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Methods for analytic intercategorical intersectionality in quantitative research: Discrimination as a mediator of health inequalities

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ABSTRACT

Rationale: Intersectionality as a theoretical framework has gained prominence in qualitative research on social inequity. Intercategorical quantitative applications have focused primarily on describing health or social inequalities across intersectional groups, coded using cross-classified categories or interaction terms. This descriptive intersectionality omits consideration of the mediating processes (e.g., discrimination) through which intersectional positions impact outcome inequalities, which offer opportunities for intervention.

Objective: We argue for the importance of a quantitative analytic intersectionality. We identify methodological challenges and potential solutions in structuring studies to allow for both intersectional heterogeneity in outcomes and in the ways that processes such as discrimination may cause these outcomes for those at different intersections.

Method: To incorporate both mediation and exposure-mediator interaction, we use VanderWeele's three-way decomposition methodology, adapt the interpretation for application to analytic intersectionality studies, and present a step-by-step analytic approach. Using online panel data collected from Canada and the United States in 2016 (N = 2542), we illustrate this approach with a statistical analysis of whether and to what extent observed inequalities in psychological distress across intersections of ethnoracial group and sexual or gender minority (SGM) status may be explained by past-year experiences of day-to-day discrimination, assessed using the Intersectional Discrimination Index (InDI).

Results and conclusions: We describe actual and adjusted intersectional inequalities in psychological distress and decompose them to identify three component effects for each of 11 intersectional comparison groups (e.g., Indigenous SGM), versus the reference intersectional group that experienced the lowest levels of discrimination (white non-SGM). These reflect the expected inequality in outcome: 1) due to membership in the more discriminated-against group, if its members had experienced the same lower levels of discrimination as the reference intersection; 2) due to unequal levels of discrimination; and 3), due to unequal effects of discrimination. We present considerations for use and interpretation of these methods.

1. Introduction

Intersectionality is a critical theoretical framework that focuses attention on the ways that experiences of those at different sociodemographic intersections are differentially shaped by social power in structural and interpersonal contexts (Collins, 1991; Crenshaw, 1989). As intersectionality has been taken up in empirical research, methodological implications have been identified, including that the experiences of those at an intersection of multiple social identities or positions may not be accurately described by studying each social identity/position separately (Bowleg, 2008; Cho et al., 2013; Hancock, 2007; McCall, 2005). Intersectionality now has a long history of application in qualitative research. Yet, as an "analytic sensibility" (Cho et al., 2013), its optimal applications in quantitative research remain unclear.

The quantitative problems in ignoring intersectional groupings can be illustrated with a pair of classic examples regarding the intersection of sex and race: one of the original legal cases used by Crenshaw (1989) when introducing the term intersectionality, and a well-critiqued published study of cardiac catheterization referrals (Schulman et al., 1999). In the *DeGraffenreid v General Motors* case (1976), the court held that Black women had not shown evidence of discrimination in hiring based on race, because Black people (men) were hired, and that there was no

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sex-based discrimination because (white) women were hired. The fact that there was no real possibility of employment for Black women was not legally interpretable under a framework that considered only a single axis of sex or race. In the cardiac study, findings were widely interpreted as evidence of fewer cardiac catheterization referrals for patients who were women or who were Black (Schwartz et al., 1999). However, the analysis clearly showed that reduced referrals were evident only among Black women, and this intersection was fully responsible for producing findings of overall effects for both sex and race (Bowleg and Bauer, 2016).

These examples highlight the misleading interpretations that can result from studying social identities or positions as single axes while ignoring intersectional effects. Despite the fact that quantitative data were at issue in the original legal formulation of intersectionality, and that epidemiological methodology has increasingly focused on heterogeneity (e.g., precision medicine), only recently has intersectionality been applied to addressing questions of heterogeneity within quantitative research on health and social inequity.

This article aims to push quantitative intersectionality methodology beyond consideration of heterogeneity in outcomes, toward identification of causal processes that drive intersectional inequities. First, we discuss methodology currently in use within quantitative intercategorical intersectionality research, and differentiate descriptive intersectionality focused on outcome heterogeneity across intersections from an analytic intersectionality that also examines heterogeneity in process (Bauer, 2014). We consider discrimination as one factor of interest as a mediating driver of inequalities. Next, we provide an overview of challenges, and identify a potential outcomes approach to mediation decomposition analysis as a well-specified strategy for producing clearly interpretable intersectional effects. We present a step-by-step strategy for this type of analytic intersectionality analysis, and illustrate it with an example of inequalities in current psychological distress across ethnoracial and sexual/gender minority intersectional groups, mediated by past-year experiences of day-to-day discrimination. Finally, we present considerations in designing, implementing, and interpreting results, including in situations more complex than our those illustrated in our simplified example.

1.1. The emergence of descriptive intercategorical intersectionality in quantitative research

McCall (2005) describes intercategorical complexity approaches as those that use categorization pragmatically to examine experiences across multiple intersecting social categories, in contrast with the intracategorical approach, which focuses on experience within an intersection and addresses fundamentally different questions. Intercategorical intersectionality has been applied in two primary ways within quantitative research. The first is to describe outcomes stratified on cross-coded categories (e.g., young Black men) representing intersections between multiple groups. This is an expansion of traditional equity stratifier methods, wherein outcomes are stratified on single axes for which presence of a numeric inequality may suggest a social inequity (Bambas, 2005). Statistical analysis methods may involve bivariate analysis of outcomes by intersectional groups (e.g., Lord et al., 2009), or more complex data-driven approaches such as classification tree analysis, that group or split potential intersections based on heterogeneity (e.g., Cairney et al., 2014).

