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Reconceptualizing precision public health

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ABSTRACT

As it is currently conceived, precision public health is at risk of becoming precision medicine at a population level. This paper outlines a framework for precision public health that, in contrast to its current operationalization, is consistent with public health principles, and integrates personalized and population-based approaches. We review the conceptual foundations of public health, outline a proposed framework for precision public health, and describe its operationalization within research and practice. Social position shapes individuals' unequal experiences of the social determinants of health. Thus, in our formulation, precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded. It leverages this information to uncover the precise and intersecting social structures and processes that pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups. We contend that studies informed by this framework offer greater potential to improve health than current conceptualizations of precision public health which do not address root causes. Moreover, expanding beyond master categories of social position (i.e. income, education, occupation), operationalizing these categories in more precise ways across place and time and examining overlap, can enrich public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of health risk, the causal mechanisms at play and the most appropriate interventions. Conceptualized thus, precision public health is a research endeavour with much to offer by way of understanding and intervening on the causes of poor health and health inequities.

Keywords: Precision public health; Social determinants of health; Health inequities; Social position; Social context

INTRODUCTION

From precision medicine to precision public health

In January 2015, US President Barack Obama boldly proclaimed that precision medicine would radically transform health by tailoring treatment and prevention to the biological risk profile of the individual patient.[1] These individualized medical interventions would emerge from analyzing data in large biobanks, sequencing more genomes and linking biological information to electronic health records. Efforts are now underway worldwide to achieve this aim. The idea that better health might be achieved through such approaches is consistent with a biomedical model of health which posits that health is primarily a product of individual biological (e.g. genetics, age, sex) and behavioural risk factors (e.g. dietary intake, physical activity, sleep patterns). Despite the dominance of this model within modern medical practice, evidence indicates that these individual level risk factors account for very little of the variation in disease risk at a population level.[2 3] Instead, differences in health status appear to be largely attributable to the living conditions individuals encounter on a daily basis, and cumulatively over their life course.[4]

Regardless of whether precision medicine succeeds in tailoring treatment to the biological risk profiles of individual patients, because of the limited explanatory power of individual level risk factors, it cannot yield the promised transformations in ill health at a population level. Imagine that John Snow had applied the tools of precision medicine during the 1854 cholera outbreak. He may have advised his countrymen to seek treatment individualized to their genetic susceptibility, or advised those at highest risk to alter their health behaviours. Instead, by simply removing the handle of the Broad Street pump, Snow changed the social conditions in which residents lived, preventing them from becoming sick in the first place. There must be a balance between

attention to individual biological and behavioural risk factors, and the avoidable risk factors for disease that arise from the conditions of daily life. Moreover, interventions based in a biomedical model of health remain fundamentally agnostic on the subject of health inequities, and to the extent that access to care is often greater for those with greater means,[5] may even exacerbate them.

Current conceptualizations of precision public health

Initially proposed in Australia in 2013 as a complement to the precision medicine initiative,[6] precision public health has been variously characterized as "providing the right intervention to the right population at the right time",[7] "applying emerging methods and technologies for measuring disease, pathogens, exposures, behaviors, and susceptibility in populations to improve health",[8] among others. Big data and informatics are central to most definitions, and indeed some suggest that the use of such data are the defining feature of a precision public health approach.[6 9] Priority actions centre upon collecting data from large, diverse samples, amassing unbiased genetic and environmental data, education, public health-health care partnerships, early detection especially through genome sequencing, and enhancing public health surveillance and tracking.[7 9] It has further been suggested that the aims of precision medicine and public health might be reconciled through scaling-up precision medicine approaches to whole populations,[6] and by incorporating information on environmental and socioeconomic factors into precision medicine analyses.[10]

It therefore appears that, as currently conceived, precision public health is merely precision medicine scaled-up to a population level, often through leveraging big data, the science of

'omics' and other technological advancements.[11] Noticeably absent from this body of literature is focused attention to foundational public health concepts such as social position, the social determinants of health and health inequities, nor to their political and social origins, meanings and implications. That the modern conception of precision public health should be so heavily rooted in a biomedical paradigm of health is antithetical to the very foundations of public health, and points to a need for a profound realignment.

Objectives

The purpose of this paper is to posit a precision public health approach that addresses the social causation of health and health inequities as worthy of at least equal attention and investment as is precision medicine. We offer a renewed vision for precision public health that places social position and its context-specific interacting dimensions, determinants, and health consequences at the heart of study, and seeks to study these with greater precision in order to identify points of intervention that are specific enough to be useful in reducing health inequities. In this way, the framework offers a means to integrate personalized and population-based approaches to prevention. We argue that the proposed framework may offer greater potential to improve health and reduce health inequities than both biomedically-based notions of precision public health that do not address root causes, and public health as currently practiced which, although it addresses root causes, does so in a homogenizing way. We begin with a brief review of the conceptual foundations of public health, then present a case for more precise attention to social position within a reconceptualized framework for precision public health, and describe its operationalization within research and practice.

CONCEPTUAL FOUNDATIONS OF PUBLIC HEALTH

Social determinants of health

The social determinants of health encompass the conditions of daily life in which individuals are born, grow, live, work and age, including features associated with their early childhood, employment grade, housing conditions, incomes, experiences of discrimination, neighbourhood environments and level of education.[4] Individual biology and health behaviours are included, but occupy a less prominent role. That the quality of social conditions should so fundamentally shape the health of individuals and populations was perhaps most convincingly demonstrated by the Whitehall Studies of British civil servants, whereby it was shown that health declined with each step down the social ladder, even among a group of relatively well-paid individuals with stable employment, and for whom health care was provided as a matter of right.[2] The 2008 report of the WHO Commission on the Social Determinants of Health synthesized evidence on the social determinants of health into a coherent framework and agenda for action.[4] A key contribution was its acknowledgment that addressing the social determinants of health implies a joint attack on both the social causes of poor health and health inequities.

Health inequities and social position

Health inequities are systematic differences in health between groups occupying unequal positions within society.[4] These differences are not merely a problem between the extremes of the continuum, but are evident across the entire social gradient. Health inequities are a consequence of societal structures that distribute resources, power and prestige according to factors such as income, education, occupation, and others.[4] While the term health inequalities refers to differences in health, the concept of inequities invokes a moral judgement that these

differences are unfair because they are potentially avoidable. Inherent within a social determinants perspective is the need to attend to both the social factors that shape the health of individuals and populations, and the social processes that govern their social patterning.[4 12]

The conceptual framework elaborated by the WHO Commission on Social Determinants of Health [4] has summarized the social production of health and health inequities as follows: 1) Social contexts, broadly interpreted to include the interlocking societal structures that shape the distribution of resources within society, create social stratification by assigning individuals to different social positions; 2) Social position shapes individuals' access and vulnerability to intermediary determinants of health, which include principally material and psychosocial circumstances, and secondarily behavioural and biological factors; 3) Systematic differences in health emerge across the entire social spectrum in response to these differential exposures; and 4) Poor health feeds back to exacerbate the subordinate social positions occupied by individuals, perpetuating inter-generational cycles of marginalization and poor health, and affecting the operation of social, political and economic institutions.

Thus, whereas the social determinants of health encompass all of the social factors that shape health collectively, the quality of the social determinants that individuals experience is governed by their position within the social hierarchy, which we refer to hereafter as social position.[12] Social position therefore marks the point where societal structures intersect with the lives of individuals by shaping their unequal experiences of the social determinants of health, and in this way constitutes a lynchpin mechanism through which health inequities are generated, perpetuated and maintained.[4 12 13] Understanding how multiple layers of advantage and

disadvantage overlap, interact and are embodied across the life course within the construct of 'social position' is therefore central to understanding the social production of (ill) health and corresponding points of intervention. While the terms social class, socioeconomic status, social position and socioeconomic position are often used interchangeably, we designate social position as the higher order, aggregate construct that reflects individuals' perceived and objective placement within hierarchies of prestige, power and access to resources.[14]

(Re)Conceptualizing and operationalizing social position

Given that social position is a key mediator of health and health inequities, biomedically-based conceptualizations of precision public health that largely ignore, or that relegate social position to a subordinate role, offer limited potential to improve health. However, to redefine precision public health by simply substituting social factors for biological and behavioural ones would fail to mark precision public health as distinct from current public health practice. It would also would miss the opportunity to consider whether social position might be more effectively conceptualized and operationalized to advance health and health equity, and it is to this issue that we now turn.

In modern liberal welfare states, individuals' attain different positions within the social hierarchy according to factors such as level of income, educational attainment and occupation, and as such many studies operationalize social position according to one or several of these objective indicators, what we refer to as 'master categories.'[4 15] It is important that these indicators not be conflated, however, as although they overlap, they also represent different structures of inequality. For example, income is an indicator that most directly reflects access to material

resources (e.g. housing, food, clothing), whereas education closely reflects knowledge-related assets and is a strong determinant of future employment and income.[4 16] That these three categories should consistently be accorded greater significance relative to others in explaining the patterning of health may be more a matter of convenience (i.e. the data are available) than an evidence-based practice, and disregards other powerful dimensions of inequity. Indeed, common measures of social position explain only a fraction of the structural inequities confronted by racial/ethnic minorities.[17]

Focusing on these unitary categories of difference to the exclusion of others or in isolation from one another, as many studies do, may obscure understanding of the complexity of social position. A more comprehensive perspective acknowledges social position as a context-specific social construct that represents a mixture of these and other axes of social differentiation,[15] including age, gender/sex, race/ethnicity, wealth, citizenship status, religion and disability.[4] Bourdieu's[18] notions of economic, social and cultural capital are other aspects of social position that can reflect, respectively, financial, relational and socially distinctive assets. Identity- and rank-based perceptions of ones' own social position must also be considered,[15] and, because they entail a reflective averaging of past and current statuses and future expectations,[15 19 20] may embody the cumulative, combined and interactive effects of multiple dimensions of social position more fully than objective indicators.

