SSM - Population Health 3 (2017) 1–8

Contents lists available at ScienceDirect

SSM - Population Health

journal homepage: www.elsevier.com/locate/ssmph

Article

Efficiency or equity? Simulating the impact of high-risk and population intervention strategies for the prevention of disease

Jonathan M. Platt[a,*], Katherine M. Keyes[a], Sandro Galea[b]

[a] Department of Epidemiology, Columbia University, New York, NY, USA
[b] Boston University, Boston, MA, USA

ARTICLE INFO

Keywords:
High-risk prevention
Primary prevention
High blood pressure
Smoking
equity
Efficiency
Simulation

ABSTRACT

Maximizing both efficiency and equity are core considerations for population health. These considerations can result in tension in population health science as we seek to improve overall population health while achieving equitable health distributions within populations. Limited work has explored empirically the consequences of different population health intervention strategies on the burden of disease and on within- and between-group differences in disease. To address this gap, we compared the impact of four simulated interventions using data from the National Health and Nutrition Examination Survey. In particular, we focus on assessing how population and high-risk primary prevention and population and high-risk secondary interventions efforts to reduce smoking behavior influence systolic blood pressure (SBP) and hypertension, and how such strategies influence inequalities in SBP by income. The greatest reductions in SBP mean and standard deviation resulted from the population secondary prevention. High-risk primary and secondary prevention and population secondary prevention programs all yielded substantial reductions in hypertension prevalence. The effect of population primary prevention did little to decrease population SBP mean and standard deviation, as well as hypertension prevalence. Both high-risk strategies had a larger impact in the low-income population, leading to the greatest narrowing the income-related gap in disease. The population prevention strategies had a larger impact in the high-income population. Population health approaches must consider the potential impact on both the whole population and also on those with different levels of risk for disease within a population, including those in under-represented or under-served groups.

1. Introduction

One of the central goals of population health science is to achieve equitable health distributions within populations, while seeking to maximize overall population health (Keyes & Galea, 2016). However, the impact of health policies and programs is often not distributed equally throughout a population, and health policies and programs may exacerbate health inequalities (Krieger, 2001). While not always the case (McLaren, McIntyre, & Kirkpatrick, 2010), the tension between equity and efficiency means that when resources are finite, there may be a trade-off between maximizing population health while minimizing population health inequity. Numerous scholars have described approaches to improving population health, explicating the differences between focusing on high-risk populations versus populations as a whole (Lalonde, 1974; Rose, 1985). In epidemiology and public health, such explication has been more visible in the work of Geoffrey Rose, for example, in his seminal book, *A strategy for preventive medicine* (Rose, 1985).

The high-risk approach proposes to intervene for prevention upon those with the strongest likelihood of developing disease (Lalonde, 1974). There are two different ways that prevention may be achieved. Primary prevention strategies identify high-risk individuals based on known risk factors, and intervene to reduce those exposures. The goal of this strategy is to reduce the number of incident cases of disease, or prevent a proportion of disease from ever occurring. Secondary prevention strategies seek to identify high-risk individuals with the disease and reduce disease morbidity, complications, or to decrease the disease prevalence by attenuating disease symptoms to sub-clinical levels. In the case of secondary prevention, the high-risk individuals often represent the most severe cases of disease, especially if risk factors of concern are strong causes of disease, or those with the disease face the greatest barriers to existing health services.

By contrast, rather than focusing on those defined as high-risk, a population approach is based on implementing strategies across the distribution of risk and disease. As with the high-risk approach, the population approach can be designed for both primary and secondary

* Correspondence to: Columbia University Mailman School of Public Health Department of Epidemiology 722 West 168th Street, Suite 720D New York, NY 10032, USA.
E-mail address: jmp2198@cumc.columbia.edu (J.M. Platt).

http://dx.doi.org/10.1016/j.ssmph.2016.11.002
Received 23 August 2016; Received in revised form 27 October 2016; Accepted 14 November 2016

Table 1
Summary of high-risk and population primary and secondary prevention approaches.

	Intervention goal	*Who is at risk?*	*Example*
High-risk approach			
Primary prevention	Prevent the exposure in order to reduce the number of incident cases of disease	Individuals with exposures known to significantly increase the risk of disease	Smoking cessation intervention among normotensive smokers (Hjermann, Holme, Byre, & Leren, 1981)
Secondary prevention	Treat disease to reduce morbidity and prevalence	Individuals already with the disease, often the most severe cases	Intensive smoking cessation intervention for patients with evidence of cardio-pulmonary distress (Murray, Connett, Rand, Pan, & Anthonisen, 2002)
Population approach			
Primary prevention	Reduce exposure to a highly prevalent risk factor for disease	Risk is prevalent throughout the entire population	Community-wide anti-smoking programs (Egger et al., 1983)
Secondary prevention	Identify and treat prevalent cases	Disease is prevalent throughout the population	Clinical smoking cessation interventions among hypertensive patients (Jatoi, Jerrard-Dunne, Feely, & Mahmud, 2007)

prevention. A population primary prevention strategy seeks to reduce the exposure to a highly prevalent risk factor for disease. A population secondary prevention strategy seeks to disseminate a global treatment strategy throughout an entire population to identify and/or treat cases to reduce disease morbidity or cure a proportion of those with the disease if possible. An overview and examples of each of the four approaches is presented in Table 1.

