Fundamental causes of accelerated declines in colorectal cancer mortality: Modeling multiple ways that disadvantage influences mortality risk

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ABSTRACT

Background: Improvements in colorectal cancer (CRC) mortality reflect the distribution of effective preventions. Social inequalities often generate unequal diffusion of medical interventions, resulting in disparate outcomes while preventions are being disseminated throughout the population. This study used a novel method to examine whether Race (Black versus White) and SES influenced when rates of CRC mortality started to decline, and how rapidly they did so.
Method: Mortality counts from 1968-2010 were derived from death certificates of U.S. residents aged 25 + years. Individuals' race, age, county of residence, and sex were collected from death certificates. County-level SES was measured using the decennial U.S. census. Layered joinpoint regression was used to model CRC mortality trends over time. Acceleration in rates of historical decline were used to indicate preventability within counties.
Results: Black race was associated with a 4.1-year delay in colonoscopy-attributable declines in CRC mortality and each standard deviation unit change in SES with a 5.7-year delay in such mortality. Following the onset of a decline, colonoscopy-attributable mortality change was slower by 0.5% among Blacks, and 2.0%/standard deviation in SES. Modifying the rapidity of colonoscopy uptake could have averted 12−14,000 and 83−86,000 deaths among Blacks and residents of lower SES counties, respectively.
Conclusions: Successful interventions do not uniformly benefit the U.S. population. This study highlighted the notable impact that substantial delays in the provision of interventions, and in the relative rapidity of dissemination, and estimated the extent to which there was a preventable loss of life concentrated amongst the most disadvantaged. A more egalitarian delivery of life-saving interventions could drastically reduce mortality by improving effectiveness of interventions while also addressing inequalities in health.

Colorectal cancer (CRC) mortality is increasingly preventable

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(Smith et al., 2001; Winawer, 2007; Winawer et al., 1997), and CRC mortality rates have decreased steadily for decades (Edwards et al., 2014). Still, the National Cancer Institute estimates that 49,190 Americans will die from colorectal cancer (CRC) in 2016 (American Cancer Society, 2016). These declines have been largely attributed to wide scale use of screening technologies and changes in health

behaviors (Edwards et al., 2014).

The risk of CRC incidence and, ultimately, mortality is determined by primary preventive efforts, including the avoidance of behavioral risk factors (e.g., physical inactivity), and secondary preventive efforts, including the use of fecal occult blood testing and colonoscopy (Edwards et al., 2010). CRC screening works by reducing the incidence of, and mortality from, CRC cancer through early detection and removal of precancerous and advanced adenomas (Quintero et al., 2012). Physical inactivity and obesity raise the risk of incident cancer (Giovannucci et al., 1995; Je et al., 2013), whereas exercise appears to improve survival independent of prediagnostic levels of activity (Arem et al., 2015; Campbell et al., 2013). Together, these risk and protective factors have contributed to large and accelerating decreases in mortality risk over the past 40 years due in part to large-scale dissemination efforts by the American Cancer Society and US Preventive Services Task Forces among others (Saldana-Ruiz et al., 2013).

While mortality from CRC has decreased over time, it is increasingly recognized that deaths due to CRC are unevenly distributed within the population in ways that often reflect underlying social inequalities (Doubeni et al., 2009; Enewold et al.; Frederiksen et al., 2010; Heidarnia et al., 2013; Palmer and Schneider, 2005; Saldana-Ruiz et al., 2013; Von Wagner et al., 2009; Wang et al., 2012; Whitaker et al., 2011). Indeed, social inequalities in CRC prevention, incidence, and mortality have been increasing over time, underscoring the need to better understand their health consequences, and address them as they develop (Krieger et al., 2012; Palmer and Schneider, 2005). Yet, the reason for increasing inequalities remains unclear.

Fundamental cause theory uniquely proposes that the distribution of life-saving information and technologies is instrumental in increasing social inequalities in health and illness (Phelan et al., 2010). Specifically, the theory suggests that socioeconomic resources, including knowledge, power, prestige, money, and beneficial social connections, influences who learns about and is able to effectively access medical preventions and treatments in a timely manner (Link and Phelan, 1995). Furthermore, such inequalities often determine how patients interface with complex medical institutions to make medical decisions and manage care, resulting in systematic differences in outcomes even when provided with similar information (Lutfey and Freese, 2005). Since its formulation, the theory has been tested, validated, and expanded by examining the distribution of innovative treatments, preventions, and the diseases that these interventions were developed to treat or prevent (Chang and Lauderdale, 2009; Link et al., 1998; Link and Phelan, 2009; Rubin et al., 2014; Saldana-Ruiz et al., 2013). Yet, mechanisms linking SES to CRC mortality, in particular, remain unclear.