In addition to expanding beyond master categories of social position, attending to the heterogeneity within them may further improve understanding of health inequities by examining individuals as persons whose experiences of health cannot be ascertained on the basis of any one

indicator.[15 21] Intersectionality theory uses the term social location to refer to the interplay among a variety of social determinants in shaping the unique social experiences of vulnerable groups. A key insight from this theoretical approach is that experiences of advantage and disadvantage are not merely additive in their effects.[22] Some groups experience more negative, and others more positive health effects than would be predicted on the basis of adding together their individual positions.[22-24] For instance, among Black women in the US with less than a high school education, being a Black woman has a negative effect on health beyond the main effects contributed by race, gender and other factors.[22] Notably, this effect disappears among Black women who attain a higher level of education.

What this example illustrates is that not only do inequities in the distribution of social resources correlate highly with race/ethnicity, education and gender/sex, but also that these inequities are enhanced through interactions among these factors.[22] That is, there is no prototypical experience of what it means to be a woman, instead, women experience their gender differently based on their position within other social structures of race/ethnicity, class, and others.[24] Dimensions of social position must therefore be interrogated in tandem, because it is at the nexus of these intersecting domains that a precise social identity is created whose health effects cannot be understood on the basis of its individual parts.[25] Failure to attend to these interactions may limit understanding of how the meanings of different dimensions of social position are mutually constituted, simultaneously experienced, and jointly associated with health, thereby yielding misleading results.[26]

Beyond considering its varied, mutually-constituted and reinforcing dimensions, there are many other ways in which social position could be operationalized in more precise ways to advance public health research. For instance, indicators of social position are often dichotomized (e.g. < high school education vs > high school education; White vs 'other'), which may obscure gradients across the entire social spectrum or for particular groups (e.g. racial/ethnic minorities) that might be uncovered by using more categories or continuous measures.[21 27] Studies may only consider quantitative aspects of social position (e.g. years of education), while neglecting its qualitative dimensions (e.g. quality of the education received),[28] or they may focus exclusively at the individual level and neglect factors at the contextual level (e.g. neighbourhood disadvantage) that may also be theoretically relevant.[21] Furthermore, given that social position is socially constructed, some axes of differentiation may be more salient in particular times and places. The health effects of social position should therefore be studied in particular historical moments and within particular social, political, geographic and economic contexts, including at the broader contextual level (e.g. year, nation) and specific to the life course (e.g. age, marital status, place of residence).[21] Yuval-Davis[29] has labelled these considerations translocality (how the meaning of social position varies by place), transcalarity (how the meaning of social position varies in small scale settings vs in higher level regions) and transtemporality (how the meaning of social position varies over time).

Contextual pathways to social position

The purpose of expanding beyond master categories of social position and operationalizing these categories in more precise ways is to further understanding of the nature of health risk, the causal mechanisms at play, and ultimately identify potential points of intervention that are specific

enough to be useful in reducing health inequities. Health inequities are generated within a sociopolitical context, including systems of governance, economic, social and public policies, culture and societal values.[4] These contextual factors create, configure and maintain patterns of social stratification by determining the manner in which power and resources are distributed amongst social groups. Thus, it is within the social context that the so-called 'causes of the causes' of health inequities ultimately reside.[4]

The identification of health inequities according to dimensions of social position (e.g. race/ethnicity and income) therefore provides an indication that exclusionary processes are at play (e.g. racial/ethnic segregation, inadequate minimum wage policies) that require further investigation. They can also prompt a search for inclusionary processes (e.g. opportunities for social interaction) that may buffer these same processes of marginalization. Therefore, just as the multi-faceted nature of social position requires precise quantification, so too do the broader macro level factors that structure them; and the role of the former is primarily to prompt and inform a more in-depth examination of the latter. By linking health inequities experienced by those occupying precise social positions to their precise social contexts, we can better consider causal pathways and begin to identify opportunities for intervention that address the root causes of these inequities. The interventions that arise from such analyses are likely to be more effective and efficient because they address specific sources of social differentiation.

A case in point concerns educational gradients in health in the US.[28] Although a gradient is evident in men and women[30] and among all racial/ethnic groups,[31] the incremental value of educational attainment appears strongest in women,[32] and non-Hispanic whites.[33 34] These

findings could prompt a search for educational processes responsible for these differential outcomes, such as gendered teaching styles, or curricula that ignore colonialist practices. Such analyses should also attend to the ways in which these institutional structures interact with one another and with dimensions of social position to shape health, and how their health effects vary over time. In this way, identification of heterogeneity in health outcomes can prompt a search for the sources of this underlying heterogeneity, directing resources to the most pressing and important contextual targets, particularly those that cut across positional categories.

A FRAMEWORK FOR PRECISION PUBLIC HEALTH

Reconceptualizing precision in public health

We have described social position and its complex and mutually constituted dimensions, along with the contextual factors that generate, configure and maintain patterns of social stratification as key targets for focused investigation, and have highlighted areas in which greater precision might be achieved in order to more precisely identify dimensions of social position that confer health risk, and the social contexts that configure them. We now use the preceding discussion as a basis to outline a framework for precision public health that integrates personalized and population-based approaches to population health improvement by focusing on social position as a root cause of ill health, and operationalizing this construct in more precise ways. In this way, the proposed framework affords potential for more effective intervention than both biomedically-based notions of precision public health that do not address root causes, and current public health research that homogenizes individuals' health experiences.

Central to the notion of precision in health is the concept of identifying specific risk factor profiles that confer vulnerability to poor health. Whereas precision medicine regards vulnerability as a function of biomedical and behavioural risks, vulnerability within a social determinants paradigm is an emergent process that unfolds across the life course in response to multiple and varied experiences of social privilege and marginalization in a variety of contexts. Thus, social position and its context-specific interacting dimensions, determinants, and health consequences constitute the central locus of study within a precision public health approach. That the context exerts its influence on health via social position marks both as important priorities of investigation. However, because the causes of health inequities originate within the social context, it is the context, rather than social position itself, that presents the most effective opportunities for intervention. A more fulsome and precise characterization of social position may more accurately pinpoint the origins of health inequities within the social context, enabling development of interventions that have a greater likelihood of success because they attend to the particular experiences and contexts of affected groups.

We therefore propose that attention to social position reframes the practice and aims of precision public health to be:

Precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded. It leverages this information to uncover the precise social structures and processes that pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups.

OPERATIONALIZING PRECISION PUBLIC HEALTH IN RESEARCH TO INFORM PRACTICE

Based on this definition and related substantive considerations, the accompanying Text Box proposes six recommendations for operationalizing a precision public health study from theoretical premise through identifying promising interventions. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study, while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

Use theory within a precision public health framework as a conceptual and operational guide to research

Precision public health provides a framework for investigating the precise contextual pathways, mediated by social position, through which health inequities arise. This broader framework can accommodate theoretical and methodological diversity. For instance, precision public health studies could investigate materialist or psychosocial mechanisms underlying health inequities. Therefore, the starting point for precision public health studies is to articulate the hypothesized theoretical processes and experiences of social stratification at play. This theory can then provide a conceptual and operational guide for conducting the research, and in particular, to select meaningful social positions and contexts for study in relation to the health outcomes of interest.

Precision public health does not entail the study of all possible social position-social context combinations, but encourages scientists to attend to meaningful diversity within samples that

capture salient social experiences, while acknowledging the potential implications of excluding others.[35] A key consideration concerns whether all social positions are equally deserving of study, or only those that are associated with the greatest disadvantage.[36] Importantly, health inequities exist across the entire social spectrum,[2 4 37 38] and most populations will experience forms of advantage and disadvantage across the life course.[36] It is therefore important to understand how experiences of advantage and disadvantage interact to shape health in all social groups, and how they vary across place and time, to ensure a more comprehensive understanding of the social production of health. The acronym PROGRESS-PLUS[39] (Place of residence; Race/ethnicity/culture/language; Occupation; Gender/sex; Religion; Education; socioeconomic position and social capital; PLUS captures all other indicators of disadvantage) includes many indicators of disadvantage, and may be helpful in identifying salient social categories that interact.

Identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups

Having developed a theory-informed research plan, analyses can then proceed to identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups.

A variety of methods, both existing and new, and bridging all three traditions – quantitative, qualitative and mixed - can contribute to precision public health analyses. Machine learning, in which machines learn from patterns in the data rather than being pre-programmed to follow a particular analytical routine, is among the most promising approaches for uncovering novel

intersections worthy of further study. However, caution is required given the potential to exacerbate existing inequities when data are missing or incomplete for some social groups.[40] Other quantitative methods that can be adapted for precision public health applications span traditional techniques (e.g. including interaction terms in regression analyses,[22 41] structural equation modelling, and latent class,[42] mediation,[43] and path analysis), to the more novel and complex (e.g. multilevel modelling,[23] signal detection models,[44] Chi-Square Automatic Interaction Detection,[45-47] quantifying discriminatory accuracy,[48] agent-based modelling[49]). Modelling approaches that explicitly allow consideration of multiplicative, rather than simply additive positionalities, may be particularly helpful.[22] Situating the analyses in particular historical and social moments, both to provide background for the reader, and when interpreting findings, is essential. Methods such as qualitative comparative analyses[50] and multiple case studies[51] that explicitly account for context may be particularly valuable in this respect, as can longitudinal analyses that examine change in social positions in relation to change in health over time. Marginalized groups that co-locate geographically may be subject to similar policy, environmental and social exposures; and therefore area-based analyses to identify areas with a high burden of disease, and/or where income inequality is high may help to identify contexts for focused study.[52]

Reconceptualizing constructs such as race/ethnicity and gender as social processes (i.e. experiences of racism and sexism), rather than as characteristics of individuals may prove valuable in helping to uncover structural causes of inequities, particularly those that cut across intersections of social position.[26 35] Experimental techniques that manipulate subjective social position[53] and that prime certain identities[54] are also promising. Finally, qualitative methods are

well-suited to understanding the experience of health inequities and the social mechanisms that generate and configure them. In particular, phenomenology can provide an in-depth perspective of the lived experience of social position,[55] while ethnography can help to understand the collective cultures and norms of specific social groups from an 'emic' perspective.[56] These and other types of qualitative analyses can complement, supplement or triangulate quantitative analyses within mixed methods studies. Bauer[36] and Warner[35] have summarized a variety of intersectional methods that might also be adapted for precision public health applications.

