



## Article

# Communicating the benefits of population health interventions: The health effects can be on par with those of medication



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## ABSTRACT

How can we communicate to the public that population level health interventions are effective at improving health? Perhaps the most familiar “currency” of effect is that which can be brought about via medication. Comparisons of effect sizes may be effective ways of communicating the benefits of population health interventions if they are seen and understood in the same way that medications are. We developed a series of comparisons to communicate benefits of population health interventions in terms of similar gains to be obtained from statins, metformin and antihypertensive medications for prevention of cardiovascular events, type 2 diabetes, obesity and hypertension. A purposive search identified evidence of population health intervention-related benefits. This evidence ranged from meta-analyses of RCTs to that from observational cohort studies. Population health interventions included implementation of national smoke free legislation, enhanced neighbourhood walkability, increased opportunities for active travel and protection of urban green space. In some cases, the benefits of population health interventions were found to be equivalent to, or even outweighed those of the medications to which they were compared. For example, RCT-based evidence suggested that exercise taken with a view of a green space was associated with 12 mmHg and 6 mmHg reductions in systolic and diastolic blood pressure, respectively, which was at least on par with the reductions associated with antihypertensive medications. Future work will test the effectiveness of these comparisons for increasing the familiarity, credibility and acceptability of population health interventions and, in particular, examine the importance of communicating putative mechanisms and potential co-benefits.

## Introduction

Over the last 30 years, scientists have shown that investing in population health interventions can, in many cases, save lives and reduce health inequities (Bambra et al., 2009; Centers for Disease Control Prevention, 2011). Population health interventions are often delivered by people and organisations which operate outside the health sector (e.g. urban planning and environmental agencies, Frumkin, Frank, & Jackson, 2004) and help to keep people healthy and out of hospital through public policy, regulatory initiatives, single strategy projects and multi-component programmes that can benefit entire populations (Rychetnik, Frommer, Hawe, & Shiell, 2002). For 50% of all the known risk factors for chronic disease, a population or community-level preventive program or policy of known effectiveness could be put in place

(Task Force on Community Preventive Services, 2005). Despite the existence of effective policies and programs, many are not implemented in practice and investment in chronic disease prevention remains insufficient.

Over the same 30 year time period the pharmaceutical industry has expanded its capacity to treat and prevent a range of diseases. For example, new vaccines, such as those for hepatitis B and haemophilus influenza type B avert hundreds of thousands of deaths annually, while antiretroviral therapy has assisted the worldwide decline in HIV/AIDS mortality (Centers for Disease Control Prevention, 2011). Moreover, pharmaceutical companies have developed a range of medications for the management (and in some cases, prevention) of non-communicable diseases, including statins for cardiovascular disease, metformin for type 2 diabetes mellitus, and antihypertensive medications for high

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blood pressure.

Unlike public health, the pharmaceutical industry invests heavily in communicating the benefits of their products. It has been estimated that pharmaceutical companies spend almost twice as much on promotion of their products as they do in research and development (Gagnon & Lexchin, 2008). In addition, pharmaceutical companies have been active in what has been called “medicalisation”, that is, in expanding their brands and products to conditions that do not warrant treatment and in setting up patient groups to lobby for expanded use of medications (Moynihan, Heath, & Henry, 2002; Spielmans & Parry, 2010).

The prominence of pharmaceutical companies in public life also creates a secondary challenge. The public might be forgiven for thinking of pharmaceuticals as the *only* effective solutions for ill-health, overshadowing the health gains to be accrued from investment in public policies, such as tobacco control that *prevent* disease at the population level. Simultaneously, and perhaps as a result of disproportionate investment in pharmaceutical marketing and industry lobbying, public understandings of the health benefits that accrue from investing in public policies are partial and possibly skewed towards narrow interpretations of what is possible (e.g. lifestyle education campaigns). We therefore need effective ways of communicating the benefits of population health interventions such that they are seen, understood and valued.

One means of communicating the benefits of population health interventions may involve comparing the health benefits of public policy directly with those of medication. Reeves and colleagues, for example, investigated the benefits to mental health gained by low salaried workers as a result of the UK Government’s minimum wage legislation of 1999 in comparison to the benefits of taking antidepressant medications (Reeves, McKee, Mackenbach, Whitehead, & Stuckler, 2016). This was an invitation for politicians to take notice. By framing their findings in this way, the scientists were attempting to leverage public familiarity and acceptance of medical treatment for depression to demonstrate the benefits of public policy.

We have recently explored the capacity of such comparisons of the effects of medication and public policy to communicate problems and solutions in public health (Astell-Burt, Rowbotham, & Hawe, Unpublished). We highlighted the potential appeal of such comparisons and considered the need for these to be well-constructed to protect against miscommunication. Within the present paper, we have assembled a series of comparisons to communicate the benefits of population health interventions in terms of similar the gains to be obtained by medication. With these comparisons we attempt to express the effect of unfamiliar or poorly understood interventions within the context of interventions that might be better understood, or, at least more familiar. In doing so our purpose is to develop a set of robust comparisons through which to communicate evidence about the benefits of population health interventions, which can then be tested to examine their utility in creating greater public understanding of and regard for population health interventions.

### Approach to developing the comparisons of effect sizes

We sought to develop a set of statements which compared the benefits of population health interventions with those obtained through medications commonly used in the prevention and management of chronic disease (metformin, statins and antihypertensive medications). We defined the outcomes *a priori* as prevention of type 2 diabetes, cardiovascular events, reduction in body mass index (BMI), and/or high blood pressure. A purposive search that drew upon knowledge from the authors and experts in relevant fields was used to gather evidence for developing the comparisons.