Social inequalities may emerge at various levels including individuals, hospitals, and clinical care, along with administrative policy, and type of prevention used. For example, examining the early history of colonoscopy, starting in 1969 with the first colonoscopy, Wolff (1989), the progenitor of colonoscopy, notes that many rank-and-file hospitals took more than a decade to adopt such life-saving technologies. Another study notes that differences in physicians' practices, and in particular engaging in continuing medical education, was more important to patients' prognoses than patient characteristics or disease etiology (Miller et al., 2008). Individual risk factors include systematic barriers to access; fears of pain or diagnosis; lack of desire or motivation; dissuasion by others; and lack of knowledge about, or lack of provider recommendations for, preventive health care (Green et al., 2008).

Lack of access to effective treatments or utilization of cheaper but less effective screening techniques may result in delays to effective preventions, in part because they disjoint care. For example, the FOBT is meant to screen for prevalent CRC; when positive, an FOBT should be followed by a colonoscopy within 60 days. Yet, this often does not occur. One study found that only 44% of veterans in the Veterans Health Administration with a positive FOBT were followed-up with any further screening despite being free of cost (Fisher et al., 2006), while another analysis found that the time between positive FOBT and colonoscopy in a screening clinic was approximately 236 days (Gellad et al., 2009).

Concurrently, behavioral changes may play a potentially large role in associations between social inequalities and CRC mortality. Indeed, behavioral risk factors form the basis of the health lifestyles that people enact (Cockerham, 2005), and are often integrated into individual *habitus* starting early in life (Freese and Lutfey, 2011; Lutfey and Freese, 2005). Indeed, such behaviors have become sufficiently important that they are often embedded in intergenerational educational transfer mechanisms in advantaged communities (Masters et al., 2014). SES and racial inequalities clearly predict the ability to engage in physical activity as well as intergenerational transfers of behaviors influencing obesity in childhood (Gibbs and Forste, 2014) and into adulthood (Watts et al., 2016). Each of these may reasonably reduce the use of, or delay access to, preventive techniques.

Barriers may not be related solely to tangible and fungible resources. Intangible social factors may further lead to the delayed uptake in segregated communities. For example, individuals facing discrimination may distrust the healthcare system or believe that medical treatments are not for them (Armstrong et al., 2013), potentially delaying uptake in minority communities. Slowed diffusion of innovation may be compounded if communities seeking health care are segregated in geographical or social space, since knowledge about and resources for care in those communities may be similarly segregated (Halberstam and Knight, 2016). Racism and racial disparities have long been known to play a substantial role in reducing life expectancy (Chae et al., 2011). Examining CRC specifically, prior research has shown that there is a substantial racial disparity in CRC mortality and that this disparity is growing (Robbins et al., 2012). Mechanisms for such inequalities abound but many are linked to the higher levels of obesity in minority populations, reduced levels of physical activity, and less access to timely healthcare. Potentially highlighting the necessity of improving timely access to knowledge about, and preventions for, CRC in disadvantaged communities, one study concludes that the most effective route to reducing the racial survival disparity [in CRC mortality] is to find ways to reduce the disparity in presentation, so fewer black patients present with advanced disease (Silber et al., 2014). Thus, ensuring that Blacks have timely access to preventions is a core element in efforts seeking to reduce health disparities in colorectal cancer mortality.

Recently, fundamental cause theorists have considered the shape of mortality declines, claiming that SES inequalities emerge in part through both delayed access to effective preventive technologies and slowed rates of decline after access are gained. Specifically, slowed diffusion within these groups reduces the ability for individuals to effectively access and utilize preventive knowledge (Clouston et al., 2016). Fig. 1 formalizes that theory and highlights the role of social disadvantage in slowing access to and reducing the impact of preventability, which may be indicated by acceleration in decline over time. Specifically, it posits that social disadvantage predicts both a delayed onset of mortality decline and a slower rate of decline once mortality rates begin their decline. Thus, although advantaged groups start with a much higher risk of CRC (Hypothesis 1: $\alpha_1 > \alpha_2$), we propose that with the advent of preventive knowledge and technology advantaged groups will experience slower rates of increase and/or more rapid rates of decline in CRC mortality over time (Hypothesis 2: $\beta_1 < \beta_2$). At the