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Incorporating intersectionality theory into population health research methodology: Challenges and the potential to advance health equity

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ABSTRACT

Intersectionality theory, developed to address the non-additivity of effects of sex/gender and race/ethnicity but extendable to other domains, allows for the potential to study health and disease at different intersections of identity, social position, processes of oppression or privilege, and policies or institutional practices. Intersectionality has the potential to enrich population health research through improved validity and greater attention to both heterogeneity of effects and causal processes producing health inequalities. Moreover, intersectional population health research may serve to both test and generate new theories. Nevertheless, its implementation within health research to date has been primarily through qualitative research. In this paper, challenges to incorporation of intersectionality into population health research are identified or expanded upon. These include: 1) confusion of quantitative terms used metaphorically in theoretical work with similar-sounding statistical methods; 2) the question of whether all intersectional positions are of equal value, or even of sufficient value for study; 3) distinguishing between intersecting identities, social positions, processes, and policies or other structural factors; 4) reflecting embodiment in how processes of oppression and privilege are measured and analysed; 5) understanding and utilizing appropriate scale for interactions in regression models; 6) structuring interaction or risk modification to best convey effects, and; 7) avoiding assumptions of equidistance or single level in the design of analyses. Addressing these challenges throughout the processes of conceptualizing and planning research and in conducting analyses has the potential to improve researchers' ability to more specifically document inequalities at varying intersectional positions, and to study the potential individual- and group-level causes that may drive these observed inequalities. A greater and more thoughtful incorporation of intersectionality can promote the creation of evidence that is directly useful in population-level interventions such as policy changes, or that is specific enough to be applicable within the social contexts of affected communities.

1. Population health research and the need for explicit theory

The term "population health research" can be used to refer to quantitative research across a range of disciplines (e.g. population epidemiology, social epidemiology, public health, medical sociology, health promotion, community medicine, community psychology) that aims to understand and impact the health and well-being of populations. In a classic paper, Geoffrey Rose (1985) distinguished between the causes of disease among individual persons and the causes of disease incidence among populations. Even in cases where the causes of individual disease are the same (e.g. the same virus, the same individual genetic or environmental susceptibilities), population groups often experience extremely different incidence or prevalence of disease (Rose, 1985). The drivers of specific health inequalities can involve intrinsic biological factors, such as inherited differences in genetic susceptibilities across populations. However, where inequalities are structured across socio-demographic factors, they are often driven by social inequity, or social policies and practices that create the context for increased incidence of disease in some groups while protecting others. These factors represent what Rose described as "the determinants of population incidence rate".

Currently, a full examination of such causes remains hampered by a focus on measuring health inequalities and production of research documenting corresponding social gradients (Lofters & O'Campo, 2012; Mowat and Chambers, 2012). While documentation of inequalities is important, it too often fails to provide

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evidence that can be used to intervene (Lofters & O'Campo, 2012), either on a population level (e.g. through policy) to shift overall risk, or at a specifically local level within the social contexts of highly affected communities. Moreover, repeatedly documenting health inequalities that apply to broad segments of a population may serve to reinforce existing notions of the intractability of injustice, while failing to identify intervenable factors that might be candidates for potential solutions.

Documentation of health inequalities is often done with a focus on one unitary category of difference, which is itself simplified. For example, race-based inequalities are still sometimes theorized as biological, or are followed with speculation on a range of possible causes, such as racism, family structure, diet, or even poverty; researchers in race, ethnicity and health have urged other researchers to avoid using race/ethnicity as a proxy for such factors (Jones, 2001; Muntaner et al., 1996). While "race" may be a biological fiction, the social process of racialization is real. The structural and interpersonal discriminatory processes of racism are themselves measurable (Krieger et al., 2005). Likewise, within sex/gender research, research on inequalities is often seen as confirming expectations of "obvious" biological differences, with little attention given to verifying biological similarities, distinguishing the effects of biologically sexed mechanisms from gendered social processes, or allowing for their interaction (Springer et al., 2012a,b). Examining such unitary approaches to research surfaces the need for careful delineation of related constructs that are often conflated under a lowest common denominator approach of documenting socio-demographic variation. Moreover, such research studies may expand beyond one master category of social position to consider multiple categories, but do not consider the unique intersections between the categories or intersectional positions within a category.