Studies were selected based on a number of principles. First, we ensured that we compared ‘like with like’ in terms of the same outcomes over similar time-periods and with the same measures of effect (e.g. relative risks). Second, our focus was on published analyses of person-

level data with prevention focussing on the average person (e.g. the influence of banning tobacco smoking in public places on the relative risk of experiencing a heart attack in a cohort of people tracked over time). We did not include ecological studies focussing on changes in count data observed within areas (e.g. the influence of the above-mentioned smoking ban on the average count of heart attacks observed annually within a sample of cities).

We prioritised high quality evidence known for each case, with quality determined by the study design. Meta-analyses of randomised controlled trials (RCT) were considered the best evidence and used wherever available, followed by single RCTs, then studies using non-experimental (e.g. observational) data. When using observational evidence, we focussed explicitly on evidence derived from cohort data that had been analysed using statistical methods designed to minimise and/or eliminate confounding. For example, ‘fixed effect’ models (Gunasekara, Richardson, Carter, & Blakely, 2013) eliminate all time-invariant sources of confounding, leaving multivariate adjustment required only for time-varying confounders. Studies of cross-sectional design, including cross-sectional time-series, were not included for reasons of non-comparability, as the studies of medication-related benefits we drew upon for comparison also focussed upon repeated measurements of the same people over time. We recognised at the outset that while experimental evidence is usually considered paramount, a reliance upon observational studies for population health interventions was expected as it is not always feasible or appropriate to conduct an RCT. Comparisons were developed from the evidence gathered, and took the form of concise messages comparing effect sizes from the studies of medications and population health interventions. Descriptive characteristics of the papers featuring analyses of singular studies (as opposed to results from meta-analyses) are reported in Table 1.

We were cognizant that evidence on medications would mostly derive from highly selected samples common to experimental designs, whereas the samples studied for evidence of population health intervention benefits would likely be for more heterogeneous populations. As such, our focus was strictly on comparisons of effect size estimates rather than re-expression of potential benefits at a larger scale through calculation of population attributable fractions (Rockhill, Newman, & Weinberg, 1998). Similarly, while there is a worthwhile discussion to be had about incorporation of cost-effectiveness in these comparisons, our focus was on communicating the effect size of population health interventions relative to medications for prevention of the same outcome and not to promote the idea that one could be chosen over another. We acknowledge that for the most part they reach different groups. Our purpose was to develop comparisons to communicate (to the general public) that less familiar interventions, such as public policies, may be as effective at improving health as something they see every day on the pharmacy shelves. Our purpose is to devise ways to arouse public interest in public health rather than to provide advice for clinicians or policy makers.

In the following section, we outline the evidence for each medication under consideration, contrast this with the evidence from population health interventions and present the comparisons in tabular form with the component data.

## Results

### 1. Comparisons group 1: prevention of type 2 diabetes and obesity

The first set of comparisons (Table 2) compared the benefits of population health interventions to the impact of metformin on type 2 diabetes and obesity prevention. Metformin is a pharmacological agent commonly used to improve glycaemic control among people living with type 2 diabetes (Bailey & Turner, 1996). Metformin reduces the amount of glucose that is absorbed into the bloodstream through reducing the amount that is released from the liver. It can also increase insulin

**Table 1**  
Characteristics of Single Studies.

Treatment	Ref.	Country	Sample size	Age of sample	Percentage female	Time period	Statistical analysis
<b>Improved socioeconomic circumstances</b>	Ludwig et al. (2011). Neighborhoods, obesity, and diabetes—a randomized social experiment. <i>New England Journal of Medicine</i> , 365, 1509–1519.	United States	4498	Age distribution given across intervention and control groups at follow-up, stratified by age group: < 35 y = 13.5% to 14.7% 36–40 y = 21.5% to 23.9% 41–45 y = 21.7% to 23.5% 46–50 y = 17.1% to 20.5% > 50 y = 20.4% to 21.7% Mean age at baseline = 51	100%	Mean follow-up time = 12.6 years	Linear and logistic regressions with adjustment for baseline characteristics and also use of the voucher allocation as an instrumental variable
<b>More and regular physical activity</b>	Diabetes Prevention Program Research Group (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. <i>The New England Journal of Medicine</i> , 346, 393–403.	United States	3234	Mean age at baseline = 51	68%	Mean follow-up time = 2.8 years	Life tables and fixed effects regressions of an Intention To Treat sample
<b>Initiating cycling</b>	Rasmussen et al. (2016). Associations between recreational and commuter cycling, changes in cycling, and type 2 diabetes risk: a cohort study of Danish men and women. <i>PLoS Medicine</i> , 13, e1002076.	Denmark	52,513	Mean age at baseline = 56	53%	Mean follow-up time = 14.2 years	Survival analysis (Cox regression) with multivariate controls for potential confounding
<b>Switching to active modes of travel</b>	Flint, Webb, and Cummins (2016). Change in commute mode and body-mass index: prospective, longitudinal evidence from UK Biobank. <i>The Lancet Public Health</i> , 1, e46–e55.	United Kingdom	5861	Mean age at baseline = 51	49%	Mean follow-up time = 4.4 years	Linear regressions with multivariate controls for potential confounding
<b>Increasing urban density</b>	Hirsch et al. (2014). Built environment change and change in BMI and waist circumference: Multi-ethnic Study of Atherosclerosis. <i>Obesity</i> , 22, 2450–2457.	United States	5506	Mean age at baseline = 62	53%	Median follow-up time = 9.1 years	Fixed effects regressions with multivariate controls for time-varying sources of confounding
<b>Protecting local tree canopy</b>	Donovan et al. (2015). Is tree loss associated with cardiovascular-disease risk in the Women's Health Initiative? A natural experiment. <i>Health &amp; Place</i> , 36, 1–7.	United States	156,246	Mean age at baseline = 63	100%	Approximately 8 years (from first detection of the Emerald Ash Borer in 2002 to the end of the study in 2010)	Survival analysis (Cox regression) with multivariate controls for potential confounding
<b>Physical activity in green space</b>	Pretty et al. (2005). The mental and physical health outcomes of green exercise. <i>International Journal of Environmental Health Research</i> , 15, 319–337.	United Kingdom	100	Mean age at baseline = 25	55%	Approximately 25 min (5 min after completing 20 min of exercise)	One-way ANOVA
<b>Increasing neighbourhood walkability</b>	Braun et al. (2016). Changes in walking, body mass index, and cardiometabolic risk factors following residential relocation: Longitudinal results from the CARDIA study. <i>Journal of Transport &amp; Health</i> , 3, 426–439.	United States	1079	Mean age at baseline = 40	55%	Approximately 6 years	Fixed effects regressions with multivariate controls for time-varying sources of confounding
<b>Metformin (over nearly 3 years)</b>	Diabetes Prevention Program Research Group (2002). Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. <i>The New England Journal of Medicine</i> , 346, 393–403.	United States	3234	Mean age at baseline = 51	68%	Mean follow-up time = 2.8 years	Life tables and fixed effects regressions of an Intention To Treat sample
<b>Metformin (over 10 years)</b>	Diabetes Prevention Program Research Group (2009). 10-year follow-up of diabetes incidence and weight loss in the Diabetes Prevention Program Outcomes Study. <i>The Lancet</i> , 374, 1677–1686.	United States	2766	Mean age = 55	68%	Approximately 10 years	ANOVA or t-tests, and regressions adjusted for baseline values
<b>Metformin (over 15 years)</b>	Diabetes Prevention Program Research Group (2015). Long-term effects of lifestyle intervention or metformin on diabetes development and microvascular complications over 15-year follow-up: the Diabetes Prevention Program Outcomes Study. <i>The Lancet Diabetes &amp; Endocrinology</i> , 3, 866–875.	United States	2776	Mean age at baseline = 51	68%	Approximately 15 years	Generalised Estimating Equations (GEE) Models