The second common use is in assessing a joint inequality and its composition by regressing an outcome on two or more social identity/position categories and their interaction(s), including a test of whether the effects for a particular intersection differ from those expected by combining effects for each separate identity/position (Jackson et al., 2016). Hypothesis testing can involve adding an interaction term for two social categories in a regression model (e.g., Agénor et al., 2014), or more complex multi-level methods for studying interaction effects across a large number of high-dimensional intersections (e.g., Evans et al., 2018; Merlo, 2018). While useful in estimating inequalities and generating theories, all interactions generate some technical and interpretive hazards. First, only in the additive scale is the difference between the joint effects and the sum of individual effects interpretable as an excess or reduced risk for those at an intersection. Thus, multiplicative-scale analyses (e.g., in logistic regression) require additional analysis for additive-scale interpretability (Bauer, 2014; Jackson et al., 2016). Second, a finding of an antagonistic interaction may be too readily interpreted as a 'good news' case where a negative outcome occurs less frequently than expected. This type of interpretation risks losing track of the actual outcome level, which may still be more extreme at such an intersection than at all others.

Hancock (2016) has called this type of analysis the "intersectionality-as-testable-explanation approach". While common, it may reinforce a limited interpretation of intersectionality. Intersectionality is not the hypothesis that synergistic interaction exists wherever two marginalization-related factors co-occur. Rather, it is an acknowledgement of the fundamental inability to describe an intersection as the sum of its parts, and a recognition that power shapes the processes that produce different life experiences and outcomes for those at different intersections. In fact, one advantage of quantitative intersectionality is the ability to represent a wide range of participants' embodied positions, including those who do not exclusively experience marginalization (Bauer, 2014).

Well-conceptualized descriptive intercategorical intersectionality studies are neither atheoretical in their design nor in their interpretation and are valuable not only for documenting inequalities but for informing the development or revision of theory. However, to the extent that they include only non-modifiable social categories, each of these approaches remain fundamentally descriptive in nature, regardless of the simplicity or complexity of methods and interpretation (Bauer, 2014). While describing inequalities in finer detail is a critical first step, such descriptive intersectionality in the absence of discussion or analysis of causal process may unintentionally reinforce concepts of inequalities as normalized and intractable. May (2015) identified this flattening of intersectionality to only descriptive use as one way that practitioners "blunt its critical edge and transformative aims". While adding adjustment for confounding may move such analyses away from pure description to produce estimates of total causal effects, additional consideration of modifiable factors that drive these inequalities is necessary both to understand and remedy inequalities.

1.2. Quantitative analytic intersectionality

Within intercategorical intersectionality research, we label studies that examine the distribution of outcomes across groups defined by intersectional positions of power and privilege as *descriptive intersectionality* and argue for the importance of an *analytic intersectionality* that also seeks to identify the causal processes that drive inequalities of outcomes, while necessarily allowing for causal processes to unfold heterogeneously across intersectional groups. Intersectionality demands an approach that does not assume outcomes are the sum of their parts. We argue that it also demands that we consider that the mediators of these outcomes may have a different effect for those at different intersections, one that may also not be equal to the sum of its parts. A move to analytic intersectionality is ultimately a call to prioritizing heterogeneity of processes as well as of outcomes.

We thus define quantitative analytic studies of intercategorical intersectionality as having the following four characteristics: 1) Intersections are structured around dimensions that reflect some difference in current or historic social power. 2) Where possible, analysis makes intersectional inequalities visible by starting with a descriptive approach to ensure frequencies or levels of outcomes for those at particular intersections are not obscured. 3) Theoretical models consider the causal processes that may contribute to intersectional inequalities. And 4), methods that are used to estimate effects for these causal

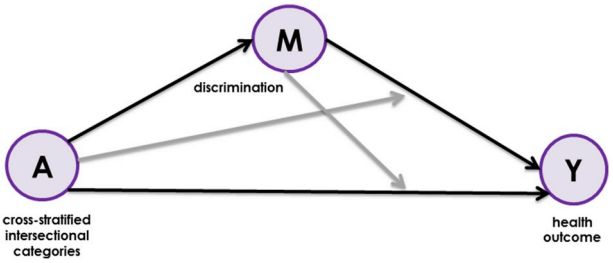


Fig. 1. Basic formulation for analytic intersectionality research question. Cross-stratified intersectional categories (A) are considered with regard to their total effects on an outcome (Y), both in crude analysis (actual observed inequalities) and in confounder-adjusted analysis (total causal effect). A potential mediator (M) such as discrimination may at least partially explain the causal effect, and is modifiable. The necessary allowance for heterogeneity in process is illustrated by two grey arrows. While non-standard with regard to causal diagram methodology, these provide a clear visual representation that the effect of the mediator on the outcome (M→Y) may vary for each intersectional group. Since interaction is reciprocal, it will also be true that where interaction exists, the effect of membership in an intersectional group must vary at different levels of the mediator.

processes allow for effects to vary in magnitude, direction, and existence for groups at different intersections. Studies that meet these conditions have the potential to contribute to etiologic understanding of intersectional inequalities, and to generate more refined causal hypotheses. Moreover, they offer the potential for identification of both intersection-specific inequality 'hotspots' and overall or intersection-specific intervention targets. The model in Fig. 1 presents a causal diagram describing one formulation of this type of question.

1.3. Discrimination as a potential mediator of inequalities

While analytic intersectionality studies may involve a range of potential mediating drivers of inequalities, discrimination is of broad and obvious interest. Discrimination encompasses explicit and implicit policies, practices, and behaviors ranging from institutionalized, legal subjugation to interpersonal mistreatment (Krieger, 2014). Enacted interpersonal discrimination has been the focus of most research on discrimination and health, in part due to its amenability to self-report (Krieger, 2014). It has been broadly categorized as *day-to-day* (or "everyday") versus *major* discrimination, interpersonal slights that are chronic in nature versus discrete events that are likely to restrict future life chances (Williams et al., 1997). We note, however, that the methods presented herein can also be used to examine the mediating roles of indicators of structural discrimination (e.g., incarceration, housing quality).

Discrimination is theorized to negatively impact health through biological, psychosocial, and material pathways with psychosocial stress processes dominant in the study of self-reported discrimination and health (Krieger, 2014). Meta-analyses have confirmed a robust relationship between perceived discrimination and negative mental health outcomes within targeted groups (Paradies et al., 2015; Schmitt et al., 2014). Within-group studies, however, do not reflect between-group variation in discrimination, which may produce and maintain the inequalities which ultimately motivate this field of research (Schwartz and Meyer, 2010). A direct test of the hypothesis that discrimination is causally related to population health inequalities requires between-group analysis of mediating effects (Schwartz and Meyer, 2010). In turn, this procedure necessitates measures that function across groups and that are not limited to a single attributional basis (e.g., racism, homophobia) (Scheim & Bauer, unpublished).