Population health research has been increasingly critiqued for its failure to explicitly acknowledge the theory (or lack of theory) underlying analyses, and for the failure of research teams to deliberately consider theoretical frameworks on which their research may then be built (Krieger, 2003; Bartley, 2004). It has also been critiqued for stripping away the context of people's lives through identifying single sets of health determinants for entire populations (Raphael and Bryant, 2003). Several recent books have begun to integrate population health theory and methodology (Bartley, 2004; Krieger, 2011). However, even books that incorporate a range of theoretical models and address health inequity may address inequalities in only a unitary way, for example, exploring health inequalities through a master category of sex/gender, or alternatively through race/ethnicity (Bartley, 2004).

2. Intersectionality theory

First termed "intersectionality" by African–American feminist legal scholar Kimberlé Crenshaw (1989), intersectionality theory sought to complicate understandings of race- and sex/gender-based scholarship by arguing that multiple marginalisations, such as those experienced by African–American women, were mutually constituted and could not be understood or ameliorated by approaches that treated race and sex/gender as distinct subjects of inquiry. Though developed as a response to second-wave feminist ideals that were implicitly white and middle-class, and to anti-racist organizing that was implicitly male in its issues and ideals, intersectionality has the potential to improve research not only on sex/gender and race/ethnicity, but on all other domains of social position, such as socio-economic status, legal Aboriginal status, educational background, or age cohort.

Intersectional approaches differ from unitary and multiple approaches to research (Hancock, 2007). In a unitary approach, only one master category of social position is of primary research interest (Hancock, 2007). For example, all analyses can focus on sex/gender or on race/ethnicity or on socioeconomic status. A multiple approach in which more than a single category is of interest operates under an additive assumption that treats multiple marginalisations or privileges as individual categories that can be layered (Hancock, 2007). While this allows for consideration of a greater number of social categories, it is not in itself an intersectional approach. Using such an approach, the health status of Aboriginal women in Canada, for example, would be assumed to be sufficiently understood through adding together the independent health impacts of being Aboriginal with those of being female. In contrast, the intersectional approach assumes that an individual's experience, and their health, are not simply the sum of their parts, and that, for example, what it means to be a woman and what the health implications are, may be different for Aboriginal women versus non-Aboriginal women. This makes sense in that gender can be constituted (and health affected) through cultural meanings and processes including those that are potentially positive, such as indigenous cultures, and also through negative policies and their impacts, such as through gendered aspects of historical trauma in residential schools or under policies such as the Indian Act. Sex, gender, race, ethnicity, income, social class, education, age, sexuality, immigration history… each may be understood in greater complexity through intercategorical approaches to intersectionality, which use categorization pragmatically to explore the health impacts of multiple identities or social positionalities (McCall, 2005).

3. Intersectionality theory in health research

As an overarching concept, intersectionality has much to offer to population health in providing more precise identification of inequalities, in developing intervention strategies, and ensuring results are relevant within specific communities. It was recently identified as an important theoretical framework for public health (Bowleg, 2012), and as well as for sex, gender and health (Springer et al., 2012a).

While intersectionality has been explicitly incorporated into feminist academic work for over two decades, its use in health research has been primarily in the form of qualitative studies. For example, two recent journal special issues on intersectionality were devoted entirely to qualitative work (Phoenix and Pattynama, 2006; Bilge and Denis, 2010). While intersectionality scholars have acknowledged that such scholarship can use quantitative as well as qualitative methods (Hancock, 2007; McCall, 2005), and examples of explicitly intersectional quantitative research exist in fields such as sociology of health (Veenstra, 2011; Warner and Brown, 2011; Sen and Iyer, 2012; Seng et al., 2012; Hinze et al., 2012), epidemiology (Marcellin et al., 2014), psychology (Stirrat et al., 2008), and education (Covarrubias, 2011), some have posited that qualitative research is better suited to the examination of intersectionality (Wilkinson, 2003; Bowleg, 2008). However, it may well be that intersectionality theory has much to offer population health research, and even that population health research may turn out to have some surprising things to contribute to intersectionality theory and knowledge. As intersectionality scholars acknowledge the potential for quantitative work, and population health researchers call for greater theorization of analyses, much unrealized potential exists in building theoretical and methodological bridges between intersectionality and population health research.