Note: This table provides further information on the non-meta-analytic studies used in this paper, to provide background information on data/samples and analytical approaches. The meta-analyses that were also used in this paper are as follows: Adler et al. (2014). Reduced dietary salt for the prevention of cardiovascular disease. *Cochrane Database Syst Rev*, 12, CD009217. Law et al. (2009). Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. *BMJ*, 338, 1665. Tan and Glantz (2012). Association between smoke-free legislation and hospitalizations for cardiac, cerebrovascular, and respiratory diseases a meta-analysis. *Circulation*, 126, 2177–2183. Taylor et al. (2013). Statins for the primary prevention of cardiovascular disease. *The Cochrane Library*.

sensitivity and reduce appetite. These qualities make it a useful prescription for weight loss and prevention of type 2 diabetes among people identified as at 'high risk', as defined by an HbA1c test of 5.7% to 6.4%, which is often referred to as 'pre-diabetes' (American Diabetes Association, 2013). The Diabetes Prevention Program RCT reported metformin compared with placebo resulted in lower incidence of type 2 diabetes of 31% (95%CI 17% to 43%) and average weight loss of 2.1 kg at 3 years (Diabetes Prevention Program Research Group, 2002). Similar findings have been reported at longer-term follow-up of the same RCT (Diabetes Prevention Program Research Group, 2002, 2009, 2015).

The comparisons developed for prevention of type 2 diabetes and obesity are displayed in Table 2, along with the evidence used for their development. Explanations of each comparison are provided in the following sections.

### 1.1 Improving socioeconomic circumstances

Evidence suggests that improving socioeconomic circumstances can reduce the probability of developing type 2 diabetes. The 'Moving To Opportunity' study in the US used an experimental design to track individuals over a 10–15 year period after random assignment (Ludwig et al., 2011). The 'treatment' was a voucher that enabled a person to move away from highly disadvantaged areas to relatively less disadvantaged neighbourhoods, with the people in the control group given no voucher. 'Intention to treat' analyses (i.e. people in the 'treatment' group were analysed as such, regardless of whether or not they remained in their new neighbourhood) indicated that 20% of people who had remained in highly disadvantaged neighbourhoods had developed type 2 diabetes over the 12.6 year mean period of follow-up. By comparison, type 2 diabetes observed at follow-up among people who had moved to substantially more affluent areas was 4.31 percentage points lower (95%CI -7.82 to -0.80;  $p = 0.02$ ). This represented a reduction of approximately 22% (15.7/20.0) in type 2 diabetes due to improved socioeconomic circumstances, in comparison to the 18% reduction attributable to metformin over a similar time period (Diabetes Prevention Program Research Group, 2015). This highlights that public policies which help to improve socioeconomic circumstances can contribute to prevention of type 2 diabetes and achieve results at least on par with, or better than providing all people considered 'at high risk' with daily metformin.

### 1.2 Promoting physical activity

The benefits of a more physically active and less sedentary lifestyle are well-known in the scientific community and guidelines to this effect have been produced. While simply telling people to be more physically active is generally not sufficient to bring about behaviour change, public policy can help make it easier for people to participate in more active and less sedentary lifestyles (Lee et al., 2012). Evidence from the Diabetes Prevention Program RCT in the US contrasted the effect of taking metformin on diabetes incidence with those accrued from participating in at least the standard recommended 150 min of physical activity per week, plus receipt of a 16-lesson one-on-one curriculum covering diet, exercise, and behaviour modification, plus subsequent individual and group follow-up sessions to reinforce behaviour change (Diabetes Prevention Program Research Group, 2002). After an average of 2.8 years, type 2 diabetes incidence in the lifestyle arm vs. placebo was 58% lower (95%CI 48% to 66%), whereas metformin vs. placebo was 31% lower (95%CI 17% to 43%). This draws attention to the idea that supporting people to be physically active can result in benefits for type 2 diabetes prevention that may considerably outweigh those accrued from daily metformin use.

