demonstrates how having more time care managers devote to coaching can help slow the disease progression rate from stage 3 to 4.

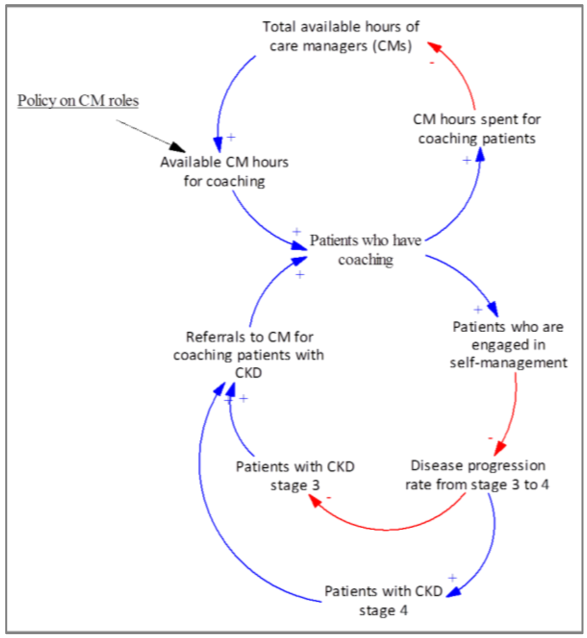

Figure 1. Segment 1 of the causal loop diagram

A stock flow diagram will be built upon the empirical data obtained from various sources. Using the model, we will be able to predict the long-term behaviors of the system that change over time by corresponding to interventions, and highlight areas of improvement. The system dynamics model will also play a significant role in supporting policy decision-making through what-if scenarios and sensitivity analysis.

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