Knowledge-to-action: Precision public health in the real-world

The aims of precision public health will only be realized to the extent that findings are mobilized into real-world interventions that effectively address the social drivers of poor health and of health inequities. Current public health approaches to mitigating inequities primarily consist of universal programs and policies that operate across entire populations, and targeted approaches that direct attention to those considered to be the worst off.[14] Precision public health is most closely aligned with the notion of targeting, however the two are not synonymous, as in many cases, targeting problematizes the broad behavioural and social risk factor profiles of individuals, rather than the structural forces responsible for situating them within disadvantaged social contexts. Although limited progress is evident in some cases,[57] these programs and policies have largely proven incapable, on their own, of substantially reducing health inequities,[58-63] suggesting that new, complementary approaches may be needed.

Interventions formulated within a precision public health paradigm may represent one such complementary approach. Greater precision in formulating public health interventions may help

to avoid creation of programs and policies that meaningfully apply to no one because they concern factors that shape the health of 'average' disadvantaged individuals who may not actually exist. Moreover, a precision public health approach appropriately targets social processes and contexts rather than high-risk individuals and groups, and seeks to directly alter these social processes and contexts rather than to simply mute the unhealthy effects of social position (i.e. an approach we liken to prescribing an 'equitinol' pill that dampens the pathophysiologic response to allostatic load (e.g. [64])). Nevertheless, given that health is shaped by a chain of social processes, interventions of all types – universal, targeted and precise - and spanning all leverage points - upstream, midstream and downstream – are needed, and can complement one another.[37 65-70] Precision public health interventions might therefore be most usefully enacted within a reframed proportionate universalist approach whereby some interventions are universally provided, while others are targeted or precisely tailored to meet the needs of, and offset barriers to health encountered by vulnerable subgroups.[71 72] This approach integrates personalized and population strategies and modelling studies support its efficacy in reducing health inequities.[73] A precision public health lens also encourages attention to the effects of interventions on subgroups who are not the intended targets.

DISCUSSION AND CONCLUSIONS

The renewed vision of precision public health presented herein endeavours to disrupt biomedical approaches to health and linear thinking that essentializes the health experiences of heterogeneous groups. Social position is an inherently dynamic social construct, consisting of mutually constituted objective and subjective components. It is precisely this complexity that most previous investigations have ignored, that we maintain may in fact be perpetuating health

inequities. Embracing this complexity through a precision public health approach may yield considerable progress in improving health and reducing health inequities, but will require a fundamental paradigm shift in the manner in which social position is conceptualized and operationalized within research, and ultimately within practice (Table 1).

Health inequities constitute inequities in people's capacity to function and realize their full potential, making them a priority for intervention within any just society. However, despite attempts to eliminate them, health inequities persist and have even widened in some cases. If we accept that health inequities are socially patterned, then it follows that their solutions must also be. Current conceptualizations of precision public health based in a biomedical model of health are therefore fundamentally incapable of yielding progress toward this end. Precision public health is not simply precision medicine at a population level.

Health inequities may be driven by multiply marginalized populations who experience excess health risk.[21-23 41 74] Expanding beyond master categories of social position, and operationalizing these categories in more precise ways across place and time, can enrich public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of risk, the causal mechanisms at play and the most appropriate interventions. Conceptualized thus, precision public health is a research endeavour and an aspect of public health practice with much to offer by way of understanding and intervening on the causes of poor health and health inequities.

Authors' contributions

DLO and LM conceived of and wrote the paper. All authors read and approved the final manuscript.

Competing interests

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Text Box 1: Recommendations for achieving greater precision in public health. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study, while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

1. Provide explicit and **precise descriptions of the theoretical rationale** underlying the selection and operationalization of social positions, social contexts, health outcomes, and potential confounders. **The proposed causal pathways should be precisely identified a priori**.
2. **Identify the precise social positions of populations of interest** and investigate their associations with health by expanding beyond common unitary categories to examine other dimensions of social position, and the heterogeneity that exists within social categories. Measures of **perceived social position** should be explored more fully.
3. **Operationalize social position in more precise ways**, such as by using continuous measures or more categories, considering qualitative and quantitative features, and considering factors at multiple levels.
4. **Describe the precise time and context of measurement of social position** and study the health effects of social position **in a variety of contexts and at multiple time points across the life course**.
5. Use **precise language to describe health inequities** (e.g. inequities in cardiovascular disease according to wealth and gender).
6. Use knowledge of the health effects of individuals' precise social positions to inform the study of **precise contextual mechanisms** responsible for situating them there. Leverage this information to propose **precise interventions** to ameliorate health inequities

Table 1 Reconceptualizing precision in public health

Move away from…	Move towards…
Biomedical model of health	Social determinants model of health
The functions (e.g. surveillance) and methods (e.g. big data) of public health	The foundations (e.g. social determinants) and core aims (e.g. improve population health, reduce health inequities) of public health
Unitary, master categories of objective social position (i.e. income, education, occupation)	Social position as a construct that is both objective and perceived through lived experiences
Problematizing individuals and their behaviours	Problematizing the social contexts that create social stratification
Scaled-up versions of individual level interventions	Interventions that address the root causes of health inequities
Precision medicine for the population	Precision public health

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Reconceptualizing precision public health

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ABSTRACT

As it is currently conceived, precision public health is at risk of becoming precision medicine at a population level. This paper outlines a framework for precision public health that, in contrast to its current operationalization, is consistent with public health principles, and integrates personalized and population-based approaches. We review the conceptual foundations of public health, outline a proposed framework for precision public health, and describe its operationalization within research and practice. Social position shapes individuals' unequal experiences of the social determinants of health. Thus, in our formulation, precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded, while considering relevant biological and behavioural factors. It leverages this information to uncover the precise and intersecting social structures and processes that pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups. We contend that studies informed by this framework offer greater potential to improve health than current conceptualizations of precision public health which do not address root causes. Moreover, expanding beyond master categories of social position (i.e. income, education, occupation) and operationalizing these categories in more precise ways across place and time can enrich public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of health risk, the causal mechanisms at play and the most appropriate interventions. Conceptualized thus, precision public health is a research endeavour

with much to offer by way of understanding and intervening on the causes of poor health and health inequities.

Keywords: Precision public health; Social determinants of health; Health inequities; Social position; Social context

INTRODUCTION

From precision medicine to precision public health

In January 2015, US President Barack Obama boldly proclaimed that precision medicine would radically transform health by tailoring treatment and prevention to the biological risk profile of the individual patient.[1] These individualized medical interventions would emerge from analyzing data in large biobanks, sequencing more genomes and linking biological information to electronic health records. Efforts are now underway worldwide to achieve this aim. The idea that better health might be achieved through such approaches is consistent with a biomedical model of health which posits that health is primarily a product of individual biological (e.g. genetics, age, sex) and behavioural risk factors (e.g. dietary intake, physical activity, sleep patterns). Despite the dominance of this model within modern medical practice, evidence indicates that these individual level risk factors account for limited variation in disease risk at a population level.[2 3] Instead, differences in health status appear to be largely attributable to the living conditions individuals encounter on a daily basis, and cumulatively over their life course.[4]

Regardless of whether precision medicine succeeds in tailoring treatment to the biological risk profiles of individual patients, because of the limited explanatory power of individual level risk factors, it cannot on its own yield the promised transformations in ill health at a population level. Imagine that John Snow had applied the tools of precision medicine during the 1854 cholera outbreak. He may have advised his countrymen to seek treatment individualized to their genetic susceptibility, or advised those at highest risk to alter their health behaviours. Instead, by simply removing the handle of the Broad Street pump, Snow changed the social conditions in which residents lived, preventing them from becoming sick in the first place. There must be a balance

between attention to individual biological and behavioural risk factors, and the avoidable risk factors for disease that arise from the conditions of daily life. Moreover, interventions based in a biomedical model of health remain fundamentally agnostic on the subject of health inequities, and to the extent that access to care is often greater for those with greater means,[5] may even exacerbate them.

Current conceptualizations of precision public health

Initially proposed in Australia in 2013 as a complement to the precision medicine initiative,[6] precision public health has been variously characterized as "providing the right intervention to the right population at the right time",[7] and "applying emerging methods and technologies for measuring disease, pathogens, exposures, behaviors, and susceptibility in populations to improve health",[8] among others. Big data and informatics are central to most definitions, and indeed some suggest that the use of such data are the defining feature of a precision public health approach.[6 9] Priority actions centre upon collecting data from large, diverse samples, amassing unbiased genetic and environmental data, education, public health-health care partnerships, early detection especially through genome sequencing, and enhancing public health surveillance and tracking.[7 9] It has further been suggested that the aims of precision medicine and public health might be reconciled through scaling-up precision medicine approaches to whole populations,[6] and by incorporating information on environmental and socioeconomic factors into precision medicine analyses.[10]

It therefore appears that, as currently conceived, precision public health is precision medicine scaled-up to a population level, often through leveraging big data, the science of 'omics' and

other technological advancements.[11] Noticeably absent from this body of literature is focused attention to foundational public health concepts such as social position, the social determinants of health and health inequities, nor to their political and social origins, meanings and implications. That the modern conception of precision public health should be so heavily rooted in a biomedical paradigm of health is antithetical to the very foundations of public health, and points to a need to both enlarge the scope of, and refocus current definitions on core public health concepts.