While researchers have recently argued for the importance of rigorous studies of mediation effects to identify drivers of health-related inequalities (Naimi et al., 2016), analysis of mediation without mediated interaction requires the assumption that mediators will have the same effect on an outcome for all groups. Analytic intersectionality requires consideration of potential interactions between intersectional group membership and a mediator such as discrimination in producing outcomes. Discrimination occurs in varied social and historical contexts for those at different intersections and may have different meanings and impacts. Meta-analyses confirm that such interactions exist when considering unitary axes of social identity/position (Paradies et al., 2015; Schmitt et al., 2014), and there is no reason to assume they could not for multiple intersecting axes.

2. Methodological challenges in analytic intersectionality

2.1. Intersectional groups as causes of health outcomes

Health inequalities across social identity/position groups present a particular type of question for causal analysis. Given that no intervention is possible or even desirable to change most social identities or positions, and that for most individuals, category membership is consistent from birth (e.g., race, sex/gender), the key question is one of mediation. What are the factors that flow from membership in a particular category, in a particular social context, which promote or hinder the health of those within that category?

We note that saying in an epidemiological sense that race or gender causes discrimination is quite different from saying this in common language. The implication is not that one causes their own poor treatment, but rather that others may react to one's perceived characteristics in ways that are discriminatory. Therefore, two individuals who are similar with regard to all other relevant factors may receive differential treatment, something for which there is ample experimental evidence (Schulman et al., 1999; Zschirnt and Ruedin, 2015). That social identities or positions (or perceptions of them) can cause discrimination or other mediating factors which themselves impact health leads us to understand intersectional groups as causes of health outcomes through mediating pathways.

2.2. Mediation analysis for intersectional effects

Analysis of mediating factors along the causal pathway from the initial exposure to the final outcome of interest has traditionally been done in one of two ways. In epidemiology, the difference method has been used, wherein estimates of the effect of an exposure on an outcome are compared between models with and without inclusion of the mediator as a covariate (Richiardi et al., 2013). In the social sciences, the product method popularized by Baron and Kenny (1986) is frequently used, with some updates (Zhao et al., 2010). However, these older methods can produce inconsistent results with some types of data, and newer methods for causal mediation analysis have better validity (Naimi et al., 2016; Richiardi et al., 2013).

Moreover, because analytic intersectionality demands that we consider how the processes that generate outcome inequalities may differ in their effect across intersecting positions, any mediation method used must allow for exposure-mediator interaction. Some mediated effects may exist only for those at particular intersections, and effects of mediating processes may vary in magnitude, or even in direction, across groups. Traditional methods do not allow for a combined analysis of mediation and interaction that can be decomposed into clear causal components.

Mediation analysis of discrimination poses an additional challenge in that many discrimination measures focus on a single attributional basis (e.g. racism, homophobia). An analysis of discrimination across intersectional groups requires a measure of discrimination that functions across attributes. A companion article (Scheim and Bauer, in press) presents a validation study of three discrimination measures designed specifically for intercategorical intersectionality analyses.

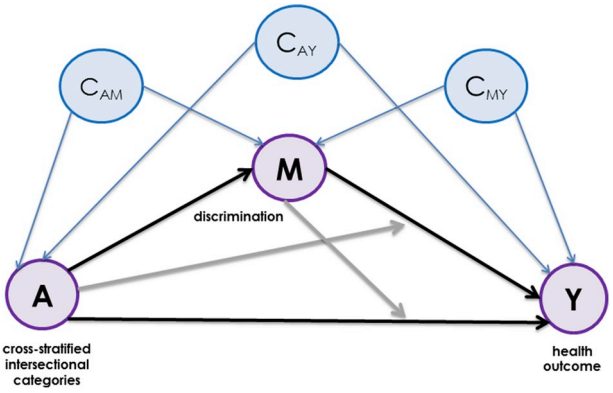


Fig. 2. Types of confounding in mediated effects.

2.3. Confounding

Because analytic intersectionality attempts to identify causal mediating processes and potential intervention targets, identifiability of effects depends on control of exposure-outcome, exposure-mediator, and mediator-outcome confounding (C_{AY}, C_{AM} and C_{MY} in Fig. 2, respectively). Causal models, or directed acyclic graphs (DAGs), present an approach to assessing dependence and independence between variables, based on causal relationships between each variable in a model (Greenland et al., 1999). Their use within epidemiology has become well established, and corresponding probability functions can be derived from them (Pearl et al., 2016). They represent a visual and functional arrangement of potential outcomes, such that a change in frequency or level for any variable would be assumed to affect the population frequency of level of any causal "descendants".

3. A potential outcomes approach for analytic intersectionality studies

3.1. Potential outcomes

Potential outcomes approaches are based on a counterfactual definition of causation. At the individual level, causation is defined by a comparison of observed outcomes under observed exposures, in contrast to the unobservable (counter to fact) condition wherein all is the same, other than the exposure and its causal effects. This may be expressed for each individual as $Y_1 - Y_0$, the outcome Y given that the individual is in intersectional group A = 1 minus the outcome given that the individual is in the reference intersectional group A = 0. At least one of these conditions must be counterfactual. At an individual level, such causal reasoning is commonplace ("if I hadn't smoked, then I wouldn't have cancer"), and it is easy to see that such logic extends to non-modifiable categories such as race ("the officer never would have responded that way if the driver was white").

Causal effects for a group at a particular intersection may then be understood as an average of the individual causal effects, $E[Y_1 - Y_0]$. While such total effects may be interesting in establishing causal relationships, they are not informative in developing strategies to address intersectional inequalities, given the non-modifiability of most social identities/positions. Since identification of modifiable mediating factors has been identified as being of primary importance for guiding strategies for reducing inequalities (Howe et al., 2018; Naimi et al., 2016), mediation methods must be applied to intersectional inequalities and given intersectional interpretations.

