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OPTIMIZING PUBLIC HEALTH SPENDING WITH A FOCUS ON HEALTH OUTCOMES USING SIMULATION

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ABSTRACT

Optimizing limited public health budgets to make the largest impact on health outcomes is a policy priority. For chronic disease, in particular, one avenue through which public health interventions make their effect is through improving individuals screening decisions. Public health programs such as educational campaigns and health care access improvement programs result in outcomes benefits by improving individuals screening decisions. We have identified several specific educational and access programs that would improve screening for colorectal cancer. We wish to optimize our spending on public health spending on these interventions over our population's lifespan and identify which intervention (or group of interventions) is the most cost effective for the population. In order to perform this optimization we needed to develop a set of tools and techniques. First, we utilize an individual simulation model of colorectal cancer progression to evaluate the effects of individuals' changed behavior. Secondly, we develop a generalized representation of how individuals make decisions probabilistically over time to provide a framework for representing changed decision making within the simulation model. Finally, we develop a technique that utilizes a generalized form of the logistic function for translating units of public health effort into changes in this representation of the probability of making screening decisions.

In any optimization procedure we must have a model that allows us to evaluate the effects of our policies. We utilize an individual simulation model of colorectal cancer progression and individuals' decision-making over time to evaluate public health policies. The individual simulation modeling approach allows us to account for heterogeneity in disease progression between individuals of different demographic groups and differing rates of disease progression over time as individuals age. The individual simulation modeling approach allows us to test dynamic polices in such a way that we can fully comprehend their effects, both at the person level and on aggregate.

Within our individual simulation model we need a representation of individuals' screening choices or "agency". We use a probabilistic representation of individuals' choice behavior whereby we represent the probability that they screen in every screening decision period. We use a baseline representation of individuals' behavior that is estimated using statistical models. Our intervention efforts change individuals' behavior compared to their baseline screening behavior.

The controls determined directly by the by public health planners, and hence the variables that will be characterized in an optimal policy, are which intervention to choose and how to allocate units of effort of that intervention over a populations' life course. There is need to translate these unit allocations of effort into the representation of individual choice described previously. We utilize a generalized form of the logistic function to describe how effort is translated into changes in the likelihood of testing at decision

points. The parameters of the logistic function can be meaningfully estimated from data. Additionally, the functional form of the logistic function exhibits characteristics that we would naturally expect such as increasing returns to scale for initial units of effort and decreasing returns to scale from substantial effort. All of these properties can be controlled by the parameters of the generalized logistic function. The translation of effort into probabilities is crucial in our methodology to evaluate solutions that are expressed in unit level of effort.

The policies that result from our optimization procedures yield valuable information to health policy planners. First, we are able to determine the most cost effective intervention policy. Early results have indicated that a mailed reminder type intervention is a cost-effective intervention. Within a given intervention we are also able to characterize the optimal distribution of spending over time. For our experiments with colorectal cancer screening interventions, results have indicated that focusing our efforts around age 60 is the most cost-effective. Additionally, our detailed representation of population demographics has enabled us to evaluate the value of targeting our interventions to specific subgroups. These techniques allow real model-based insights into the design of optimal health policy with regards to colorectal cancer screening promotion and can inform public health planners on how to spend their limited budgets.