1. Introduction

Between March 19 and April 7, various lockdown and social distancing measures were issued around the United States. Most of these restrictions were initially slated to last 30 days, after which the states reevaluated and decided on different paths forward. Since then, most states have begun some form of reopening process. While these policy choices vary from state to state, all of these restrictions apply to every member of the population uniformly. This simultaneous-release methodology ignores the importance of differential impacts of disease on various subsets of the population.

Severity and survival rates for COVID-19 infections vary significantly. They are a function of age and various comorbidities [1]. In this paper, we use documented infection–response variation to COVID-19 to design modified lockdown and social distancing restrictions that reduce overall death rates while increasing economic activity. Staggered-release policies are compared to the benchmark policy of simultaneously releasing all groups at a predetermined time. Policies are specifically evaluated on the reduction of overall death rates from the resulting projected outbreak.

Reported data show that infected individuals over the age of 65 face a much higher case mortality than individuals under the age of 44, while those between the ages 45 and 65 have an intermediate case mortality ([2,3], see also Fig. 1). Thus far, lockdown and social distancing restrictions have kept the overall number of deaths much lower than they would have been otherwise, particularly among the elderly. However, there are deleterious effects on the economy as well. Since restrictions were put in place in America, visits to commercial venues are down two-thirds [4], a decrease in activity that has led to small business closure and layoff rates of around 50% in the Mid-Atlantic states [5]. Shutdown sectors represent over 20% of all US payroll employment [6] and the burden of these job losses has fallen primarily on the poor [7]. All told, the economic cost of closing non-essential businesses could total nearly $10,000 per household per quarter [8], which may cause persistent harm in the form of lower output and employment and associated higher overall morbidity and mortality even after the shutdown ends [9].

While saving lives must be the primary concern, judiciously increasing economic activity is an important secondary goal as well. Perhaps the most important result from the analysis in this paper is tied to the identification of policies that can responsibly mitigate the economic effects of a sustained shutdown without jeopardizing the most vulnerable members of the population. This paper analyzes the costs and benefits of policies that are predicated upon the timely release of younger individuals who face lower risk from COVID-19 infections from social distancing restrictions before the release of older individuals. Compared to a policy that simultaneously releases all subpopulations, carefully planned and executed staggered-release policies are likely to lead to:

- Fewer infections over the entire duration of the outbreak
- Lower disease mortality rate among the elderly
- Fewer total disease deaths across the whole population
- Increased economic activity at an earlier date

The intuition behind the merit of staggered-release policies is closely related to the ‘flattening the curve’ narrative that motivated initial public support for restrictions in the first place [1,10]. The worst case