Within population health research, the importance of intersectionality may be better grasped by researchers if its relationship to core methodological (e.g. validity) concerns were made clear, underscoring its importance for all researchers, and not just those

whose work has sex/gender, race/ethnicity, and/or social inequality as primary foci. Similarly, researchers working in intersectionality may have a greater appreciation for the potential of quantitative research to provide population- and intervention-relevant information if they were able to clearly understand the relationship between social, biological or psychological theory and population health methodology, and understand that statistics may be estimated and interpreted in ways that are neither simply positivist nor atheoretical. More fully incorporating intersectionality theory into population health research presents a range of challenges, seven of which are discussed in some detail below. Some challenges are conceptual or linguistic, some relate to measurement and specification, and others arise from difficulties or confusion in matching the social theory to the statistical theory underlying particular quantitative analysis methods. However, each challenge also presents an opportunity to improve the quality of research, particularly with regard to its potential to more accurately document health inequalities, and to identify causes of these inequalities and their potential solutions.

4. Challenges in incorporating intersectionality theory in population health research

4.1. Quantitative theoretical language versus quantitative methods

Multiple statistical methods have been proposed or used for incorporating intersectionality into quantitative analysis, including ANOVA (Warner, 2008), hierarchical class analysis (Stirrat et al., 2008), cross-tabulation (Covarrubias, 2011), dichotomous or polytomous logistic regression (Veenstra, 2011; Hinze et al., 2012; Seng et al., 2012; Marcellin et al., 2013), multi-level modelling (Black and Veenstra, 2011), and latent class analysis (Garnett et al., 2013), though it is not clear which, if any, provide a good match between statistical theory and specific intersectional research questions. This lack of clear methodology for studying intersectionality constitutes one tension within intersectionality research (Nash, 2008). Interestingly, quantitative applications of intersectionality can be obfuscated by the predominance of mathematical-like language in intersectionality theory, though its use there is conceptual rather than strictly mathematical. In the original paper in which Crenshaw coined the term intersectionality (1989), she refers to "the interaction of race and gender". Ange-Marie Hancock's often-cited paper (2007) is simply titled "When multiplication doesn't equal quick addition: Examining intersectionality as a research paradigm" and Lisa Bowleg's paper (2008) is titled "When black + lesbian + woman ≠ black lesbian woman: The methodological challenges of qualitative and quantitative intersectionality research" (Bowleg, 2008). Thus, the very language used in intersectionality can create confusion for quantitative researchers. For example, studying how gender and race interact multiplicatively (in an intersectional sense) does not imply that one needs to − or even should − use a multiplicative-scale statistical interaction model. If intersectionality is to be implemented in quantitative research, then terminology will need to be disaggregated in order to allow for clear communication and to prevent the conflation of identical- or similar-sounding concepts.

4.2. Questioning whether all intersectional identities or social positions are of equal value, or of sufficient value to merit study

Given that intersectionality research originated in a critique of the failure of unitary and multiple approaches to address issues for those who were multiply marginalised (Hancock, 2007), it is not surprising that research has, as McCall (2005) notes, "tended to reflect multiple subordinate locations as opposed to dominant or mixed locations". Nash (2008) has identified the question of whether all identities are intersectional, or only those of multiply marginalised subjects, as a major tension within intersectionality research. Hancock's position that all intersectional positions are of equal interest (2007) offers the potential to represent the embodied positions of all research participants in large population samples, few of whom will experience marginalisation nearly exclusively, without concurrently experiencing some form of privilege (see challenge 4.4 for more on embodiment, oppression, and privilege).