### 1.3 Increasing physical activity through changing transport mode

Public policy that invests in infrastructure such as safe, well designed bicycle lanes, can promote walking and cycling (Panter, Heinen, Mackett, & Ogilvie, 2016). A cohort study in Denmark examined the benefits of initiating cycling over a follow-up period of approximately

14.2 years on average. Cox proportional hazards models adjusted for a range of potential confounders showed a 20% reduction (Hazard Ratio (HR) 0.80, 95%CI 0.69 to 0.91) in incident type 2 diabetes among participants who initiated cycling for recreational or commuter travel, compared with those who continued to rely upon private motor vehicles (Rasmussen et al., 2016). This 20% reduction in type 2 diabetes risk compares favourably with the 18% reduction (HR 0.82, 95%CI 0.72 to 0.93) attributable to metformin (vs. placebo) in the 15-year follow-up study of the Diabetes Prevention Program (Diabetes Prevention Program Research Group, 2015). This suggests that making it easier for people to take up cycling on a regular basis for commuting and for leisure may have virtually the same effect for preventing type 2 diabetes as daily use of metformin.

### 1.4 Reducing weight through changing transport mode

Provision of safe and user-friendly built environments not only helps to support active lifestyles and reduce type 2 diabetes risk, but also contributes to weight loss and obesity prevention. We drew upon data from a cohort study derived from the UK Biobank with a median follow-up time of 4.4 years (Flint, Webb, & Cummins, 2016). Statistical models adjusted for a range of confounders indicate that participants who switched transport mode from private motor vehicle to bicycle experienced a mean BMI reduction of 0.30 kg/m<sup>2</sup> (95%CI -0.47 to -0.13). According to the authors, this translated into a 1.0 kg reduction in body weight for the average man at 176.6 cm tall and weighing 81.5 kg, or a reduction of 0.8 kg for the average woman at 163.9 cm tall and weighing 70 kg. These reductions are about half those attributable to daily metformin use, which is approximately 2.1 kg on average over 4 years (Diabetes Prevention Program Research Group, 2002), though some increased muscle mass that can occur through sustained physical activity resulting from active travel also needs to be taken into account.

### 1.5 Reducing weight through increasing the number of places people can walk to nearby

Safe and user-friendly transport infrastructure is a necessary but insufficient condition for promoting physical activity as, increasingly, studies suggest increasing the number of places people can walk to can be a key motivating factor for not using cars over short distances. This was the focus of the fifth comparison, which utilised data from a cohort study with median follow-up time of 9.1 years in the US (Hirsch et al., 2014). 'Fixed effect' models were used to eliminate sources of time-invariant confounding, with only adjustment for time-varying confounders required. It reported a 1-standard deviation increase in the density of local built environment (a proxy for the number of places people can walk to, including the number of restaurants, shops and parks) resulted in an average reduction in BMI of 0.15 kg/m<sup>2</sup> (95%CI -0.26 to -0.05). According to the authors, this effect size translates to a 0.48 kg reduction in body weight for the average man (178.2 cm average height) and a 0.40 kg reduction for the average woman (164.1 cm average height), across a median follow-up of 9.1 years. Although 0.48 kg and 0.40 kg reductions for men and women, respectively, are less than 20% of the benefit of taking metformin for weight loss over a 10-year period (Diabetes Prevention Program Research Group, 2009), the reduction is still meaningful. Furthermore, authors in this field point out that many benefits that can accrue from increasing the number of places people can walk to, including other improvements in mental and physical health, reductions in traffic pollution emissions and other environmental co-benefits (Giles-Corti et al., 2016).

## 2. Comparison set 2: prevention of cardiovascular events

The second set of comparisons (see Table 3) compared the benefits of a range of existing and potential public policy interventions to the impact of statins on prevention of cardiovascular events. Statins are the first-choice pharmacological agent for the prevention of cardiovascular morbidity and mortality, taken once a day in pill-form. Research has