3.2. Decomposition of causal effects

The first (Robins and Greenland, 1992) and most commonly used two-way causal mediation decompositions separate the total effect (TE) into two components: the pure direct effect (PDE) and the total indirect effect (TIE), also referred to as the natural direct effect (NDE) and natural indirect effect (NIE). Conceptually, these reflect the common non-counterfactual concepts of direct and indirect effects used in product methods (e.g., Baron and Kenny, 1986).

While a range of additional decompositions are available (VanderWeele, 2014), VanderWeele's (2013) three-way decomposition provides the most relevant measures of effect for analytic intersectionality. First, it allows for comparisons between groups set to an arguably achievable intervention level, here the lowest mean level of discrimination for any intersection, rather than the absolute absence of even a single event of day-to-day discrimination. Second, it addresses a central tenet of intersectionality: that outcomes for those at different intersections can be differently shaped by processes. The total indirect effect can be decomposed into the pure indirect effect (PIE) and the mediated interaction (INT_{med}), which combine with the pure/natural direct effect (PDE or NDE) to sum to the total effect (TE) of exposure on outcome: $TE = PDE + PIE + INT_{med}$.

Using this approach for discrimination as a mediator, we are able to decompose the intersectional inequalities in an outcome to identify the following component effects for each intersectional group, in comparison to the reference intersection that experienced the lowest levels of discrimination: 1) PDE: the expected inequality in outcome due to membership in the comparison ("exposed") intersectional group, if they had experienced the same lower levels of discrimination for the reference ("unexposed") intersectional group; 2) PIE: the difference in outcome due to the higher level of discrimination experienced by the comparison intersection, where the effect of discrimination on the outcome is that experienced by the reference intersection, and; 3) INT_{med}: the added interaction effect of discrimination on the outcome due to membership in the comparison group. The total indirect effect (TIE) is the sum of PIE and INT_{med}. Here, the TIE represents the effect due to discrimination, with PIE indicating the portion due to unequal exposure to discrimination and INT_{med} the portion due to unequal magnitude of effect for discrimination. The total effect TE is the sum of the PDE and the TIE.

Table 1 provides definitions and interpretations of each component effect. Notation refers to values of the outcome at different levels of the exposure and mediator; $E[Y_{1M_1}]$ for example, refers to the expected level of outcome Y for exposure level 1 (the comparison intersection) at the mean level the mediator naturally takes for this group. $E[Y_{0M_0}]$ then refers to the expected outcome level for the reference intersection, at the level the mediator takes for this group. Note that mediated interaction is sometimes presented as a difference in effects of the exposure at two levels of the mediator—that which would occur with exposure versus that which would occur given lack of exposure. This equation $E[(Y_{1M_1} - Y_{0M_1}) - (Y_{1M_0} - Y_{0M_0})|c]$ is algebraically equivalent to the one in Table 1, $E[(Y_{1M_1} - Y_{1M_0}) - (Y_{0M_1} - Y_{0M_0})|c]$ which describes the difference in the effects of the mediator at two levels of the exposure, conditional on a sufficient set of confounders. Doing so provides a clearer interpretation in an intersectional sense, as we are interested in whether the average effects of discrimination vary for those at different intersections.

For these three component effects to be identified from data, the general assumptions that apply to all mediation analyses must be met: 1) the effect of the exposure on the outcome is unconfounded after conditioning on a set of confounders; 2) the effect of the mediator on the outcome is unconfounded after conditioning on the set of confounders and the exposure; 3) the effect of the exposure on the mediator is unconfounded after conditioning on the set of confounders, and; 4) none of the mediator-outcome confounders are themselves affected by the exposure (VanderWeele, 2013). Therefore, it is essential that these analyses be adjusted for confounders, including common mediator-outcome confounders representing other social identities or positions (e.g., disability) that can trigger discrimination and affect the outcome. Note that while Assumptions one through three may be addressed in the

Table 1
The components of total intersectional effects: Definitions and interpretations.

Effect	Counterfactual definition	If statistically significant	Interpretation	Application to example
pure direct effect (PDE)[a]	$E[Y_{1M_0} - Y_{0M_0} \| c]$	Intersection has an effect on the outcome, when the mediator is set to the level of the reference intersection.	Direct unmediated effect. Difference in expected value of outcome for comparison versus reference intersection, if both experienced the reference intersection's level of the mediator. Expected residual inequality after intervention.	What would be the expected difference in psychological distress for Indigenous SGM people in comparison to white non-SGM people, if Indigenous SGM people experienced the same lower level of past-year day-to-day discrimination as white non-SGM people?
pure indirect effect (PIE)	$E[Y_{0M_1} - Y_{0M_0} \| c]$	Intersection has an effect on the mediator; mediator has an effect on the outcome for the reference intersection	Effect due to mediation only. Difference in expected value of outcome due to difference in mediator levels for comparison versus reference intersections.	What would be the expected difference in psychological distress due to the higher levels of past-year day-to-day discrimination experienced by Indigenous SGM versus the lower levels experienced by white non-SGM, if the effect of discrimination on psychological distress were of the same magnitude and direction observed for white SGM?
mediated interaction (INT_{med})	$E[(Y_{1M_1} - Y_{1M_0} \| c) - (Y_{0M_1} - Y_{0M_0} \| c)]$	Mediator's effect on the outcome is different for the comparison and reference intersections.	Effect due to mediation and interaction. Difference in expected value of outcome due to difference in mediator's effect for the comparison versus reference intersections.	What would be the additional effect of past-year day-to-day discrimination on psychological distress for the Indigenous SGM group versus the white non-SGM group?

[a] Also called natural direct effect (NDE).

methods and model analysis we present below, in cases where Assumption four is not met, changes to the design, analysis and/or interpretation of effects are required; we discuss these strategies later in this article after presenting the general approach.