Considering all intersectional positions within the domains under study, and generating absolute measures of the incidence or prevalence of disease or other health-related phenomena for each, has the potential to provide new and interesting observations on the distribution of the burden of disease across social location, a sort of socio-demographic mapping. Moreover, where economies of time and intensity of analysis in qualitative research may place limits on the breadth of analysis across intersectional positions that is feasible, the potential provided by large population data sets presents no such restrictions. Through examining a larger set of intersectional positions, comparisons across position may also illuminate the effects of privilege as well as marginalisation and the health impacts for those at positions that are both privileged and marginalised can be better understood, without neglecting the study of those at multiply marginalised intersectional locations.

Beyond such broad mapping, intersectional analyses involving deeper or more locally specific research questions and theoretical formulations will need to focus on those positions or identities that are relevant. Given that a focus on inequalities driven by social inequity necessitates an anti-oppressive or social justice approach to research, here positions of multiple marginalisation will continue to require prioritization in order to address potential remedies for those who are multiply oppressed.

4.3. Intersecting identities, positions, processes, and policies

Many research studies using intersectional approaches, as well as many papers discussing intersectionality theory, have considered primarily intersecting *identities* or intersecting categories of *social position*, whereas others have extended an intersectional framework to *processes*. Drawing on earlier work (Hankivsky and Cormier, 2009), Dhamoon and Hankivsky (2011) now characterize intersectionality as "concerned with simultaneous intersections between aspects of social difference and identity (as related to meanings of race/ethnicity, indigeneity, gender, class, sexuality, geography, age, disability/ability, migration status, religion) and forms of systemic oppression (racism, classism, sexism, ableism, homophobia) at macro and micro levels in ways that are complex and interdependent." This makes an important distinction between *social identities* or *social positions* that are related to potential privilege or oppression and the *social processes* or *policies* that may generate, amplify or temper inequalities between groups, both of which can be studied intersectionally. Without an emphasis on intervenable processes or policies, a quantitative intersectionality focused purely on intersecting identities or positions would run the risk of continuing to reinforce the intractability of inequity, albeit in a more detailed or nuanced way.

However, there are methodological considerations in examining intersections of identity or social position (e.g. ethnoracial group, sexual orientation), versus intersecting processes (e.g. racism, homophobia), versus analysis of policies or practices, versus combinations of these (e.g. whether experiences of homophobia have a different impact on health among members of different ethnoracial groups). For example, in a descriptive intersectional analysis (e.g. one that has as its aim to identify the burden of disease among those at different socio-demographic intersections) it would

generally be inappropriate to statistically adjust for other variables. However, in a process-oriented analysis examining what Lofters and O'Campo (2012) call "solution-focused variables", those that drive heterogeneity across descriptive categories, careful attention to the concept of confounding and its control is necessary in order to identify potential interventions. Moreover, depending on theory, the relationship between intersecting identities, positions, processes or policies may be constructed as an interaction, as effect-measure modification, as mediation, or as moderated mediation. To add to this complexity, policies and institutional practices play a structural role in discrimination that cannot simply be captured at the individual level, and so a group-level or multi-level analysis may be necessary (see further discussion of the issue of level in challenge 4.8).

In addition to making distinctions between social categories and the processes that generate inequalities, it may be important to draw more careful distinctions between *social identities* and *social positions*, in order to both more precisely communicate the domains under consideration and to open up possibilities to examine additional intersections. While sometimes conflated, there is not necessarily concordance between one's personally held identity and a social position one occupies, as indicated either by objective measure (e.g. income or wealth) or the way one is perceived and treated by others (e.g. racialization). A woman migrating to the United Kingdom may find herself racialized as black, despite holding no such identity in her home country; a bisexual-identified woman may be assumed by others to be heterosexual based on her male partner; and one does not have to identify as impoverished to live in poverty. Adoption of identities is a developmental process (Phinney, 1989; D'Augelli, 1994), and identities themselves can be understood as multidimensional, encompassing not just personally held identity but also degree of importance, as well as personal attachment to and social embeddedness within a group (Ashmore et al., 2004). Moreover, identities are context-specific and may shift with regard to place and time, or with the need to align with others around shared identity. Social position then may have an impact independently of identity, or may interact with it in ways that impact health.