Objectives

The purpose of this paper is to posit a precision public health approach that expands upon and refocuses current definitions on the social causation of health and health inequities. We offer a renewed vision for precision public health that places social position and its context-specific interacting dimensions, determinants, and health consequences at the heart of study, and seeks to study these with greater precision in order to identify points of intervention that are specific enough to be useful in reducing health inequities. In this way, the framework offers a means to integrate personalized and population-based approaches to prevention. We argue that the proposed framework may offer greater potential to improve health and reduce health inequities than primarily biomedically-based notions of precision public health that do not address root causes, and public health as currently practiced which, although it addresses root causes, does so in a homogenizing way. We begin with a brief review of the conceptual foundations of public health, then present a case for more precise attention to social position within a reconceptualized framework for precision public health, and describe its operationalization within research and practice.

CONCEPTUAL FOUNDATIONS OF PUBLIC HEALTH

Social determinants of health

The social determinants of health encompass the conditions of daily life in which individuals are born, grow, live, work and age, including features associated with their early childhood, employment grade, housing conditions, incomes, experiences of discrimination, neighbourhood environments and level of education.[4] Individual biology and health behaviours are included, but occupy a less prominent role. That the quality of social conditions should so fundamentally shape the health of individuals and populations was perhaps most convincingly demonstrated by the Whitehall Studies of British civil servants, whereby it was shown that health declined with each step down the social ladder, even among a group of relatively well-paid individuals with stable employment, and for whom health care was provided as a matter of right.[2] The 2008 report of the WHO Commission on the Social Determinants of Health synthesized evidence on the social determinants of health into a coherent framework and agenda for action.[4] A key contribution was its acknowledgment that addressing the social determinants of health implies a joint attack on both the social causes of poor health and health inequities.

Health inequities and social position

Health inequities are systematic differences in health between groups occupying unequal positions within society.[4] These differences are not merely a problem between the extremes of the continuum, but are evident across the entire social gradient. Health inequities are a consequence of societal structures that distribute resources, power and prestige according to factors such as income, education, occupation, and others.[4] While the term health inequalities

refers to differences in health, the concept of inequities invokes a moral judgement that these differences are unfair because they are potentially avoidable. Inherent within a social determinants perspective is the need to attend to both the social factors that shape the health of individuals and populations, and the social processes that govern their social patterning.[4 12]

The conceptual framework elaborated by the WHO Commission on Social Determinants of Health [4] has summarized the social production of health and health inequities as follows: 1) Social contexts, broadly interpreted to include the interlocking societal structures that shape the distribution of resources within society, create social stratification by assigning individuals to different social positions; 2) Social position shapes individuals' access and vulnerability to intermediary determinants of health, which include principally material and psychosocial circumstances, and secondarily behavioural and biological factors; 3) Systematic differences in health emerge across the entire social spectrum in response to these differential exposures; and 4) Poor health feeds back to exacerbate the subordinate social positions occupied by individuals, perpetuating inter-generational cycles of marginalization and poor health, and affecting the operation of social, political and economic institutions.

Thus, whereas the social determinants of health encompass all of the social factors that shape health collectively, the quality of the social determinants that individuals experience is governed by their position within the social hierarchy, which we refer to hereafter as social position.[12] Social position therefore marks the point where societal structures intersect with the lives of individuals by shaping their unequal experiences of the social determinants of health, and in this way constitutes a lynchpin mechanism through which health inequities are generated,

perpetuated and maintained.[4 12 13] Understanding how multiple layers of advantage and disadvantage overlap, interact and are embodied across the life course within the construct of 'social position' is therefore central to understanding the social production of (ill) health and corresponding points of intervention. While the terms social class, socioeconomic status, social position and socioeconomic position are often used interchangeably, we designate social position as the higher order, aggregate construct that reflects individuals' perceived and objective placement within hierarchies of prestige, power and access to resources.[14]

(Re)Conceptualizing and operationalizing social position

Given that social position is a key mediator of health and health inequities, primarily biomedically-based conceptualizations of precision public health that largely ignore, or that relegate social position to a subordinate role, offer limited potential to improve health. However, to redefine precision public health by simply substituting social factors for biological and behavioural ones would fail to mark precision public health as distinct from current public health practice. It would also would miss the opportunity to consider whether social position might be more effectively conceptualized and operationalized to advance health and health equity, and it is to this issue that we now turn.

In modern liberal welfare states, individuals' attain different positions within the social hierarchy according to factors such as level of income, educational attainment and occupation, and as such many studies operationalize social position according to one or several of these objective indicators, what we refer to as 'master categories.'[4 15] It is important that these indicators not be conflated, however, as although they overlap, they also represent different structures of

inequality. For example, income is an indicator that most directly reflects access to material resources (e.g. housing, food, clothing), whereas education closely reflects knowledge-related assets and is a strong determinant of future employment and income.[4 16] That these three categories should consistently be accorded greater significance relative to others in explaining the patterning of health may be more a matter of convenience (i.e. the data are available) than an evidence-based practice, and disregards other powerful dimensions of inequity. Indeed, common measures of social position explain only a fraction of the structural inequities confronted by racial/ethnic minorities.[17]

Focusing on these unitary categories of difference to the exclusion of others or in isolation from one another, as many studies do, may obscure understanding of the complexity of social position. A more comprehensive perspective acknowledges social position as a context-specific social construct that represents a mixture of these and other axes of social differentiation,[15] including age, gender/sex, race/ethnicity, wealth, citizenship status, religion and disability.[4] Bourdieu's[18] notions of economic, social and cultural capital are other aspects of social position that can reflect, respectively, financial, relational and socially distinctive assets. Identity- and rank-based perceptions of ones' own social position must also be considered,[15] and, because they entail a reflective averaging of past and current statuses and future expectations,[15 19 20] may embody the cumulative, combined and interactive effects of multiple dimensions of social position more fully than objective indicators.

In addition to expanding beyond master categories of social position, attending to the heterogeneity within them may further improve understanding of health inequities by examining

individuals as persons whose experiences of health cannot be ascertained on the basis of any one indicator.[15 21] Intersectionality theory uses the term social location to refer to the interplay among a variety of social determinants in shaping the unique social experiences of vulnerable groups. A key insight from this theoretical approach is that experiences of advantage and disadvantage are not merely additive in their effects.[22] Some groups experience more negative, and others more positive health effects than would be predicted on the basis of adding together their individual positions.[22-24] For instance, among Black women in the US with less than a high school education, being a Black woman has a negative effect on health beyond the main effects contributed by race, gender and other factors.[22] Notably, this effect disappears among Black women who attain a higher level of education.

What this example illustrates is that not only do inequities in the distribution of social resources correlate highly with race/ethnicity, education and gender/sex, but also that these inequities are enhanced through interactions among these factors.[22] That is, there is no prototypical experience of what it means to be a woman, instead, women experience their gender differently based on their position within other social structures of race/ethnicity, class, and others.[24] Dimensions of social position must therefore be interrogated in tandem, because it is at the nexus of these intersecting domains that a precise social identity is created whose health effects cannot be understood on the basis of its individual parts.[25] Failure to attend to these interactions may limit understanding of how the meanings of different dimensions of social position are mutually constituted, simultaneously experienced, and jointly associated with health, thereby yielding misleading results.[26]

Beyond considering its varied, mutually-constituted and reinforcing dimensions, there are many other ways in which social position could be operationalized in more precise ways to advance public health research. For instance, indicators of social position are often dichotomized (e.g. < high school education vs > high school education; White vs 'other'), which may obscure gradients across the entire social spectrum or for particular groups (e.g. racial/ethnic minorities) that might be uncovered by using more categories or continuous measures.[21 27] Studies may only consider quantitative aspects of social position (e.g. years of education), while neglecting its qualitative dimensions (e.g. quality of the education received),[28] or they may focus exclusively at the individual level and neglect factors at the contextual level (e.g. neighbourhood disadvantage) that may also be theoretically relevant.[21] Furthermore, given that social position is socially constructed, some axes of differentiation may be more salient in particular times and places. The health effects of social position should therefore be studied in particular historical moments and within particular social, political, geographic and economic contexts, including at the broader contextual level (e.g. year, nation) and specific to the life course (e.g. age, marital status, place of residence).[21] Yuval-Davis[29] has labelled these considerations translocality (how the meaning of social position varies by place), transcalarity (how the meaning of social position varies in small scale settings vs in higher level regions) and transtemporality (how the meaning of social position varies over time).

Contextual pathways to social position

The purpose of expanding beyond master categories of social position and operationalizing these categories in more precise ways is to further understanding of the nature of health risk, the causal mechanisms at play, and ultimately identify potential points of intervention that are specific

enough to be useful in reducing health inequities. Health inequities are generated within a sociopolitical context, including systems of governance, economic, social and public policies, culture and societal values.[4] These contextual factors create, configure and maintain patterns of social stratification by determining the manner in which power and resources are distributed amongst social groups. Thus, it is within the social context that the so-called 'causes of the causes' of health inequities ultimately reside.[4]

The identification of health inequities according to dimensions of social position (e.g. race/ethnicity and income) therefore provides an indication that exclusionary processes are at play (e.g. racial/ethnic segregation, inadequate minimum wage policies) that require further investigation. They can also prompt a search for inclusionary processes (e.g. opportunities for social interaction) that may buffer these same processes of marginalization. Therefore, just as the multi-faceted nature of social position requires precise quantification, so too do the broader macro level factors that structure them; and the role of the former is primarily to prompt and inform a more in-depth examination of the latter. By linking health inequities experienced by those occupying precise social positions to their precise social contexts, we can better consider causal pathways and begin to identify opportunities for intervention that address the root causes of these inequities. The interventions that arise from such analyses are likely to be more effective and efficient because they address specific sources of social differentiation.