4. Method

Analysis can be undertaken by following these steps:

1. Where possible, descriptive intersectional analysis is first conducted to assess existence and magnitude of outcome inequalities. Outcome distributions are estimated for each cross-stratified intersectional group, with statistical testing for significant differences for pairwise comparisons to assess patterns in inequalities.
2. Mean levels of the mediator are estimated for each of the cross-stratified intersectional groups. The group with the most advantageous mean is identified (lowest in the case of discrimination) and serves as the reference intersection.
3. Potential confounding variables are identified based on existing theory and evidence using a DAG, including exposure-outcome, exposure-mediator, and mediator-outcome confounders.
4. A set of dummy variables is coded for each intersectional comparison group versus the reference intersection, and for each categorical confounder.
5. Means are estimated for each confounder, separately for each comparison intersection group.
6. For each comparison-reference subset, two regression models are estimated—controlling for confounders (represented as a vector)—the first predicting the outcome as a function of exposure, mediator, and an exposure-mediator interaction term, and the second predicting the mediator as a function of the exposure, both controlling for confounding (VanderWeele, 2013).

$$E[Y|a, m, c] = \theta_0 + \theta_1 a + \theta_2 m + \theta_3 am + \theta'_4 c \quad \text{Eq. 1}$$

$$E[M|a, c] = \beta_0 + \beta_1 a + \beta'_2 c \quad \text{Eq. 2}$$

7. Using the parameter estimates from these regressions, effect estimates are calculated for the pure direct effect (PDE), the pure indirect effect (PIE), and the mediated interaction (INT_{med}) as follows:

$$PDE = \theta_1(a - a^*) + \theta_3(a - a^*)(\beta_0 + \beta_1 a^* + \beta'_2 c) \quad \text{Eq. 3}$$

$$PIE = \beta_1(a - a^*)(\theta_2 + \theta_3 a^*) \quad \text{Eq. 4}$$

$$INT_{med} = \theta_3(a - a^*)\beta_1(a - a^*) \quad \text{Eq. 5}$$

8 95% confidence intervals are constructed around effects using the delta method or bootstrapping.

In equations three through five, $(a - a^*)$ represents the difference in exposure. Within equation (3), $(\beta_0 + \beta_1 a^* + \beta'_2 c)$ predicts the value that M would take for the reference intersection or unexposed. As this component is the only estimate that is a prediction rather than a contrast, the comparison group means for confounders are used for prediction, given that a hypothetical intervention could not be expected to alter the confounder levels in this target group. The PDE formula thus expresses the effect of the exposure on the outcome where $M = M_{a^*}$. In equation four, $\beta_1(a - a^*)$ is the effect of the exposure on the mediator, and $(\theta_2 + \theta_3 a^*)$ is the effect of the mediator on the outcome at the reference exposure level. Equation five estimates the additional effect of the mediator on the outcome among the “exposed” intersection (versus the “unexposed” reference intersection). It is estimated as the product of the interaction parameter θ_3, the difference in exposure $(a - a^*)$, and the corresponding difference in mediator $\beta_1(a - a^*)$.

These effects will be estimated separately for each comparison of an intersection to the reference intersection. Thus, for the intersectional

group comparisons described, wherein $a = 1$, $a^* = 0$ and $(a - a^*) = 1$, these general mediation decomposition equations simplify as follows:

$$PDE = \theta_1 + \theta_3(\beta_0 + \beta'_2 c) \quad \text{Eq. 6}$$

$$PIE = \beta_1\theta_2 \quad \text{Eq. 7}$$

$$INT_{med} = \theta_3\beta_1 \quad \text{Eq. 8}$$

5. Demonstration

Below, we present a simplified demonstration analysis to illustrate how this method may be employed. In this tutorial, we will initially provide instruction on how results would be interpreted in an ideal counterfactual design, wherein all assumptions were met, and then discuss real-world design and analytic considerations, as well as limitations to causal interpretation even in the context of a causal design.

5.1. Data set

Data for the example analysis come from a survey designed to validate the Intersectional Discrimination Index (InDI) (Scheim and Bauer, in press). As the InDI was designed to allow for assessment of (separately) anticipated, day-to-day, and major discrimination across social categories, without ignoring the importance of social position, this demonstration also serves to outline one of its intended uses. Recruitment and data collection procedures are described in detail elsewhere (Scheim and Bauer, in press). Briefly, data were collected by a commercial company, Legerweb, through their online survey panel, with quota sampling for each of six ethnoracial groups and SGM individuals. The final sample included 2583 participants aged 18 to 88 (59% in the United States and 41% in Canada), of whom 2542 participants with non-missing data are included in these demonstration analyses. Surveys were completed online, and participants received a small monetary or AirMiles honorarium. The Non-Medical Research Ethics Board at Western University approved this study.

5.2. Measures

For this analysis, our exposure consisted of six ethnoracial categories (white, Indigenous, Latin American/Hispanic, Middle Eastern, Black, or Asian) cross-stratified by two sexual or gender minority categories (SGM versus heterosexual and cisgender, or non-SGM), for a total of 12 *intersectional groups*. Our outcome, *psychological distress*, was measured with the Kessler 6 scale (Kessler et al., 2002) and modeled as a continuous outcome; the Kessler 6 is scored over a possible range of zero to 24. We considered *past-year day-to-day discrimination* as a mediator, using summary scores from the InDI-D, a nine-item measure assessing the occurrence and frequency of nine forms of interpersonal discrimination (Scheim and Bauer, in press). Items scores were zero to indicate no past-year experience, one to indicate once or twice, and two to indicate many times, with total scores ranging from zero to 18.

Guided by a DAG, we included *age* (continuous), *sex assigned at birth* (male vs. female), *immigration history* (immigrant or temporary resident vs. citizen from birth), and physical or mental *disability* (yes vs. no) as confounders in the initial demonstration.