**Table 2**  
Comparisons for type 2 diabetes and obesity prevention (set 1).

N	Effect size of medication	Effect size of the population health intervention	Interpretation
1.1	<b>Metformin:</b> At a mean follow-up time of 15 years, diabetes incidence was reduced by 18% in the metformin group (HR 0.82, 95%CI 0.72 to 0.93), compared with the placebo group, across a 15 year timespan (Diabetes Prevention Program Research Group, 2015).	<b>Improved socioeconomic circumstances: An RCT showed</b> 21.6% reduced risk of type 2 diabetes among people moving to more affluent surroundings after 10–15 years of follow-up, compared with a control group that remained in disadvantaged neighbourhoods (Ludwig et al., 2011).	Enhancing socioeconomic circumstances in disadvantaged populations could reduce the average risk of getting diabetes by 22% over 15 years, compared with an 18% reduction from daily metformin use over a similar period of time.
1.2	<b>Metformin:</b> Reduced risk of diabetes incidence by 31% (95%CI 17% to 43%) among people receiving metformin, in comparison to a placebo group (Diabetes Prevention Program Research Group, 2002).	<b>More and regular physical activity: An RCT showed</b> reduced risk of diabetes incidence by 58% (95%CI 48% to 66%) among people receiving a lifestyle intervention, in comparison to a placebo group (Diabetes Prevention Program Research Group, 2002).	Supporting people to be more physically active (e.g. through safe, walkable environments) could reduce the risk of getting diabetes by 58% over 3 years, compared with a 31% reduction from daily metformin use over a similar period of time.
1.3	<b>Metformin:</b> At a mean follow-up time of 15 years, diabetes incidence was reduced by 18% in the metformin group (HR 0.82, 95%CI 0.72 to 0.93), compared with the placebo group, across a 15 year timespan (Diabetes Prevention Program Research Group, 2015).	<b>Initiating cycling: A cohort study showed</b> reduced risk of diabetes by 20% (HR 0.80, 95%CI 0.69 to 0.91) for initiating cycling, compared with not cycling, across a mean follow-up period of 14.2 years (Rasmussen et al., 2016).	Supporting people to begin and continue cycling (e.g. through provision of cycle lanes physically separated from traffic lanes) could reduce a person's risk of getting diabetes by 20%, compared with an 18% reduction from daily metformin use over a similar period of time.
1.4	<b>Metformin:</b> Average weight loss of 2.1 kg among participants receiving metformin across a 4-year period (Diabetes Prevention Program Research Group, 2002).	<b>Switching to active modes of travel: A cohort study showed</b> changing commute mode from car to active transport resulted in reduction in BMI of 0.30 kg/m <sup>2</sup> (95%CI -0.47 to -0.13). According to the authors, this translates to a 1.0 kg reduction in body weight for the average man 176.6 cm tall and weighing 81.5 kg, and a reduction of 0.8 kg for the average woman 163.9 cm tall and weighing 70 kg, across a median follow-up of 4.4 years (Flint et al., 2016).	Supporting people to switch from cars to active modes of transport could lead to an average weight reduction of 1 kg over 4 years, as well as a range of other mental and physical health benefits, compared with a just over 2 kg from daily metformin use over a similar period of time.
1.5	<b>Metformin:</b> Average weight loss of 2.5 kg among participants receiving metformin across a 10-year period (Diabetes Prevention Program Research Group, 2009).	<b>Increasing urban density: A cohort study showed</b> a 1-standard deviation increase in the density of local built environment resulted in a mean reduction in BMI of 0.15 kg/m <sup>2</sup> (95%CI -0.26 to -0.05). According to the authors, this translates to a 0.48 kg reduction in body weight for the average man (178.2 cm average height) and a 0.40 kg reduction for the average woman (164.1 cm average height), across a median follow-up of 9.1 years (Hirsch et al., 2014).	Increasing the number of places nearby people can easily walk to could lead to an average weight reduction of 0.4–0.5 kg over 4 years, compared with a just over 2 kg from daily metformin use over a similar period of time.

95%CI = 95% confidence interval; BMI = body mass index; RR = relative risk; HR = hazard ratio; OR = odds ratio.

shown that statins can reduce low-density lipoprotein cholesterol (LDL-C) by 2 mmol/L, with evidence from RCTs reporting a 27% reduced risk of all coronary heart disease events (RR 0.73, 95%CI 0.67 to 0.80) and a 25% reduced risk for all cardiovascular disease events (RR 0.75, 95%CI 0.70 to 0.81) (Taylor et al., 2013).

### 2.1 Preventing coronary events through smoke-free legislation

It is well known that bans on smoking in public places lead to a reduction in smoking prevalence (Fichtenberg & Glantz, 2002), with particularly strong impacts for people who smoke heavily (Borland, Chapman, Owen, & Hill, 1990), as well as reducing exposure to second-hand smoke, which can yield other important health benefits. For example, a study in Scotland reported the number of admissions for acute coronary syndrome decreased by 17% (95%CI 16 to 18) in the ten months following a ban on smoking in all public places, compared with a 4% drop observed in England during the same period where there was no comparable policy (Pell et al., 2008). Many other studies have found similar results, with a meta-analysis (Tan & Glantz, 2012) of 45 studies from multiple countries and a median follow-up of 24 months reporting a 15% reduced risk of coronary events (RR 0.85, 95%CI 0.82 to 0.88) attributable to comprehensive smoke-free legislation. This was just over half the reduction associated with use of statins (27%).

### 2.2 Preventing cardiovascular events through reducing salt-intake

Public policy can shape health for entire populations through food fortification and product reformulation (Maberly & Stanley, 2005). Reduction of salt in processed foods is one such approach taken in many countries, including most recently in the United Kingdom (He, Brinsden, & MacGregor, 2014). Salt reduction has been demonstrated to have clinically important benefits for blood pressure in randomised

controlled trials (He & MacGregor, 2002), but only recently has experimental evidence of the benefit of salt reduction for prevention of cardiovascular events emerged, with a 23% reduction reported in an updated Cochrane review of RCTs (RR 0.77, 95%CI 0.63 to 0.95) (Adler et al., 2014). Compared with the 25% risk reduction attributable to statins, this evidence suggests that a daily 2.0 g to 2.3 g reduction in salt intake could give nearly the same degree of benefit (23%).