A case in point concerns educational gradients in health in the US.[28] Although a gradient is evident in men and women[30] and among all racial/ethnic groups,[31] the incremental value of educational attainment appears strongest in women,[32] and non-Hispanic whites.[33 34] These

findings could prompt a search for educational processes responsible for these differential outcomes, such as gendered teaching styles, or curricula that ignore colonialist practices. Such analyses should also attend to the ways in which these institutional structures interact with one another and with dimensions of social position to shape health, and how their health effects vary over time. In this way, identification of heterogeneity in health outcomes can prompt a search for the sources of this underlying heterogeneity, directing resources to the most pressing and important contextual targets, particularly those that cut across positional categories.

A FRAMEWORK FOR PRECISION PUBLIC HEALTH

Reconceptualizing precision in public health

We have described social position and its complex and mutually constituted dimensions, along with the contextual factors that generate, configure and maintain patterns of social stratification as key targets for focused investigation, and have highlighted areas in which greater precision might be achieved in order to more precisely identify dimensions of social position that confer health risk, and the social contexts that configure them. We now use the preceding discussion as a basis to outline a framework for precision public health that integrates personalized and population-based approaches to population health improvement by focusing on social position as a root cause of ill health, and operationalizing this construct in more precise ways. In this way, the proposed framework affords potential for more effective intervention than primarily biomedically-based notions of precision public health that do not address root causes, and current public health research that homogenizes individuals' health experiences.

Central to the notion of precision in health is the concept of identifying specific risk factor profiles that confer vulnerability to poor health. Whereas precision medicine regards vulnerability primarily as a function of biomedical and behavioural risks, vulnerability within a social determinants paradigm is an emergent process that unfolds across the life course in response to multiple and varied experiences of social privilege and marginalization in a variety of contexts. Thus, social position and its context-specific interacting dimensions, determinants, and health consequences constitute the central locus of study within a precision public health approach, while considering relevant biological and behavioural factors. That the context exerts its influence on health via social position marks both as important priorities of investigation. However, because the causes of health inequities originate within the social context, it is the context, rather than social position itself, that presents the most effective opportunities for intervention. A more fulsome and precise characterization of social position may more accurately pinpoint the origins of health inequities within the social context, enabling development of interventions that have a greater likelihood of success because they attend to the particular experiences and contexts of affected groups.

We therefore propose that attention to social position reframes the practice and aims of precision public health to be:

Precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded, while considering relevant biological and behavioural factors. It leverages this information to uncover the precise social structures and processes that

pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups.

OPERATIONALIZING PRECISION PUBLIC HEALTH IN RESEARCH TO INFORM PRACTICE

Based on this definition and related substantive considerations, the accompanying Text Box proposes six recommendations for operationalizing a precision public health study from theoretical premise through identifying promising interventions. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study, while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

Use theory within a precision public health framework as a conceptual and operational guide to research

Precision public health provides a framework for investigating the precise contextual pathways, mediated by social position, through which health inequities arise. This broader framework can accommodate theoretical and methodological diversity. For instance, precision public health studies could investigate materialist or psychosocial mechanisms underlying health inequities. Therefore, the starting point for precision public health studies is to articulate the hypothesized theoretical processes and experiences of social stratification at play. This theory can then provide a conceptual and operational guide for conducting the research, and in particular, to select meaningful social positions and contexts for study in relation to the health outcomes of interest.

Precision public health does not entail the study of all possible social position-social context combinations, but encourages scientists to attend to meaningful diversity within samples that capture salient social experiences, while acknowledging the potential implications of excluding others.[35] A key consideration concerns whether all social positions are equally deserving of study, or only those that are associated with the greatest disadvantage.[36] Importantly, health inequities exist across the entire social spectrum,[2 4 37 38] and most populations will experience forms of advantage and disadvantage across the life course.[36] It is therefore important to understand how experiences of advantage and disadvantage interact to shape health in all social groups, and how they vary across place and time, to ensure a more comprehensive understanding of the social production of health. The acronym PROGRESS-PLUS[39] (Place of residence; Race/ethnicity/culture/language; Occupation; Gender/sex; Religion; Education; socioeconomic position and social capital; PLUS captures all other indicators of disadvantage) includes many indicators of disadvantage, and may be helpful in identifying salient social categories that interact.

Identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups

Having developed a theory-informed research plan, analyses can then proceed to identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups.

A variety of methods, both existing and new, and bridging all three traditions – quantitative, qualitative and mixed - can contribute to precision public health analyses. Machine learning, in which machines learn from patterns in the data rather than being pre-programmed to follow a particular analytical routine, is among the most promising approaches for uncovering novel intersections worthy of further study. However, caution is required given the potential to exacerbate existing inequities when data are missing or incomplete for some social groups.[40] Other quantitative methods that can be adapted for precision public health applications span traditional techniques (e.g. including interaction terms in regression analyses,[22 41] structural equation modelling, and latent class,[42] mediation,[43] and path analysis), to the more novel and complex (e.g. multilevel modelling,[23] signal detection models,[44] Chi-Square Automatic Interaction Detection,[45-47] quantifying discriminatory accuracy,[48] agent-based modelling[49]). Modelling approaches that explicitly allow consideration of multiplicative, rather than simply additive positionalities, may be particularly helpful.[22] Situating the analyses in particular historical and social moments, both to provide background for the reader, and when interpreting findings, is essential. Methods such as qualitative comparative analyses[50] and multiple case studies[51] that explicitly account for context may be particularly valuable in this respect, as can longitudinal analyses that examine change in social positions in relation to change in health over time. Marginalized groups that co-locate geographically may be subject to similar policy, environmental and social exposures; and therefore area-based analyses to identify areas with a high burden of disease, and/or where income inequality is high may help to identify contexts for focused study.[52]

Reconceptualizing constructs such as race/ethnicity and gender as social processes (i.e. experiences of racism and sexism), rather than as characteristics of individuals may prove valuable in helping to uncover structural causes of inequities, particularly those that cut across intersections of social position.[26 35] Experimental techniques that manipulate subjective social position[53] and that prime certain identities[54] are also promising. Finally, qualitative methods are well-suited to understanding the experience of health inequities and the social mechanisms that generate and configure them. In particular, phenomenology can provide an in-depth perspective of the lived experience of social position,[55] while ethnography can help to understand the collective cultures and norms of specific social groups from an 'emic' perspective.[56] These and other types of qualitative analyses can complement, supplement or triangulate quantitative analyses within mixed methods studies. Bauer[36] and Warner[35] have summarized a variety of intersectional methods that might also be adapted for precision public health applications.

Knowledge-to-action: Precision public health in the real-world

The aims of precision public health will only be realized to the extent that findings are mobilized into real-world interventions that effectively address the social drivers of poor health and of health inequities. Current public health approaches to mitigating inequities primarily consist of universal programs and policies that operate across entire populations, and targeted approaches that direct attention to those considered to be the worst off.[14] Precision public health is most closely aligned with the notion of targeting, however the two are not synonymous, as in many cases, targeting problematizes the broad behavioural and social risk factor profiles of individuals, rather than the structural forces responsible for situating them within disadvantaged social contexts. Although limited progress is evident in some cases,[57] these programs and policies have

largely proven incapable, on their own, of substantially reducing health inequities,[58-63] suggesting that new, complementary approaches may be needed.

Interventions formulated within a precision public health paradigm may represent one such complementary approach. Greater precision in formulating public health interventions may help to avoid creation of programs and policies that meaningfully apply to no one because they concern factors that shape the health of 'average' disadvantaged individuals who may not actually exist. Moreover, a precision public health approach appropriately targets social processes and contexts rather than high-risk individuals and groups, and seeks to directly alter these social processes and contexts rather than to simply mute the unhealthy effects of social position (i.e. an approach we liken to prescribing an 'equitinol' pill that dampens the pathophysiologic response to allostatic load (e.g. [64])). Nevertheless, given that health is shaped by a chain of social processes, interventions of all types – universal, targeted and precise - and spanning all leverage points - upstream, midstream and downstream – are needed, and can complement one another.[37 65-70] Precision public health interventions might therefore be most usefully enacted within a reframed proportionate universalist approach whereby some interventions are universally provided, while others are targeted or precisely tailored to meet the needs of, and offset barriers to health encountered by vulnerable subgroups.[71 72] This approach integrates personalized and population strategies and modelling studies support its efficacy in reducing health inequities.[73] A precision public health lens also encourages attention to the effects of interventions on subgroups who are not the intended targets.

DISCUSSION AND CONCLUSIONS

The renewed vision of precision public health presented herein endeavours to disrupt biomedical approaches to health and linear thinking that essentializes the health experiences of heterogeneous groups. Social position is an inherently dynamic social construct, consisting of mutually constituted objective and subjective components. It is precisely this complexity that most previous investigations have ignored, that we maintain may in fact be perpetuating health inequities. Embracing this complexity through a precision public health approach may yield considerable progress in improving health and reducing health inequities, but will require a fundamental paradigm shift in the manner in which social position is conceptualized and operationalized within research, and ultimately within practice (Table 1).

Health inequities constitute inequities in people's capacity to function and realize their full potential, making them a priority for intervention within any just society. However, despite attempts to eliminate them, health inequities persist and have even widened in some cases. If we accept that health inequities are socially patterned, then it follows that their solutions must also be. Current conceptualizations of precision public health based primarily in a biomedical model of health cannot therefore, on their own, yield significant progress toward this end. Precision public health is not simply precision medicine at a population level, and therefore its definition must illuminate social position as a determinant of health and health inequities.

Some might question whether the term 'precision public health' is even necessary. We believe that 'precision' may be a valuable addition to the public health lexicon because it signals a departure from the conventional public health paradigm by drawing attention to the heterogeneity of social position. Health inequities may be driven by multiply marginalized

populations who experience excess health risk.[21-23 41 74] It is precisely this complexity that most previous investigations have ignored, that we maintain may be perpetuating health inequities. Expanding beyond master categories of social position, and operationalizing these categories in more precise ways across place and time, can enrich conventional public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of risk, the causal mechanisms at play and the most appropriate interventions. Conceptualized thus, precision public health is a research endeavour and an aspect of public health practice with much to offer by way of understanding and intervening on the causes of poor health and health inequities.