5.3. Statistical analysis

Statistical analysis was undertaken following the steps presented above. White non-SGM persons were chosen as the reference intersection for analysis based on having the lowest mean for past-year day-to-day discrimination ($\bar{x} = 1.517$). Data analysis was conducted using SAS software, version 9.4 (2017); a recent update to SAS/STAT included the new PROC CAUSALMED procedure for causal mediation (steps four and five). Since this procedure only allows for two categories in an exposure, a set of dichotomous variables must be dummy coded for each comparison intersection versus the reference intersection, and analysis conducted separately for each reference-comparison subset. The SAS syntax for intersectional mediation analysis follows, wherein A = dummy variable for one comparison-reference intersectional group, M = mediator, and Y = outcome. C1 through C4 represent confounding covariates and are set to the comparison group means. Comparison group means are used to produce effects for common confounder values among the target intersection populations, as any intervention will be targeted to changing the mediator rather than the confounders. This also ensures that specified confounder levels reflect those that may actually be observed at these intersections.

```
proc causalmed data=intersect decomp=3;

 class A (ref='0');

 model Y = A M A*M;

 mediator M = A;

 covar C1 C2 C3 C4;

 evaluate _default C1=<value> C2=<value> C3=<value> C4=<value>;

run;
```

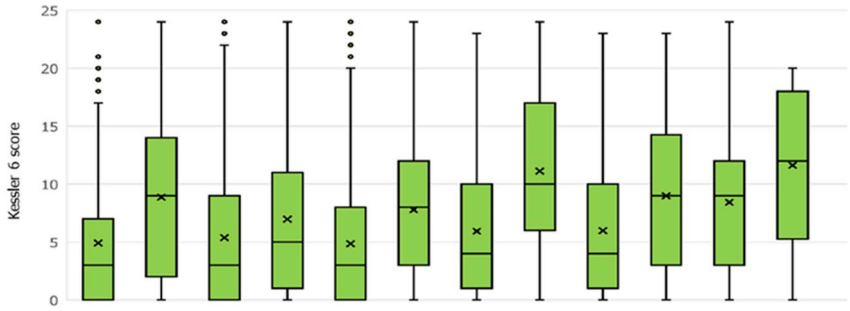
5.4. Results and basic interpretation

A boxplot and table of pairwise comparisons between groups appears in Fig. 3. (Means for discrimination and psychological distress for each of the intersectional groups are included in supplemental data.) Lowest levels of psychological distress were observed for white, Black and Asian non-SGM groups, which did not differ significantly from each other. Highest levels of psychological distress were observed for Indigenous and Middle Eastern SGM groups, which each differed significantly from all groups other than each other. Among all six ethnoracial groups, SGM had statistically significantly higher psychological distress than non-SGM.

Adjusted total effects and the three component effects for each of 11 intersectional groups in comparison with the white non-SGM reference intersection are shown numerically in Table 2 and graphically in Fig. 4. Effects represent modeled changes in psychological distress levels on the Kessler 6. After adjustment for confounding, one non-SGM group had levels of psychological distress significantly higher than the reference intersection (Middle Eastern non-SGM, TE = 1.366), as did four SGM groups: white, Indigenous, Latin American/Hispanic, and Middle Eastern, with TEs ranging from 1.710 (white SGM) to 5.203 (Middle Eastern SGM).

Assuming that all assumptions were met, the PDE can be interpreted as the residual causal intersectional effects on psychological distress that would be estimated to persist, if discrimination could be reduced for all groups to the same achievable low levels of the white non-SGM group. PDEs were statistically significant and positive among Indigenous and Middle Eastern SGM (PDE = 1.861 and 4.229, respectively), and protective for Black non-SGM (PDE = −0.891). Results suggest that inequalities would thus persist for some groups, but Black non-SGM would have lower levels of psychological distress than the reference intersection, in the absence of excess discrimination.

The effect of discrimination on psychological distress due to mediation alone (PIE) was statistically significant and positive for all groups except Latin American and Asian non-SGM, with PIEs ranging from 0.339 among Indigenous non-SGM to 1.544 among Middle Eastern SGM. Results would indicate a consistent causal role for differing levels of discrimination in producing psychological distress. Finally, there were no statistically significant mediated interactions, indicating that the effect of discrimination on psychological distress for each comparison intersectional group did not differ significantly from the effect



In comparison with...	White non-SGM	White SGM	Asian non-SGM	Asian SGM	Black non-SGM	Black SGM	Indig. non-SGM	Indig. SGM	Latin non-SGM	Latin SGM	Middle Eastern non-SGM	Middle Eastern SGM
White non-SGM		+	nd	+	nd	+	+	+	+	+	+	+
White SGM	-		-	-	-	nd	-	+	-	nd	nd	+
Asian non-SGM	nd	+		+	nd	+	Nd	+	nd	+	+	+
Asian SGM	-	+	-		-	nd	nd	+	nd	+	+	+
Black non-SGM	nd	+	nd	+		+	+	+	+	+	+	+
Black SGM	-	nd	-	nd	-		-	+	-	nd	nd	+
Indigenous non-SGM	-	+	nd	nd	-	+		+	nd	+	+	+
Indigenous SGM	-	-	-	-	-	-	-		-	-	-	nd
Latin American non-SGM	-	+	nd	nd	-	+	nd	+		+	+	+
Latin American SGM	-	nd	-	-	-	nd	-	+	-		nd	+
Middle Eastern non-SGM	-	nd	-	-	-	nd	-	+	-	nd		+
Middle Eastern SGM	-	-	-	-	-	-	-	nd	-	-	-	

nd = no statistically significant difference; F=17.61, p<0.001.

Fig. 3. Patterns in statistically significant differences in psychological distress (Kessler 6) between intersectional groups (N = 2542).

among those at the reference intersection.

Together, these results would provide some interesting points to consider. Highest levels of psychological distress were observed for two infrequently studied intersections (Indigenous and Middle Eastern SGM groups), highlighting the potential for quantitative intersectionality to identify intersectional locations that may be "hotspots" for inequalities. Total adjusted effects remained sizeable and significant for both of these groups. Discrimination accounted for a minority of the effect among both of these groups. Our results suggest that Middle Eastern SGM could expect a large residual causal effect on psychological distress (PDE = 4.229) following a successful intervention to reduce discrimination. For the Black non-SGM group, PDE and PIE were both statistically significant, albeit in different directions, resulting in no net inequality in psychological distress, an overall effect consistent with existing research (Schwartz and Meyer, 2010). These patterns highlight the importance of decomposition methods even in the absence of an intersectional inequality to be explained, as excess day-to-day discrimination still had an adverse effect. Overall, results would indicate that inequalities in past-year day-to-day discrimination account for a large portion of inequalities, and support an effect driven by unequal levels of discrimination, rather than to unequal effects of discrimination.