Careful distinction between intersecting identities, positions, processes, policies and practices, as well as the methods that are needed to analyse each, has the potential to advance health equity in multiple ways. It averts the problem of conflating identity with position or experience, opens up possibilities in studying interactions across these different domains or for examining mediation models, and allows for attention to the differing methodological needs and requirements of different types of intersectional questions.

4.4. Embodiment and experiences of oppression and privilege

Measurement of oppression involves scales that may combine experiences of oppression within one domain, such as racism or ethnic discrimination (Krieger et al., 2005; Diaz et al., 2001) or homophobia (Diaz et al., 2001) requiring experiences to be disaggregated by participants and attributed to specific domains of discrimination. Such scales have been designed with an implicit additive (non-intersectional) assumption, that discrimination or marginalisation is distinct and identifiable for each type of identity/group. Other scales are composed of a single series of items on discrimination experiences, but ask participants to secondarily attribute any experiences to one or more domain of oppression (Krieger et al., 2005; Williams et al., 1997). However, it is clear that individuals who are members of multiply marginalised groups cannot simply dissect out the "types" of oppression specific to each part of their identity or experience. Bowleg (2008) reasons that "it is virtually impossible, particularly in quantitative research, to ask questions about intersectionality that are not inherently additive". She questions whether quantitative research is really compatible with intersectionality, contending that not only are approaches to individual questions typically additive, but also unsuccessfully so, building on her experience of asking research participants at a particular intersection (black lesbian women) to attempt to decompose their identities into single additive layers of experience (e.g. the experience of being black). In applying an ecosocial approach to the study of discrimination and health, Nancy Krieger (2012) maintains that, as researchers, "our research needs to integrate these conjoint social facts the same ways our bodies do, each and every day". The embodied nature of human beings, whose selves cannot be stratified into parts representing their multiple dimensions, needs to be both reflected and respected in research.

It is precisely the impossibility of expecting individuals to decompose their individual experience that reveals the need for comparison groups, providing contrasts between participants at each intersectional position under study (e.g. black gay men, white lesbian women, straight white men) in order to render the health impacts at each intersectional position visible. While it may indeed be difficult to impossible to ask questions that are not additive, it is certainly possible to conduct analyses that are not additive, but rather that elucidate the effects of social position and social processes through comparisons that break free from assumptions of additivity and allow for intersectional multiplicativity. It may thus be that experiences of discrimination are best measured using a single discrimination scale, the effects of which can be compared at intersections with social position categories.

Since the focus of such scales is on discrimination or marginalisation, privilege is by default defined as the pole on the other end of the continuum: the absence of these experiences. While there remains much work to do in understanding how processes of oppression impact health, there is less understanding of the impacts of privilege, social inclusion and how these may facilitate and protect health. It seems clear that it is not safe to assume that privilege functions purely through the absence of overtly negative experiences of discrimination. Not being fired or denied a job based on who you are does not represent the same "privilege" as does getting a job or being promoted because you know someone with influence, are perceived to "fit in", or because your social interactions are lubricated by perceptions that you are friendly, smart, and decidedly not scary. Moreover, many or most individuals occupy social positions that include both privileged and marginalised domains; given that they will experience processes of privilege, marginalisation, and even their complex co-constituted occurrence, intersectionality theory is necessary to understand these experiences.

Moreover, the processes through which oppression and privilege function may not be those that we traditionally capture in the "-ism" scales, which assess self-reported individual-level experiences of discrimination, and so a careful theorization of process is necessary. Both structural forms of discrimination and the subconscious experience or internalization of marginalisation are often unmeasured (Krieger, 2012). It is important to also note here that particularly in localized or sub-group studies, there may not be variation in structural factors such as policies or other group-level variables within the study sample, though such factors may continue to play a causal role in impacting health. Schwartz and Carpenter (1999) have identified this as one form of conceptual or interpretation bias that is inherent in attempting to explain health-related inequalities through studying inter-individual variation within marginalised groups.