### 2.3 Preventing cardiovascular mortality through protection of local tree canopy

There is rapidly growing evidence from experiments and large-scale epidemiological studies to suggest green and natural areas within cities restore mental health, promote social and active lifestyles, and mitigate against air pollution and hot temperatures (Hartig, Mitchell, de Vries, & Frumkin, 2014). We drew upon a study that examined what happens if we fail to protect an important attribute of green spaces: local tree canopy. The Emerald Ash Borer in the US has rapidly killed over 100 million ash trees since it was first detected in 2002 (Donovan, Michael, Gatzolis, Prestemon, & Whitsel, 2015). Cox proportional hazards models were used to examine incidence of cardiovascular events cumulatively over the course of approximately 8 years, adjusting for confounders tracked among a cohort of women living in counties affected by the Emerald Ash Borer compared with those which were not. The study found an adjusted risk of 25% (Hazard Ratio (HR) 1.25, 95%CI 1.20 to 1.31). This means that women residing in affected areas died at approximately one quarter higher the rate of death per year as was observed among their counterparts in unaffected areas, with all other things being equal. The scientists analysing this cohort study claimed that it qualified for the status of a 'natural experiment', and that it was unlikely that tree loss and cardiovascular disease were

**Table 3**  
Comparisons for protecting cardiovascular health (set 2).

N	Effect size of medication	Effect size of the population health intervention	Interpretation
2.1	<b>Statins:</b> Meta-analysis indicated that the risk of fatal or non-fatal CHD events was reduced by 27% due to statin use (RR 0.73, 95%CI 0.67 to 0.80) (Taylor et al., 2013).	<b>Smoke-free legislation:</b> Meta-analysis indicated that the implementation of smoke-free legislation resulted in a 15% reduction in coronary events (RR 0.85, 95%CI 0.82 to 0.88) (Tan and Glantz, 2012).	Enforcing smoke-free public spaces could reduce the risk of coronary events by 15%, compared with a reduction of 27% through use of statins.
2.2	<b>Statins:</b> Meta-analysis indicated that the risk of fatal or non-fatal CVD events was reduced by 25% due to statin use (RR 0.75, 95%CI 0.70 to 0.81) (Taylor et al., 2013).	<b>Reducing salt content in food:</b> Meta-analyses indicated a reduction in salt-intake resulted in a 23% reduced risk of cardiovascular events (RR 0.77, 95%CI 0.63 to 0.95) (Adler et al., 2014).	Industry-driven product reformulation that reduces salt consumption per person by 2.0 g to 2.3 g could reduce the risk of cardiovascular events by 23%, compared with a reduction of 25% through use of statins.
2.3	<b>Statins:</b> Meta-analysis indicated that the risk of fatal or non-fatal CVD events was reduced by 25% due to statin use (RR 0.75, 95%CI 0.70 to 0.81) (Taylor et al., 2013).	<b>Protecting local tree canopy:</b> A cohort study showed women living in a county that experienced an acute and substantial loss of green space had a 25% increased risk of CVD events (HR 1.25, 95%CI 1.20 to 1.31) (Donovan et al., 2015).	Protecting local tree canopy could reduce the risk of cardiovascular events by 20%, compared with a reduction of 25% through use of statins.

95%CI = 95% confidence interval; BMI = body mass index; RR = relative risk; HR = hazard ratio; OR = odds ratio; CHD (coronary heart disease) events include, for example, heart attacks (myocardial infarction); CVD (cardiovascular disease) events include those caused by CHD and also those caused by cerebrovascular disease, for example, a stroke.

confounded by unmeasured phenomena given the speed and quasi-random pattern of the Emerald Ash Borer's spread. As with many natural experiments, however, the study was opportunistic and only had access to data on a cohort of women, so potential impacts on men and children could not be investigated. With the reciprocal of a 1.25 hazard ratio being 0.80, this suggests that the benefit of residing in a neighbourhood that contains green space for preventing cardiovascular events could be as much as 20%, or nearly the equivalent of taking statins (RR 0.75, 95%CI 0.70 to 0.81). It is worth noting that while evidence from the Emerald Ash Borer study can be used loosely to infer the health benefits of providing more tree canopy, studies that explicitly test this intervention would strengthen this inference. Overall, this comparison suggests that by protecting and restoring tree canopy we are investing in our own health.

### 3. Comparisons set 3: prevention of hypertension

The third set of comparisons (see Table 4) compared the benefits of a range of population health interventions to the impact of anti-hypertensive medications for prevention of hypertension. Anti-hypertensive medications help to reduce high blood pressure, for which the standard treatment goal is usually < 140 mmHg and < 90 mmHg for systolic and diastolic blood pressure, respectively. Depending upon pre-treatment level, the effect of one standard dose of antihypertensive medications is estimated to be 5.7 mmHg to 11.7 mmHg and 3.1 mmHg to 6.9 mmHg for systolic and diastolic blood pressure, respectively (Law, Morris, & Wald, 2009). These values may vary depending upon age and the presence of co-morbidities such as type 2 diabetes and chronic kidney disease.

#### 3.1 Exercise plus contact with green space and enhanced reduction of high blood pressure

In the ninth comparison we consider the potential of green space to enhance relaxation and reduce blood pressure. An RCT in the UK showed 12 mmHg and 6 mmHg reductions in systolic and diastolic blood pressure, respectively, among participants exercising with a view of a large green space compared with those exercising without a view (Pretty, Peacock, Sellens, & Griffin, 2005). These effects compare favourably with the effect of a standard dose of antihypertensive medications, estimated at 5.7 mmHg to 11.7 mmHg and 3.1 mmHg to 6.9 mmHg reductions in systolic and diastolic blood pressure, respectively. This suggests reductions in blood pressure that are equal to, if not greater than those accrued through use of antihypertensive medications could be achieved by exercising indoors with a view or, or within a large park or rural setting.