This simplified example serves to illustrate the general method, but has many limitations, including the use of a non-random online sample. While the analysis has a causal design, true causal interpretation is only as strong as warranted by the sampling, validity of measures, and control of confounding. We present this example as an illustration of the basic method, and caution against overinterpretation of these specific results, particularly given limitations in our measures (e.g., aggregation of sexual and gender minorities) and in our control of confounders (e.g., socioeconomic status).

6. Discussion

The methods we describe address one particular formulation of analytic intersectionality, the identification of intercategorical health inequalities across cross-stratified intersectional groups, and the analysis of mediating effects. While applied to discrimination, this formulation will similarly work for other potential mediators. It allows us to structure questions with direct relevance and clear and arguably

Table 2
Components of effects of intersectional group on psychological distress, mediated by discrimination.

	Total effect		Direct effect		Indirect effect			
	TE		PDE		PIE		INTmed	
	est.	95% *CI*	est.	95% *CI*	est.	95% *CI*	est.	95% *CI*
White non-SGM	ref	–	ref	–	ref	–	ref	–
White SGM	**1.710**	**0.359, 3.060**	0.921	−0.435, 2.276	**0.797**	**0.293, 1.301**	−0.008	−0.544, 0.529
Asian non-SGM	−0.656	−1.464, 0.153	−0.670	−1.439, 0.098	0.009	−0.219, 0.238	0.005	−0.121, 0.131
Asian SGM	0.188	−0.944, 1.320	−0.578	−1.646, 0.490	**0.455**	**0.0775, 0.833**	0.310	−0.025, 0.645
Black non-SGM	−0.518	−1.231, 0.195	**−0.891**	**−1.573, -0.208**	**0.430**	**0.148, 0.713**	−0.057	−0.243, 0.129
Black SGM	0.626	−0.839, 2.090	−0.202	−1.690, 1.285	**1.096**	**0.470, 1.721**	−0.268	−0.936, 0.401
Indigenous non-SGM	0.229	−0.569, 1.027	−0.126	−0.893, 0.641	**0.339**	**0.071, 0.608**	0.016	−0.148, 0.180
Indigenous SGM	**2.886**	**1.552, 4.221**	**1.861**	**0.530, 3.193**	**0.929**	**0.392, 1.465**	0.096	−0.507, 0.700
Latin American non-SGM	0.145	−0.740, 1.029	−0.083	−0.923, 0.758	0.195	−0.077, 0.467	0.032	−0.072, 0.136
Latin American SGM	**1.881**	**0.384, 3.377**	1.173	−0.333, 2.679	**0.849**	**0.284, 1.414**	−0.141	−0.698, 0.415
Middle Eastern non-SGM	**1.366**	**0.257, 2.474**	0.872	−0.220, 1.964	**0.731**	**0.273, 1.188**	−0.237	−0.645, 0.171
Middle Eastern SGM	**5.203**	**3.394, 7.012**	**4.229**	**2.137, 6.322**	**1.544**	**0.735, 2.354**	−0.570	−1.823, 0.683

Note. All estimates are adjusted for age, sex assigned at birth, immigration history, and disability status. Confounder levels are set to comparison intersection means.

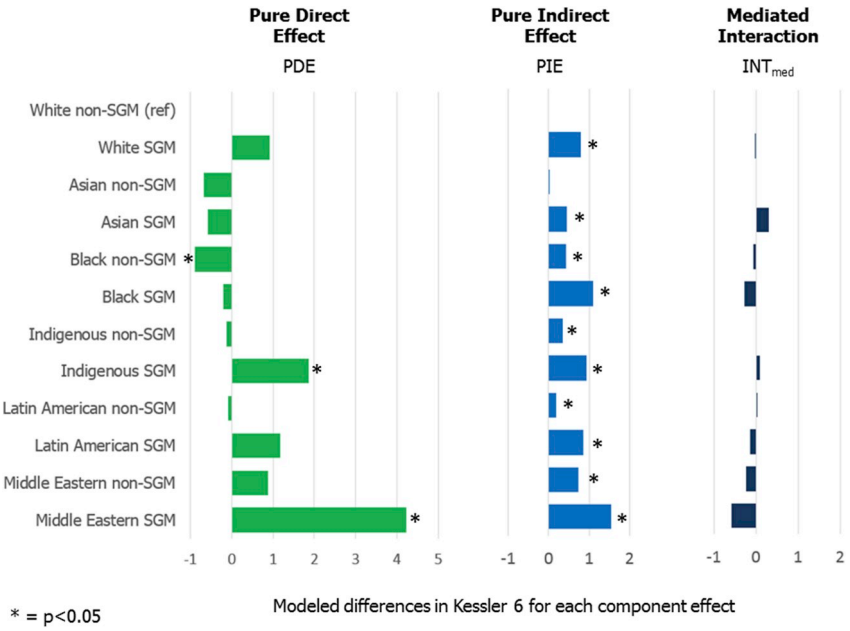


Fig. 4. Intersectional components of effects on psychological distress, mediated by past-year day-to-day discrimination.

achievable intervention targets based on equalizing modifiable factors. It results in actual (crude) and causal (adjusted) estimates for total effects, as well as components of total causal effects. As such, it provides more relevant information than other methods that may also meet the requirements of analytic intersectionality (e.g., an analysis of discrimination's effect on an outcome, with intersectional group as an effect-measure modifier). It should be noted that one further decomposition is possible, with the PDE decomposed into a controlled direct effect (CDE) of the exposure on the outcome with the mediator set to a zero value and a reference interaction (INTref) representing the additional effect with the mediator at the level of (in our case) the reference intersection (VanderWeele, 2014). This additional decomposition may be of interest where a mediator's zero value is both meaningful and representative of a plausible intervention target.