4.5. Understanding differences between types of regression models for intersectional applications

It is not always clear to researchers how to produce statistical measures that are most relevant to population health, or most interpretable. If using regression modelling, the scale of the model impacts both. For example, linear regression models typically used with continuous outcome variables are in the additive scale, while logistic regression, Poisson regression, and other log-scale regressions typically used with dichotomous outcome variables are in the multiplicative scale. This means that when a main effects analysis is conducted, multiple main effects are combined mathematically in different ways. In linear regression they are added together, in log-scale regression they are multiplied, though neither represents a multiplicative approach in an intersectionality sense.

Since the additive assumption is thus defined differently in different models, a departure from additivity (e.g. intersectional multiplicativity) has different meanings depending on model scale. Including a cross-product (interaction) term in a model, and thus opening up potential to reflect Hancock's intersectional approach and McCall's intercategorical complexity, will produce results with differing interpretations and potentially different implications. Nevertheless, published studies using interaction terms explicitly for the purpose of intersectionality analysis have been sometimes conducted in the multiplicative scale (e.g. Veenstra, 2011; Hinze et al., 2011) and sometimes in the additive scale (Seng et al., 2012), without an explicit rationale.

With linear regression, including a cross-product term results in an additive-scale assessment of interaction. However, with log-scale regression models, it results in an assessment of multiplicative-scale interaction, unless additional steps are taken. This can be problematic, as true absence of multiplicative-scale interaction almost always indicates precisely the presence of an additive-scale interaction (Greenland et al., 2008). It is additive-scale interaction that is both more consistent with biological or social causation (if studying potentially causal processes) and of greater relevance to population health and disease prevention (Szklo and Nieto, 2012).

For these reasons, assessment of additive-scale interaction is more relevant for intersectionality research. For example, an additive-scale analysis can provide estimates of proportions or numbers of people affected, to illustrate the health or disease burden or benefit within the sub-population at each specific intersectional location. In an intersectional analysis with a dichotomous outcome, the presence of an additive-scale interaction indicates that the number of outcome cases (e.g. the prevalence of a health-related condition) for those at an intersection differs from what would be expected based on adding together the individual effects from the separate identities, positions, or processes. In other words, it represents a departure from what Hancock (2007) terms the additive assumption of the multiple approach. It may be worth reiterating, given the linguistic similarities, that *additive-scale* interaction breaks free of the additivity assumption inherent in Hancock's multiple approach, and represents an analysis strategy that is intersectionally multiplicative rather than additive. This reinforces the need to distinguish these terms linguistically (e.g. intersectional additivity or additive assumptions versus additive scale).

In simple descriptive analyses with no adjustment for other covariates, assessment of additive-scale interactions can be done through comparisons of excess risks, structured as per textbook examples (e.g. Szklo and Nieto, 2012). When linear regression is used, interactions will be in the additive scale. However, when logistic and other multiplicative-scale regression models are used, additional steps must be taken. It is possible, and in fact not difficult, to construct measures of additive-scale interaction and their confidence intervals from multiplicative-scale models (Skrondal, 2003; Greenland et al., 2008; Zou, 2008), and these may be of use to intersectionality researchers. Such measures include the relative risk due to interaction (RERI), synergy index, and the attributable proportion due to the interaction; of these, the synergy index performs best when additional covariates are included in a multiple regression model (Skrondal, 2003). These measures have clear interpretations with regard to intersectionality. For example, in an analysis of the intersection of two social positions, the synergy index represents the ratio of the excess risk observed among those at the intersection of those positions to that expected if their outcomes were simply a function of adding together the excess risks for each of the positions.

Producing clear intersectional results using regression models can be further complicated by the use of odds ratios. Incidence risk ratios are commonly produced from longitudinal study designs with dichotomous outcomes. If designed properly, even case–control studies can accurately estimate an incidence risk ratio (Pearce, 1993). However, the most commonly used regression-based measure for dichotomous or polytomous outcomes in cross-sectional population health research remains an odds ratio produced using logistic regression, despite the existence of easy-to-use alternatives that produce prevalence risk ratios rather than odds ratios for dichotomous outcomes (Barros and Hirakata, 2003; Zou, 2004; Bieler et al., 2010; Lin and Wei, 1989). Odds ratios are difficult to interpret in main effects analysis – as often the only intuitive interpretation is to erroneously interpret them as risk ratios – resulting in sometimes dramatic overestimates of effects, particularly when outcomes are not rare, for example reporting one group as "40% less likely" when in fact they were 7% less likely (Schwartz et al., 1999). Odds ratios can similarly lead to errant interpretations of multiplicative-scale interactions when they are assumed to stand in for risk ratios (Morabia et al., 1997), even in cases where the rare disease assumption is met (Campbell et al., 2005). Moreover, false results can also result if odds ratios are used as a basis for assessing additive-scale interactions (Kalilani and Atashili, 2006).