In sum, both high-risk and population intervention strategies can be implemented as primary prevention, which seeks to prevent the incidence of disease, and secondary prevention, which seeks to treat or cure those with disease. The main difference between strategies is who is the focus of the intervention. The high-risk strategy is generally implemented to decrease risk or course of disease among those with the greatest potential burden, while the population strategy seeks to maximize the number of individuals reached by an intervention, with less concern for the differential risk that individuals face in developing disease.

In addition to the potential tradeoff between equity and efficiency due to scarce resources, there are times that the advancement of a population strategy approach may inadvertently worsen health inequalities within a population (Frohlich & Potvin, 2008). Recent theoretical work has been done to develop different high-risk strategies that can be targeted to specific groups depending on the context and goal of the intervention (Benach, Malmusi, Yasui, & Martínez, 2013; Graham, 2004). For example, an intervention may target only those who are the worst-off, or to opt to improve population health through redistribution of health maximizing resources in a population from the most well-off to the least. The goal of these types of approaches is to avoid exacerbating existing inequalities by understanding specific contextual and population concerns.

Building off of prior research outlining population versus high-risk strategies, the purpose of this paper is to assess which approach is optimal for maximizing population health through the use of simulations and sensitivity analyses, while keeping the central focus of all strategies of the tradeoffs between equity and efficiency. While many studies focus on comparisons between population and high-risk interventions, our focus was to compare the impact of four strategies: high-risk primary prevention, high-risk secondary prevention, population primary prevention, and population secondary prevention, simulating versions of each intervention in a U.S. nationally representative sample in order to understand the effects of different strategies on the population prevalence and distribution of disease. In particular, we assessed whether interventions to reduce smoking were associated with lower systolic blood pressure (SBP) and reductions in hypertension prevalence. Hypertension is a highly relevant condition in the US context, as it represents both a disease outcome and is a modifiable risk-factor for many other highly prevalent diseases such as cardiovascular disease (Kannel, 1996) and stroke (Collins et al., 1990). Further, hypertension is a largely symptomless condition, which has implications for intervention strategies. Individuals with chronic asymptomatic conditions are less likely to present in clinical settings and are also less likely to adhere to treatment regimens, compared to those with more perceptible symptoms (Miller, 1997). Therefore, it is critical to understand the impact of high-risk and population prevention strategies on hypertension, as they inform critical public health thinking needed to reverse the incidence and consequences of hypertension in a population. We also compared changes between two subsamples of the population, those in low- vs. high-income households (less than $35,000 vs. more than $100,000, respectively), groups with well-known differences in hypertension prevalence (Diez-Roux, Link, & Northridge, 2000), to examine the extent to which visible behavioral risk factors were attributable to hypertension inequalities.

2. Methods

2.1. Analytic approach

Using data from the National Health and Nutrition Examination Survey (NHANES) 2011–2012, we modeled the sample distribution of respondents' SBP. Our analytic sample was limited to respondents for which SBP data were available. SBP was chosen because it is easily measured and is a fairly normally distributed continuous variable for which there is a generally accepted threshold for disease (hypertension) in the US population. Although hypertension is typically defined as SBP > 139 mmHg (Chobanian et al., 2003), we included those with SBP greater than 130 mmHg as hypertensive, in order to avoid unstable results due to small sample sizes. The impact of each intervention was generally similar using the SBP > 139 mmHg threshold for hypertension. We limited the current consideration to SBP rather than both SBP and diastolic blood pressure for purposes of simplicity.

The NHANES sample comprised 7053 individuals who had reported at least one measure of SBP. The average SBP value was recorded among those with multiple measurements. The overall sample mean SBP was 118.8 mmHg and the standard deviation (SD) was 18.4. However, to reduce the influence of extremely high or low SBP measures, we excluded individuals who reported an SBP greater than 2 standard deviations outside of the full sample distribution. Similarly, to avoid the potential selection bias from very young or very old study participants, we limited our analytic sample to those age 25–65. The final analytic sample comprised 3393 individuals. The mean SBP in this sample was 119.6 and the SD was 13.7. The full sample distribution is shown in Supplementary Fig. 1.

2.2. Risk factors

Tobacco smoking is positively associated with increased blood pressure and incident hypertension (Sleight, 1993). Current smoking was defined as self-reported use of tobacco every day or some days over the past 30 days. Smoking was chosen as illustrative because it