Authors' contributions

DLO and LM conceived of and wrote the paper. All authors read and approved the final manuscript.

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Text Box 1: Recommendations for achieving greater precision in public health. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study, while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

1. Provide explicit and **precise descriptions of the theoretical rationale** underlying the selection and operationalization of social positions, social contexts, health outcomes, and potential confounders. **The proposed causal pathways should be precisely identified a priori**.
2. **Identify the precise social positions of populations of interest** and investigate their associations with health by expanding beyond common unitary categories to examine other dimensions of social position, and the heterogeneity that exists within social categories. Measures of **perceived social position** should be explored more fully.
3. **Operationalize social position in more precise ways**, such as by using continuous measures or more categories, considering qualitative and quantitative features, and considering factors at multiple levels.
4. **Describe the precise time and context of measurement of social position** and study the health effects of social position **in a variety of contexts and at multiple time points across the life course**.
5. Use **precise language to describe health inequities** (e.g. inequities in cardiovascular disease according to wealth and gender).
6. Use knowledge of the health effects of individuals' precise social positions to inform the study of **precise contextual mechanisms** responsible for situating them there. Leverage this information to propose **precise interventions** to ameliorate health inequities

Table 1 Reconceptualizing precision in public health

Move away from…	Move towards…
Biomedical model of health	Social determinants model of health
The functions (e.g. surveillance) and methods (e.g. big data) of public health	The foundations (e.g. social determinants) and core aims (e.g. improve population health, reduce health inequities) of public health
Unitary, master categories of objective social position (i.e. income, education, occupation)	Social position as a construct that is both objective and perceived through lived experiences
Problematizing individuals and their behaviours	Problematizing the social contexts that create social stratification
Scaled-up versions of individual level interventions	Interventions that address the root causes of health inequities
Precision medicine for the population	Precision public health

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Title: Reconceptualizing precision public health

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ABSTRACT

As currently conceived, precision public health is at risk of becoming precision medicine at a population level. This paper outlines a framework for precision public health that, in contrast to its current operationalization, is consistent with public health principles because it integrates factors at all levels, while illuminating social position as a fundamental determinant of health and health inequities. We review conceptual foundations of public health, outline a proposed framework for precision public health and describe its operationalization within research and practice. Social position shapes individuals' unequal experiences of the social determinants of health. Thus, in our formulation, precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded, while considering relevant biological and behavioural factors. It leverages this information to uncover the precise and intersecting social structures that pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups. We contend that studies informed by this framework offer greater potential to improve health than current conceptualizations of precision public health that do not address root causes. Moreover, expanding beyond master categories of social position and operationalizing these categories in more precise ways across time and place can enrich public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of health risk, the causal mechanisms at play and appropriate interventions. Conceptualized thus, precision public health is a research endeavour

with much to offer by way of understanding and intervening on the causes of poor health and health inequities.

Keywords: Precision public health; Social determinants of health; Health inequities; Social position; Social context

INTRODUCTION

From precision medicine to precision public health

In January 2015, US President Barack Obama boldly proclaimed that precision medicine would radically transform health by tailoring treatment and prevention to the biological risk profile of the individual patient.[1] These individualized medical interventions would emerge from analyzing data in large biobanks, sequencing more genomes and linking biological information to electronic health records. Efforts are now underway worldwide to achieve this aim. The idea that better health might be achieved through such approaches is consistent with a biomedical model of health which posits that health is primarily a product of individual biological (e.g. genetics, age, sex) and behavioural risk factors (e.g. dietary intake, physical activity, sleep patterns). Despite the dominance of this model within modern medical practice, evidence indicates that these individual level risk factors account for limited variation in disease risk at a population level.[2 3] Instead, differences in health status appear to be largely attributable to the living conditions individuals encounter on a daily basis, and cumulatively over their life course.[4]

Regardless of whether precision medicine succeeds in tailoring treatment to the biological risk profiles of individual patients, because of the limited explanatory power of individual level risk factors, it cannot on its own yield the promised transformations in ill health at a population level. Imagine that John Snow had applied the tools of precision medicine during the 1854 cholera outbreak. He may have advised his countrymen to seek treatment individualized to their genetic susceptibility, or advised those at highest risk to alter their health behaviours. Instead, by simply removing the handle of the Broad Street pump, Snow changed the social conditions in which residents lived, preventing them from becoming sick in the first place. There must be a balance

between attention to individual biological and behavioural risk factors, and the avoidable risk factors for disease that arise from the conditions of daily life. Moreover, interventions based in a biomedical model of health remain fundamentally agnostic on the subject of health inequities, and to the extent that access to care is often greater for those with greater means,[5] may even exacerbate them.

Current conceptualizations of precision public health

Initially proposed in Australia in 2013 as a complement to the precision medicine initiative,[6] precision public health has been variously characterized as "providing the right intervention to the right population at the right time",[7] and "applying emerging methods and technologies for measuring disease, pathogens, exposures, behaviors, and susceptibility in populations to improve health",[8] among others. Big data and informatics are central to most definitions, and indeed some suggest that the use of such data are the defining feature of a precision public health approach.[6 9] Priority actions centre upon collecting data from large, diverse samples, amassing unbiased genetic and environmental data, education, public health-health care partnerships, early detection especially through genome sequencing, and enhancing public health surveillance and tracking.[7 9] It has further been suggested that the aims of precision medicine and public health might be reconciled through scaling-up precision medicine approaches to whole populations,[6] and by incorporating information on environmental and socioeconomic factors into precision medicine analyses.[10]

It therefore appears that, as currently conceived, precision public health is precision medicine scaled-up to a population level, often through leveraging big data, the science of 'omics' and

other technological advancements.[11] Noticeably absent from this body of literature is focused attention to foundational public health concepts such as social position, the social determinants of health and health inequities, nor to their political and social origins, meanings and implications. That the modern conception of precision public health should be so heavily rooted in a biomedical paradigm of health is antithetical to the very foundations of public health, and points to a need to both enlarge the scope of, and refocus current definitions on core public health concepts.

Objectives

The purpose of this paper is to posit a precision public health approach that expands upon and refocuses current definitions on the social causation of health and health inequities. We offer a renewed vision for precision public health that places social position and its context-specific interacting dimensions, determinants, and health consequences at the heart of study, and seeks to study these with greater precision in order to identify points of intervention that are specific enough to be useful in reducing health inequities. In this way, the framework offers a means to integrate factors at all levels within an overarching population-based approach to supporting health and health equity, while illuminating social position as a fundamental determinant of health and health inequities. We argue that the proposed framework may offer greater potential to improve health and reduce health inequities than primarily biomedically-based notions of precision public health that do not address root causes, and public health as currently practiced which, although it addresses root causes, does so in a homogenizing way. We begin with a brief review of the conceptual foundations of public health, then present a case for more precise

attention to social position within a reconceptualized and more comprehensive framework for precision public health, and describe its operationalization within research and practice.

CONCEPTUAL FOUNDATIONS OF PUBLIC HEALTH

Social determinants of health

The social determinants of health encompass the conditions of daily life in which individuals are born, grow, live, work and age, including features associated with their early childhood, employment grade, housing conditions, incomes, experiences of discrimination, neighbourhood environments and level of education.[4] Individual biology and health behaviours are included, but occupy a less prominent role as mediators through which the social determinants of health act to shape health. That the quality of social conditions should so fundamentally shape the health of individuals and populations was perhaps most convincingly demonstrated by the Whitehall Studies of British civil servants, whereby it was shown that health declined with each step down the social ladder, even among a group of relatively well-paid individuals with stable employment, and for whom health care was provided as a matter of right.[2] The 2008 report of the WHO Commission on the Social Determinants of Health synthesized evidence on the social determinants of health into a coherent framework and agenda for action.[4] A key contribution was its acknowledgment that addressing the social determinants of health implies a joint attack on both the social causes of poor health and health inequities.

Health inequities and social position

Health inequities are systematic differences in health between groups occupying unequal positions within society.[4] These differences are not merely a problem between the extremes of

the continuum, but are evident across the entire social gradient. Health inequities are a consequence of societal structures that distribute resources, power and prestige according to factors such as income, education, occupation, and others.[4] While the term health inequalities refers to differences in health, the concept of inequities invokes a moral judgement that these differences are unfair because they are potentially avoidable. Inherent within a social determinants perspective is the need to attend to both the social factors that shape the health of individuals and populations, and the social processes that govern their social patterning.[4 12]

The conceptual framework elaborated by the WHO Commission on Social Determinants of Health [4] has summarized the social production of health and health inequities as follows: 1) Social contexts, broadly interpreted to include the interlocking societal structures that shape the distribution of resources within society, create social stratification by assigning individuals to different social positions; 2) Social position shapes individuals' exposures and vulnerability to intermediary determinants of health, which include material and psychosocial circumstances, along withbehavioural and biological factors; 3) Systematic differences in health emerge across the entire social spectrum in response to these differential exposures and vulnerabilities; and 4) Health outcomes feedback to affect individuals' social position (whether positively or negatively), along with the operation of social, political and economic institutions. Thus, the framework provides a means of understanding how factors at multiple levels interact to shape health at a population level, and their relative importance in this respect. With its strong emphasis on social structures the conceptual framework is perhaps overly deterministic, however the accompanying framework for tackling inequities in social determinants highlights the importance of policies that not only address social structures, but that simultaneously promote

intersectoral action and social participation and empowerment; the latter of which can assist individuals, families and communities to exercise their agency in health-promoting ways and thereby escape negative feedback loops.