#### 3.2 Increasing neighbourhood walkability and reduction of blood pressure

Many studies have reported lower hypertension risk and reduced blood pressure among residents of areas that are considered more walkable (e.g. Chiu et al., 2016), with the effect partially mediated by change in body weight (Chaix et al., 2008). A recent US-based cohort study (Braun et al., 2016) tracked change in blood pressure over 6 years among people moving from neighbourhoods of low to high walkability. 'Fixed effect' models adjusted for time-varying sources of confounding found a 1-standard deviation increase in local walkability to be associated with a 0.81 mmHg reduction (95%CI -1.55 to -0.07) in systolic blood pressure. This effect size is very small in comparison with the benefit of taking antihypertensive medications and below the 3 mmHg usually considered clinically significant. That said, it is not necessary for all comparisons to show evidence of population health interventions being as good as, or better than, pharmaceutical-based prevention strategies. Indeed, what may be of interest here is that there is still a detectable effect from what the public might consider to be an almost invisible, taken-for-granted "intervention".

## Discussion

Within this paper we have developed, through an analysis of evidence from a range of studies, a set of comparisons that communicate the benefits of population health interventions compared with those of medications. These comparisons cover a range of population health interventions, including implementation of national smoke free legislation, increasing opportunities for active travel and protecting local tree canopy, compared with standard medications for prevention of cardiometabolic diseases and related events (e.g. myocardial infarction). In some cases, the benefits of population health interventions were found to be equivalent to, or even outweighed those of the medications with which they were compared. For example, improving socioeconomic circumstances may result in a 22% reduction in type 2 diabetes risk, compared with an 18% reduction from metformin over a similar period of time. In other comparisons, the public health benefits may be less than those yielded through taking medications, such as switching from private motor vehicles to active travel for commuting purposes. The purpose of these comparisons was not to demonstrate that the benefits of population health interventions are necessarily always greater than those of medications, but to construct such comparisons as a means of anchoring the effects of population health interventions against those of familiar and possibly more widely accepted interventions (i.e. medications).

It is important to note that the benefits of the population health interventions are not isolated to those diagnosed with a non-communicable disease requiring medication. Also, population health

**Table 4**  
Comparisons for blood pressure reduction (set 3).

N	Effect size of medication	Effect size of the population health intervention	Interpretation
3.1	<b>Antihypertensive medications:</b> The effect of one standard dose of antihypertensive medications is estimated between 5.7 mmHg to 11.7 mmHg and 3.1 mmHg to 6.9 mmHg in reduced systolic and diastolic blood pressure, depending upon pre-treatment level (Law et al., 2009).	<b>Physical activity in green space:</b> An RCT showed exercise taken with a view of green space was found to lead to reductions in systolic blood pressure of 12.35 mmHg (pre = 127.95 mmHg, post = 115.60 mmHg) and diastolic blood pressure of 6.3 mmHg (pre = 77.20 mmHg, post = 70.90 mmHg), compared with a reduction of 3.8 mmHg in systolic blood pressure (pre = 122.10 mmHg, post = 118.30 mmHg) and 0.7 mmHg in diastolic blood pressure (pre = 73.50 mmHg, post = 72.80 mmHg) for a control group doing the same exercise but with no green space (Pretty et al., 2005).	Supporting regular exercise within or with a view of green spaces could reduce systolic and diastolic blood pressure by approximately 12.4 mmHg and 6.3 mmHg, respectively, compared with a reduction of between 5.7 and 11.7 mmHg in systolic blood pressure and 3.1 and 6.9 mmHg in diastolic blood pressure from a standard dose of antihypertensive medication (depending upon pre-treatment levels).
3.2	<b>Antihypertensive medications:</b> The effect of one standard dose of antihypertensive medications is estimated between 5.7 mmHg to 11.7 mmHg and 3.1 mmHg to 6.9 mmHg in reduced systolic and diastolic blood pressure, depending upon pre-treatment level (Law et al., 2009).	<b>Increasing neighbourhood walkability:</b> A cohort study showed 1-standard deviation (7.95 unit) increase in neighbourhood walkability was associated with a 0.81 mmHg reduction (95%CI -1.55 to -0.07) in systolic blood pressure (Braun et al., 2016).	Increasing neighbourhood walkability could reduce systolic blood pressure by a little under 1 mmHg, compared with a 5.7–11.7 mmHg reduction from a standard dose of antihypertensive medication (depending upon pre-treatment levels).

95%CI = 95% confidence interval; BMI = body mass index; RR = relative risk; HR = hazard ratio; OR = odds ratio.

interventions can have multiple health effects. For example, in addition to reducing the risk of acute coronary events, there is strong evidence to suggest that smoke-free legislation also contributes substantial reductions in preterm births and hospital attendance for asthma (Been et al., 2014). Indeed, the same benefits conferred by population health interventions for prevention are also desirable for the management of many diseases, such as the need to be physically active to both prevent and enhance the management of type 2 diabetes.

It is also important to acknowledge that the total *health* benefit accrued from population health interventions is often just a proportion of their total potential *overall* benefit, which may include co-benefits in other aspects of societal wellbeing. For example, public policy that increases the provision of alternatives to private motor vehicles, such as bicycle share and good quality public transport, not only helps to increase physical activity but also reduces carbon dioxide emissions and traffic congestion (Rissel, 2009). Future work could explore whether communicating the co-benefits of population health interventions within these comparisons would strengthen the impact of the messages.

This study is based on the idea that population health scientists have to produce more than just evidence if they want societies to act on their results. Population health scientists have to consider where their results are positioned in relation to the audience's preconceived views and biases (Kraft, Lodge, & Taber, 2015). The most familiar "currency" of effect amongst the general public is possibly that which can be brought about through pharmaceutical means. While pharmaceutical companies may propagate the idea of there being "a pill for every ill", population health scientists can counter with evidence of the effectiveness of public policy. This is not an argument to replace the role of a physician in choosing what is best for the patient in front of them. It is simply a strategy which could enhance the credibility and familiarity of public policy to a public increasingly exposed to the marketing of pharmaceutical solutions and could make investments in population health interventions seem less risky to governments. This is particularly important given the evidence that pharmaceutical-based prevention strategies are insufficient and likely to exacerbate health inequities (Capewell & Graham, 2010).