While risk ratio-generating options for regressions of polytomous outcomes are less developed, in the case of dichotomous outcomes existing methodology supports the need for some additional effort by intersectionality researchers to familiarize themselves with methods that produce prevalence risk ratios with cross-sectional data. Some alternatives include modified Poisson regression with robust variance estimatation (Zou, 2004), or Cox proportional hazards regression with a constant risk period assigned to remove the time function (Thompson et al., 1998; Skov et al., 1998), and with robust variance estimation (Lin and Wei, 1989). Both methods perform well (Barros and Hirakata, 2003), can be used with clustered data, and can be conducted using commercial statistical packages such as Stata and SAS. For complex survey data, SUDAAN software includes an option to produce prevalence risk ratios from logistic regressions using average marginal predictions (Bieler et al., 2010).

4.6. Structuring models to make effects visible: interaction and effect-measure modification

Use of cross-product/interaction terms in regression can constitute an assessment of interaction or effect-measure modification. If there is no bias, these will be the same (VanderWeele, 2009), though interpretation will obscure or highlight different aspects of the interaction. Each assessment may be relevant for certain questions in intersectionality research. An interaction analysis can consider whether the risk of an outcome differs at

different intersectional positions, or it can examine the risk of an outcome at different levels of interacting processes. Such interactions can be identified as synergistic or antagonistic, i.e. respectively as greater than or less than the sums of their parts. Importantly, while the language of statistical interaction (e.g. interactions between two or more variables) implies a dissection of individuals into their stratified component identities, positions, or experiences, in actuality it allows for an embodied approach, where absolute measures of disease/health frequency can be described for groups of individuals at each cross-stratified intersection.

In contrast, effect-measure modification addresses whether the impact of one factor differs across strata or level of another. For example, does the impact of racialized discrimination on mental health differ between Asian women and men? Is the effect in the same direction, or of the same magnitude? Researchers who understand the different ways to structure such analyses can make conscious decisions that match up to underlying theoretical or pragmatic concerns. For example, assessing as effect-measure modification with stratification by age (youth and non-youth) may be useful for work in fields where interventions are often targeted directly at youth.

Knol and VanderWeele (2012) provide recommendations, and even templates, for presentation of effect-measure modification and interaction results, though they assume both a causal research question and a reader's familiarity with epidemiological terminology. Their concerns are that researchers do not always provide sufficient detail in their publications for readers to understand the size and significance (both statistical and real-world) of their findings. Examples certainly exist where even researchers who published intersectional findings did not interpret them correctly. One well-documented example resulted in author and press statements on the lack of intensive cardiac diagnostic follow-up among women and black people, though the results clearly showed equal outcomes among white men, black men, and white women, with only black women receiving different levels of health care referral (Schulman et al., 1999; Schwartz et al., 1999).

4.7. Structuring models to make effects visible: avoiding equidistance and unilevel assumptions

Analytic strategies often fall into a grey area between a completely data-driven approach to exploratory analysis (e.g. backward elimination logistic regression) and a more fully theorized analysis, such as with a structural equation model, mediation model, or an analysis guided by a directed acyclic graph. It is often reasonable to expect that dimensions of identity or social position may play a role in a particular health outcome, and may interact with other categories of social position, even where previous research has not yet elucidated the issue. A purely data-driven approach to multiple regression modelling assumes that all candidate factors that play a role in producing an outcome are equidistant from the outcome (Weitkunat and Wildner, 2002). Since this is, in general, not true, this assumption may prioritize retention of the most spatiotemporally proximate factors, though these may in fact mediate the effects of other factors such as sex/gender, race/ethnicity and other categories of social position. This type of implicit value assumption within supposedly atheoretical analyses suggests the need for semi-theoretical approaches that allow for identification of both "upstream" and "downstream" factors that may play important roles in producing health and disease.