Whereas the social determinants of health encompass all of the social factors that shape health collectively, the quality of the social determinants that individuals experience is governed by their position within the social hierarchy, which we refer to hereafter as social position.[12] Social position therefore marks the point where societal structures intersect with the lives of individuals by shaping their unequal experiences of the social determinants of health, and in this way constitutes a lynchpin mechanism through which health inequities are generated, perpetuated and maintained.[4 12 13] Understanding how multiple layers of advantage and disadvantage overlap, interact and are embodied across the life course within the construct of 'social position' is therefore central to understanding the social production of (ill) health and corresponding points of intervention. While the terms social class, socioeconomic status, social position and socioeconomic position are often used interchangeably, we designate social position as the higher order, aggregate construct that reflects individuals' perceived and objective placement within hierarchies of prestige, power and access to resources.[14]

(Re)Conceptualizing and operationalizing social position

Given that social position is a key mediator of health and health inequities, primarily biomedically-based conceptualizations of precision public health that largely ignore, or that relegate social position to a subordinate role, offer limited potential to improve health. However, to redefine precision public health by merely adding a more prominent role for social factors alongside biological and behavioural ones would fail to mark precision public health as distinct

from current public health practice. It would also would miss the opportunity to consider whether social position might be more effectively conceptualized and operationalized to advance health and health equity, and it is to this issue that we now turn.

In modern liberal welfare states, individuals' attain different positions within the social hierarchy according to factors such as level of income, educational attainment and occupation, and as such many studies operationalize social position according to one or several of these objective indicators, what we refer to as 'master categories.'[4 15] It is important that these indicators not be conflated, however, as although they overlap, they also represent different structures of inequality. For example, income is an indicator that most directly reflects access to material resources (e.g. housing, food, clothing), whereas education closely reflects knowledge-related assets and is a strong determinant of future employment and income.[4 16] That these three categories should consistently be accorded greater significance relative to others in explaining the patterning of health may be more a matter of convenience (i.e. the data are available) than an evidence-based practice, and disregards other powerful dimensions of inequity. Indeed, common measures of social position explain only a fraction of the structural inequities confronted by racial/ethnic minorities.[17]

Focusing on these unitary categories of difference to the exclusion of others or in isolation from one another, as many studies do, may obscure understanding of the complexity of social position. A more comprehensive perspective acknowledges social position as a context-specific social construct that represents a mixture of these and other axes of social differentiation,[15] including age, gender/sex, race/ethnicity, wealth, citizenship status, religion and disability.[4] Bourdieu's[18]

notions of economic, social and cultural capital are other aspects of social position that can reflect, respectively, financial, relational and socially distinctive assets. Identity- and rank-based perceptions of ones' own social position must also be considered,[15] and, because they entail a reflective averaging of past and current statuses and future expectations,[15 19 20] may embody the cumulative, combined and interactive effects of multiple dimensions of social position more fully than objective indicators.

In addition to expanding beyond master categories of social position, attending to the heterogeneity within them may further improve understanding of health inequities by examining individuals as persons whose experiences of health cannot be ascertained on the basis of any one indicator.[15 21] Intersectionality theory uses the term social location to refer to the interplay among a variety of social determinants in shaping the unique social experiences of vulnerable groups. A key insight from this theoretical approach is that experiences of advantage and disadvantage are not merely additive in their effects.[22] Some groups experience more negative, and others more positive health effects than would be predicted on the basis of adding together their individual positions.[22-24] For instance, among Black women in the US with less than a high school education, being a Black woman has a negative effect on health beyond the main effects contributed by race, gender and other factors.[22] Notably, this effect disappears among Black women who attain a higher level of education.

What this example illustrates is that not only do inequities in the distribution of social resources correlate highly with race/ethnicity, education and gender/sex, but also that these inequities are enhanced through interactions among these and other factors.[22] That is, there is no prototypical

experience of what it means to be a woman, instead, women experience their gender differently based on their position within other social structures of race/ethnicity, class, and others.[24] Dimensions of social position must therefore be interrogated in tandem, because it is at the nexus of these intersecting domains that a precise social identity is created whose health effects cannot be understood on the basis of its individual parts.[25] Failure to attend to these interactions may limit understanding of how the meanings of different dimensions of social position are mutually constituted, simultaneously experienced, and jointly associated with health, thereby yielding misleading results.[26]

Beyond considering its varied, mutually-constituted and reinforcing dimensions, there are many other ways in which social position could be operationalized in more precise ways to advance public health research. For instance, indicators of social position are often dichotomized (e.g. < high school education vs > high school education; White vs 'other'), which may obscure gradients across the entire social spectrum or for particular groups (e.g. racial/ethnic minorities) that might be uncovered by using more categories or continuous measures.[21 27] Studies may only consider quantitative aspects of social position (e.g. years of education), while neglecting its qualitative dimensions (e.g. quality of the education received),[28] or they may focus exclusively at the individual level and neglect factors at the contextual level (e.g. neighbourhood disadvantage) that may also be theoretically relevant.[21] Furthermore, given that social position is socially constructed, some axes of differentiation may be more salient in particular times and places. The health effects of social position should therefore be studied in particular historical moments and within particular social, political, geographic and economic contexts, including at the broader contextual level (e.g. year, nation) and specific to the life course (e.g. age, marital status, place of

residence).[21] Yuval-Davis[29] has labelled these considerations translocality (how the meaning of social position varies by place), transcalarity (how the meaning of social position varies in small scale settings vs in higher level regions) and transtemporality (how the meaning of social position varies over time).

Contextual pathways to social position

The purpose of expanding beyond master categories of social position and operationalizing these categories in more precise ways is to further understanding of the nature of health risk, the causal mechanisms at play, and ultimately identify potential points of intervention that are specific enough to be useful in reducing health inequities. Health inequities are generated within a sociopolitical context, including systems of governance, economic, social and public policies, culture and societal values.[4] These contextual factors create, configure and maintain patterns of social stratification by determining the manner in which power and resources are distributed amongst social groups. Thus, it is within the social context that the so-called 'causes of the causes' of health inequities ultimately reside.[4]

The identification of health inequities according to dimensions of social position (e.g. race/ethnicity and income) therefore provides an indication that exclusionary processes are at play (e.g. racial/ethnic segregation, inadequate social protection policies) that require further investigation. They can also prompt a search for inclusionary processes (e.g. opportunities for social interaction) that may buffer these same processes of marginalization. Therefore, just as the multi-faceted nature of social position requires precise quantification, so too do the broader macro level factors that structure them; and the role of the former is primarily to prompt and

inform a more in-depth examination of the latter. By linking health inequities experienced by those occupying precise social positions to their precise social contexts, we can better consider causal pathways and begin to identify opportunities for intervention that address the root causes of these inequities. The interventions that arise from such analyses are likely to be more effective and efficient because they address specific sources of social differentiation.

A case in point concerns educational gradients in health in the US.[28] Although a gradient is evident in men and women[30] and among all racial/ethnic groups,[31] the incremental value of educational attainment appears strongest in women,[32] and non-Hispanic whites.[33 34] These findings could prompt a search for contextual factors that suppress the value of educational attainment for some groups, while enhancing it for others. In this respect, Zajacova et al[28] recommend that investigators leverage differences in policies and other contextual conditions that exist across geopolitical boundaries and/or changes in these over time to understand how contextual factors might exacerbate or mitigate education-health associations. . Such analyses should also attend to the ways in which these institutional structures interact with one another and with dimensions of social position to shape health, and how their health effects vary over time. In this way, identification of heterogeneity in health outcomes can prompt a search for the sources of this underlying heterogeneity, directing resources to the most pressing and important contextual targets, particularly those that cut across positional categories.

A FRAMEWORK FOR PRECISION PUBLIC HEALTH

Reconceptualizing precision in public health

We have described social position and its complex and mutually constituted dimensions, along with the contextual factors that generate, configure and maintain patterns of social stratification as key targets for focused investigation, and have highlighted areas in which greater precision might be achieved in order to more precisely identify dimensions of social position that confer health risk, and the social contexts that configure them. We now use the preceding discussion as a basis to outline a framework for precision public health that integrates factors at all levels, from the biological to the social, within an overarching population-based approach to advancing health and health equity. The framework is distinguished by its explicit focus on social position as a root cause of ill health, and in seeking to operationalize this construct in more precise ways. In this way, the proposed framework affords potential for more effective intervention than primarily biomedically-based notions of precision public health that are less comprehensive in their orientation because they do not address root causes, and current public health research that homogenizes individuals' health experiences.

Central to the notion of precision in health is the concept of identifying specific risk factor profiles that confer vulnerability to poor health. Whereas precision medicine regards vulnerability primarily as a function of individual biomedical and behavioural risks, vulnerability within a social determinants paradigm is a population level, emergent process that unfolds across the life course in response to multiple and varied experiences of social privilege and marginalization in a variety of contexts. Thus, social position and its context-specific interacting dimensions, determinants, and health consequences constitute the central locus of study within a precision public health approach, while considering relevant biological and behavioural factors. That the context exerts its influence on health via social position marks both as important

priorities of investigation. However, because the causes of health inequities originate within the social context, it is the context, rather than social position itself, that presents the most effective opportunities for intervention. A more fulsome and precise characterization of social position may more accurately pinpoint the origins of health inequities within the social context, enabling development of interventions that have a greater likelihood of success because they attend to the particular experiences and contexts of precisely characterized groups.

We therefore propose that attention to social position reframes the practice and aims of precision public health to be:

Precision public health investigates how multiple dimensions of social position interact to confer health risk differently for precisely defined population subgroups according to the social contexts in which they are embedded, while considering relevant biological and behavioural factors. It leverages this information to uncover the precise social structures and processes that pattern health outcomes, and to identify actionable interventions within the social contexts of affected groups.