Within the comparisons presented, we have considered the relative effect sizes of public policy and medication. The next step will be to consider empirically whether such comparisons do indeed serve as a valuable communication tool. By communicating population health interventions in these terms we suggest it may be possible to increase awareness and perceived credibility of such interventions in the public mindset. Previous research has illustrated that the media has interest in such comparisons, suggesting a resonance with journalists and the general public (Astell-Burt et al., Unpublished). This highlights the need

to ensure that such comparisons are robust and well communicated. The development of the ten comparisons in this paper invites opportunities to explore the extent to which they spark interest, inform and are perceived as credible by the public.

One consideration arising from this work is whether communication about public health effects may be more persuasive if scientists can specify the pathways by which they work. This may be challenging, for in many cases, causality may be partially direct and partially mediated, serially and or in parallel, by multiple pathways. The hypothesised mechanisms linking contact with green space and blood pressure reduction is a useful example for illustrative purposes. Contact with green space is hypothesised to promote health via three domain pathways known as restoration, instoration and mitigation (Markevych et al., 2017). Restoration is prompted via psychoneuroendocrine mechanisms in which contact with green space triggers positive psychological and physiological reactions (Kaplan, 1995; Ulrich, 1983), such as modification of the functioning of the hypothalamic pituitary adrenal (HPA) axis that regulates cortisol secretion. Stress reduction and cognitive restoration may also be enhanced by biodiverse green spaces that augment the visual effects with natural soundscapes (Saadatmand et al., 2013). These effects are closely entwined with instoration mediated by actions such as physical activity and social recreation that occur within or with a view of green space (Astell-Burt, Feng, & Kolt, 2014; de Vries, van Dillen, Groenewegen, & Spreeuwenberg, 2013). Over and above these benefits, there is evidence of passive health benefits in which green spaces help to keep urban areas cooler (Rosenzweig et al., 2009) and serve to mitigate exposure to traffic-related pollution (Abhijith et al., 2017; Feng and Astell-Burt, 2017). The sum benefit of all of these domain pathways has been argued to be the narrowing of health inequities, by disproportionately benefiting residents of disadvantaged communities (Mitchell and Popham, 2008; Mitchell, Richardson, Shortt, & Pearce, 2015). Future work on comparisons as a means of communicating public health research ought to explicitly test the extent that persuasion is enhanced, or maybe diminished, by specification of these (often multiple) pathways.

### Limitations

Some of the comparisons drew upon evaluations of real policies, such as smoke-free legislation, or government sponsored experiments as was the case of the Moving to Opportunity program. Several were more loosely based around known changes that have occurred nationally, such as salt reduction strategies (He et al., 2014), and locally, such as efforts to improve access to cycling infrastructure (Panter et al., 2016). Although our stated ambition was to base as many of our comparisons

on meta-analyses of RCTs as possible, the vast majority of evidence available was from single observational longitudinal studies. Accordingly, we selected longitudinal studies if they were designed to eliminate potentially large amounts of confounding through statistical techniques, such as ‘fixed effects’ models. The spread of evidence drawn upon reflects the evidence for population health interventions is mainly non-experimental. This may present a challenge for those who view the randomised controlled trial as the only source of high quality evidence.

Another potential limitation was that evidence for many of the population health interventions featured in this paper may be context specific, with economy, culture, politics and a range of other factors potentially modifying both the likelihood of implementation and the degree of benefit conferred. Further, while the health benefits yielded from the same interventions can also vary between groups within the same context who might be considered to have different degrees of underlying risk, the evidence in this paper has focussed solely on the overall effect. Evidence from population health interventions often takes into account data from communities or entire countries, in which people with varying levels of underlying risk are included. For example, work by Pell and colleagues reporting a 17% overall reduction in hospitalisations for acute coronary syndrome following the implementation of smoke-free legislation in Scotland also included reductions of 14% among smokers (i.e. higher risk) and 21% among people who had never smoked (i.e. lower risk) since the treatment was not restricted to any particular group (Pell et al., 2008). The same population-level effects are not always achievable from medications and may even be diluted, as it is not necessarily appropriate to expand medical treatment beyond high-risk groups. For example, work by Sussman and colleagues reported almost all of the benefit of taking metformin for prevention of type 2 diabetes is experienced among people in the highest risk quartile, with no benefit among those in the low risk quartile (Sussman, Kent, Nelson, & Hayward, 2015). However, the difficulty of scaling up to the population level is not uniform across medications, with evidence that those who are not high risk can still gain benefits from taking statins for primary prevention of cardiovascular events (Cholesterol Treatment Trialists, 2012).

## Conclusion

Communicating the benefits of population health interventions through comparison with medications offers a means to anchor the unfamiliar to the familiar, potentially increasing the familiarity, credibility and acceptability of population health interventions. We drew on existing literature to develop a set of comparisons and discuss the nature of the evidence used to develop these. We invite empirical exploration of the value of these comparisons in communicating the benefits of population health interventions and for others to test out and construct their own comparisons. If we are to keep people healthy and out of hospital, we need to increase public and political support for the programs and policies that we know to be effective for prevention. We believe that the use of comparisons may provide one avenue through which we can achieve this.

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## Author contributions

PH conceived the idea and secured the funding. SR and TAB searched and synthesised the literature. TAB led the methods and analysis. All authors were engaged in critical aspects of interrogation, interpretation and refining the design of the analogies. All took part in writing the paper.

## Dedication

To Associate Professor Sonia Wutzke (1970–2017). The public health community is richer for having had you as one of its most passionate advocates.

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