Chunkwise (also referred to as blockwise, hierarchical or setwise) regression is one method that may remediate the assumption of equidistance, when there is insufficient theorization or data for more fully theorized methods such as structural equation modelling. Chunkwise models separate variables into conceptually related sets, ordered to reflect plausible cause–effect relationships (Cohen and Cohen, 1983; Kleinbaum et al., 2008). Within intersectionality research, this could involve structuring models through separating social position variables from the social, biological or psychological processes that can create inequalities. Division into "chunks" could be undertaken on the basis of whether factors are precede or proceed from each other in a spatiotemporal (and thus potentially causal) sequence, which may also represent divisions of social position versus social process, or non-modifiable versus modifiable factors. Separating these may help ensure that effects are visible when all variables are not, in fact, equidistant from the health outcome of interest.

Krieger makes the compelling point that concepts of "proximal" or "distal" should not be assumed to relate to concepts of level, as group-level causal factors are not necessarily upstream from individual-level causes (Krieger, 2008). However, the existence of causes across multiple levels, some of which exist only at a group level (e.g. policies) and others only at an individual level (e.g. personal identity), implies a greater need for attention to level of measurement and analysis. Lofters and O'Campo (2012) have argued that a "misguided focus on individual-level factors" has resulted in a series of recommendations and interventions that are imaginable only as individual-level alterations in health-related behaviour, without regard to structural factors that shape or limit behaviours. This failure of imagination represents a form of conceptual bias that can be remedied through consideration of intersectional effects at multiple levels during the planning phase of research, and the greater use of multi-level regression in the analysis phase.

5. Potential to advance health equity

The explicit theorization and greater application of intersectionality within population health research has the potential to improve researchers' collective ability to more specifically document inequalities within intersectional groups, and to study the potential individual- and group-level causes of observed inequalities. It opens up the potential for examination of interesting questions regarding interactions between dimensions of oppression or privilege, including across levels. Moreover, it can serve to improve the validity of health research. For example, careful attention to intersectional issues has the potential to reduce measurement bias and improve construct validity, by identifying whether identity, position, process or policy variables are relevant, and thus avoiding inadvertent use of proxy variables. It can also help avert conceptual and interpretation biases in preventing misspecified levels and assumptions of equidistance from outcomes. Lastly, it can allow for the identification of heterogeneity of effects and the corresponding production of research results for more specific population sub-groups, and avoid the production of results (where such heterogeneity is ignored) that may truly apply to no one.

What then, can quantitative analysis of intersectional questions contribute to existing qualitatively-derived knowledge on health? Quantitative intersectional research is compatible with ecosocial theory (Krieger, 2012) and other biopsychosocial approaches that cross disciplinary divides to reflect complex realities of how social context, behaviours, and life processes are biologically embodied. As with mixed-methods research, there is the possibility for triangulation across quantitative and qualitative results to identify sites of concordance or convergence and areas of potentially interesting divergence. This has the potential not only to provide a more rich set of observations through which to understand health, but to accelerate theory generation. Well-specified and

thoughtfully designed quantitative intersectional studies that examine how privilege and marginalisation may function together to impact health have the potential to provide evidence in support of – or refuting – existing work in intersectionality and health. Moreover, the ability to test out intersectional hypotheses regarding synergistic or antagonistic effects at intersectional positions across a wide range of intersections in large data sets provides an opportunity to add a higher resolution level to existing maps of social inequalities within populations. Building on this by examining intervenable factors that may be drivers of such inequalities could allow for the identification of greater numbers of potential interventions, or provide stronger evidence in favour of an intervention. Altogether, a greater and more thoughtful incorporation of intersectionality can promote the creation of evidence that is useful in population-level interventions such as policy changes, or that is specific enough to be applicable within the social contexts of affected communities.

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