OPERATIONALIZING PRECISION PUBLIC HEALTH IN RESEARCH TO INFORM PRACTICE

Based on this definition and related substantive considerations, the accompanying Text Box proposes six recommendations for operationalizing a precision public health study from theoretical premise through identifying promising interventions. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study,

while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

Use theory within a precision public health framework as a conceptual and operational guide to research

Precision public health provides a framework for investigating the precise contextual pathways, mediated by social position, through which health inequities arise. This broader framework can accommodate theoretical and methodological diversity. For instance, precision public health studies could investigate materialist or psychosocial mechanisms underlying health inequities. Therefore, the starting point for precision public health studies is to articulate the hypothesized theoretical processes and experiences of social stratification at play. This theory can then provide a conceptual and operational guide for conducting the research, and in particular, to select meaningful social positions and contexts for study in relation to the health outcomes of interest. Nevertheless, the utility of some theories may be limited, given that they often entail rather imprecise notions of how social position shapes health. Results from precision public health analyses may, over time, contribute greater precision to these theories.

Precision public health does not entail the study of all possible social position-social context combinations, but encourages scientists to attend to meaningful diversity within samples that capture salient social experiences, while acknowledging the potential implications of excluding others.[35] A key consideration concerns whether all social positions are equally deserving of study, or only those that are associated with the greatest disadvantage.[36] Importantly, health inequities exist across the entire social spectrum,[2 4 37 38] and most populations will experience

forms of advantage and disadvantage across the life course.[36] It is therefore important to understand how experiences of advantage and disadvantage interact to shape health in all social groups, and how they vary across time and place, to ensure a more comprehensive understanding of the social production of health. The acronym PROGRESS-PLUS[39] (Place of residence; Race/ethnicity/culture/language; Occupation; Gender/sex; Religion; Education; socioeconomic position and social capital; PLUS captures all other indicators of disadvantage) includes many indicators of disadvantage, and may be helpful in identifying salient social categories that interact.

Identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups

Having developed a theory-informed research plan, analyses can then proceed to identify the precise social positions and contexts of groups with systematically poorer health relative to more advantaged groups.

A variety of methods, both existing and new, and bridging all three traditions – quantitative, qualitative and mixed - can contribute to precision public health analyses. Machine learning, in which machines learn from patterns in the data rather than being pre-programmed to follow a particular analytical routine, is among the most promising approaches for uncovering novel intersections worthy of further study. However, caution is required given the potential to exacerbate existing inequities when data are missing or incomplete for some social groups.[40] Other quantitative methods that can be adapted for precision public health applications span traditional techniques (e.g. including interaction terms in regression analyses,[22 41] structural

equation modelling, and latent class,[42] mediation,[43] and path analysis), to the more novel and complex (e.g. multilevel modelling,[23] signal detection models,[44] Chi-Square Automatic Interaction Detection,[45-47] quantifying discriminatory accuracy,[48] agent-based modelling[49]). Modelling approaches that explicitly allow consideration of multiplicative, rather than simply additive positionalities, may be particularly helpful.[22] Situating the analyses in particular historical and social moments, both to provide background for the reader, and when interpreting findings, is essential. Methods such as qualitative comparative analyses[50] and multiple case studies[51] that explicitly account for context may be particularly valuable in this respect, as can longitudinal analyses that examine change in social positions in relation to change in health over time. Marginalized groups that co-locate geographically may be subject to similar policy, environmental and social exposures; and therefore area-based analyses to identify areas with a high burden of disease, and/or where income inequality is high may help to identify contexts for focused study.[52]

Reconceptualizing constructs such as race/ethnicity and gender as social processes (i.e. experiences of racism and sexism), rather than as characteristics of individuals may prove valuable in helping to uncover structural causes of inequities, particularly those that cut across intersections of social position.[26 35] Experimental techniques that manipulate subjective social position[53] and that prime certain identities[54] are also promising. Finally, qualitative methods are well-suited to understanding the experience of health inequities and the social mechanisms that generate and configure them. In particular, phenomenology can provide an in-depth perspective of the lived experience of social position,[55] while ethnography can help to understand the collective cultures and norms of specific social groups from an 'emic' perspective.[56] These and

other types of qualitative analyses can complement, supplement or triangulate quantitative analyses within mixed methods studies. Bauer[36] and Warner[35] have summarized a variety of intersectional methods that might also be adapted for precision public health applications.

Knowledge-to-action: Precision public health in the real-world

The aims of precision public health will only be realized to the extent that findings are mobilized into real-world interventions that effectively address the social drivers of poor health and of health inequities. Current public health approaches to mitigating inequities primarily consist of universal programs and policies that operate across entire populations, and targeted approaches that direct attention to those considered to be the worst off.[14] Precision public health is most closely aligned with the notion of targeting, however the two are not synonymous, as in many cases, targeting problematizes the broad behavioural and social risk factor profiles of individuals, rather than the structural forces responsible for situating them within disadvantaged social contexts. Although limited progress is evident in some cases,[57] these programs and policies have largely proven incapable, on their own, of substantially reducing health inequities,[58-63] suggesting that new, complementary approaches may be needed.

Interventions formulated within a precision public health paradigm may represent one such complementary approach. Greater precision in formulating public health interventions may help to avoid creation of programs and policies that meaningfully apply to no one because they concern factors that shape the health of 'average' disadvantaged individuals who may not actually exist. Moreover, a precision public health approach appropriately targets social processes and contexts rather than high-risk individuals and groups, and seeks to directly alter

these social processes and contexts rather than to simply mute the unhealthy effects of social position (i.e. an approach we liken to prescribing an 'equitinol' pill that dampens the pathophysiologic response to allostatic load (e.g. [64])). Nevertheless, given that health is shaped by a chain of social processes, interventions of all types – universal, targeted and precise - and spanning all leverage points - upstream, midstream and downstream – are needed, and can complement one another.[37 65-70] Precision public health interventions might therefore be most usefully enacted within a reframed proportionate universalist approach whereby some interventions are universally provided, while others are targeted or precisely tailored to meet the needs of, and offset barriers to health encountered by vulnerable subgroups.[71 72] Modelling studies support the efficacy of such strategies in reducing health inequities.[73] A precision public health lens also encourages attention to the effects of interventions on subgroups who are not the intended targets.

DISCUSSION AND CONCLUSIONS

The renewed vision of precision public health presented herein endeavours to disrupt biomedical approaches to health and linear thinking that essentializes the health experiences of heterogeneous groups. Social position is an inherently dynamic social construct, consisting of mutually constituted objective and subjective components. It is precisely this complexity that most previous investigations have ignored, that we maintain may in fact be perpetuating health inequities. Embracing this complexity through a precision public health approach may yield considerable progress in improving health and reducing health inequities, but will require a fundamental paradigm shift in the manner in which social position is conceptualized and operationalized within research, and ultimately within practice (Table 1).

Health inequities constitute inequities in people's capacity to function and realize their full potential, making them a priority for intervention within any just society. However, despite attempts to eliminate them, health inequities persist and have even widened in some cases. If we accept that health inequities are socially patterned, then it follows that their solutions must also be. Current conceptualizations of precision public health based primarily in a biomedical model of health cannot therefore, on their own, yield significant progress toward this end. Precision public health is not simply precision medicine at a population level, and therefore its definition must encompass factors at all levels, while illuminating social position as a fundamental determinant of health and health inequities.

Some might question whether the term 'precision public health' is even necessary. We believe that 'precision' may be a valuable addition to the public health lexicon because it signals a departure from the conventional public health paradigm by drawing attention to the heterogeneity of social position. Health inequities may be driven by multiply marginalized populations who experience excess health risk.[21-23 41 74] Expanding beyond master categories of social position, and operationalizing these categories in more precise ways across time and place, can enrich conventional public health research through greater attention to the heterogeneity of social positions, their causes and health effects, leading to identification of points of intervention that are specific enough to be useful in reducing health inequities. Failure to attend to this level of particularity may mask the true nature of risk, the causal mechanisms at play and the most appropriate interventions. Conceptualized thus, precision public health is a research endeavour and an aspect of public health practice with much to offer by way of understanding and

intervening on the causes of poor health and health inequities. We anticipate that adoption of our proposed framework will accelerate progress toward this end, while also helping to generate more detailed, empirically-grounded theory of how aspects of social position interact with one another and with societal processes to shape health across the life course. Critical next steps will entail development of a common precision public health ontology and conceptual measurement models.

Authors' contributions

DLO and LM conceived of and wrote the paper. All authors read and approved the final manuscript.

Competing interests

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Text Box 1: Recommendations for achieving greater precision in public health. Precision should be sought in the areas that are the most theoretically meaningful within the context of each individual study, while acknowledging that a minimum of two should be implemented in tandem to constitute an instance of precision public health.

1. Provide explicit and **precise descriptions of the theoretical rationale** underlying the selection and operationalization of social positions, social contexts, health outcomes, and potential confounders. **The proposed causal pathways should be precisely identified a priori**.
2. **Identify the precise social positions of populations of interest** and investigate their associations with health by expanding beyond common unitary categories to examine other dimensions of social position, and the heterogeneity that exists within social categories. Measures of **perceived social position** should be explored more fully.
3. **Operationalize social position in more precise ways**, such as by using continuous measures or more categories, considering qualitative and quantitative features, and considering factors at multiple levels.
4. **Describe the precise time and context of measurement of social position** and study the health effects of social position **in a variety of contexts and at multiple time points across the life course**.
5. Use **precise language to describe health inequities** (e.g. inequities in cardiovascular disease according to wealth and gender).
6. Use knowledge of the health effects of individuals' precise social positions to inform the study of **precise contextual mechanisms** responsible for situating them there. Leverage this information to propose **precise interventions** to ameliorate health inequities

Table 1 Reconceptualizing precision in public health

Move away from…	Move towards…
Biomedical model of health	Social determinants model of health
The functions (e.g. surveillance) and methods (e.g. big data) of public health	The foundations (e.g. social determinants) and core aims (e.g. improve population health, reduce health inequities) of public health
Unitary, master categories of objective social position (i.e. income, education, occupation)	Social position as a construct that is both objective and perceived through lived experiences
Problematizing individuals and their behaviours	Problematizing the social contexts that create social stratification
Scaled-up versions of individual level interventions	Interventions that address the root causes of health inequities
Precision medicine for the population	Precision public health

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