There are of course limitations to how these methods may be used and how results may be interpreted. Some of these are not specific to intersectionality studies. Causal models, for example, require clear temporality. In our example, measure timeframes provided clarity. Temporality will not always be clear in cross-sectional data and analyses may be best suited to cohort data. In addition, while procedures allow for estimating components as proportions of total effect (VanderWeele, 2013), in order to avoid non-intuitive proportions that are negative or in excess of 100%, all component effects must be in the same direction. There is no inherent reason to expect this, and it becomes increasingly unlikely as the number of intersections increases. Thus, we recommend presentation of results based on absolute effects rather than proportions, where possible. This has the advantage of not obscuring the overall effect size. The methods outlined are theorized as a hypothetical set of interventions on each intersection versus the reference intersection. As there are no tests of significant differences across intersections, researchers should avoid such interpretations. Sampling is another general consideration, both in regard to external validity, and in ensuring a sample is not selected on criteria that are themselves affected by the exposure (e.g., pregnancy, HIV status in our example). Such selected samples may generate false or distorted associations between an exposure and outcome due to collider stratification bias (VanderWeele and Robinson, 2014, see appendix), and are of obvious concern given the long-term nature of many intersectional 'exposures'.

While these methods are explicitly causal in theory and design, causal interpretation is dependent on confounding control, and its sufficiency must always be considered. Beyond uncertain theory upon which to base a DAG and lack of data on confounders, one of the more likely challenges is one inherent to mediation analyses generally: that Assumption four (no exposure-induced mediator-outcome confounding) is not met. Exposure-induced confounders mediate both the exposure-mediator and exposure-outcome pathways. Therefore, they cannot simply be controlled for. For this reason, use of mediation methods has been more prominent in addressing questions with short timeframes between exposure and mediator, to reduce the number of potential mediators along that pathway. In intersectional mediation research, and social inequalities research generally, longer exposure-mediator timeframes are the norm.

Strategies to address a variable that serves as an exposure-induced mediator-outcome confounder can take three main forms: alterations to the intersectional categories, alterations to the analysis and interpretation, or conduct of a sensitivity analysis to explore unmeasured confounding. We can consider this as applied to the example analysis with regard to socioeconomic status (SES), which may by in the position of an exposure-induced confounder but was omitted from the basic demonstration example. The first approach is perhaps the simplest and clearest, where the variable consists of a social position that is also of interest and where the sample size is sufficient. For example, if poverty were theorized as the key socioeconomic exposure-induced confounder, we could redesign the analysis to examine intersections of ethnoracial group, SGM, and poverty. The second approach acknowledges that while counterfactual effects are not identifiable, corresponding alternative randomized intervention analogue effects are estimable. Analogues for PDE, PIE, and INTmed are presented by VanderWeele (2014, see appendix). While these do not require the assumption of no exposure-induced confounding, and thus allow for control for SES, they also provide a weaker interpretation of effects, wherein instead of the mediator being set to the value it would take for a particular exposure, it instead is set to a value randomly chosen from the distribution for a specific exposure level. Methods for analysis using inverse probability weighting are described for PDE and TIE by VanderWeele et al. (2014) and can be extended. The final option, useful when there is uncertainty as to exposure-induced confounding, is to exclude the potential exposure-induced confounder from analysis, as in the demonstration analysis, and conduct a sensitivity analysis (VanderWeele and Chiba,

2014). While this option does not account for exposure-induced confounding in the estimates, it may be helpful in providing reassurance that its effects are small, even in cases where potential confounders (such as SES) may be measured.

Additional considerations apply to use of mediation methods for intersectionality studies, in particular. First, as social groups are coded into cross-stratified categories, the number of categories will increase with the number of identities/positions considered and with the number of categories within each, increasing the potential for sparse data. While multilevel analysis of individual heterogeneity (MAIH, or MAIHDA if discriminatory accuracy analysis is included) models (Evans et al., 2018; Axelsson Fisk et al., 2018) and classification tree methods (Cairney et al., 2014) have recently been applied for descriptive intersectionality analysis across a large number of high-dimensional intersections, any potential applications for mediation analysis using these methods have not been developed. The methods we present are most appropriate for targeted questions that consider a limited number of intersections. As study intersections will contain additional unexplored intersections, researchers must remain cognizant that effects reflect net effects across still-heterogeneous social groupings.

Results are also modeled on interindividual variation within a population's current social context; thus, effects may be expected to vary across populations. Moreover, interpretation of results as potential intervention effects assumes no group-level effects, such as additional reductions in psychological distress in the context of lower population levels of discrimination. The estimation of the mediated interaction provides an additional interpretation challenge. It allows for the mediator to have different effects on the outcome for different intersections, but there are multiple possible causal explanations for such an observation (in addition to non-causal explanations such as confounding). Such findings may be due to differences in vulnerabilities or resiliencies at different intersections wherein the same level of the mediator has a different effect. However, they may also reflect unmeasured or unmeasurable differences in the mediator level for those with similar-seeming experiences that are magnified for some based on social and historical contexts. For example, being called a derogatory name may in actuality represent a different magnitude of experience for those at different intersections. Allowance for this type of heterogeneity is particularly important given the difficulty in creating mediator measures that capture the same construct (and thus wherein an intervention represents a perfect counterfactual) across all intersectional positions. Lastly, with regard to analysis of discrimination in particular, interpretation must be precise. In an analysis of a single type of discrimination, effects mediated through other forms (e.g., structural discrimination) will remain as part of the pure direct effect.

Researchers may encounter other situations requiring adaptation of the methods we have presented, including dichotomous mediators or outcomes, case-control data, multiple mediators, and complex samples. Dichotomous mediators and outcomes may be analyzed within SAS PROC CAUSALMED, with results on a ratio scale expressed as excess relative risks (VanderWeele, 2014); in the case of case-control data, presentation of descriptive intersectional results will not be possible. Bellavia and Valeri (2018) recently addressed decomposition with multiple mediators. Lastly, while methods have not been presented for causal mediation analysis involving complex survey data, extension of these methods to accommodate weighting and clustering should be possible.

6.1. Limitations

We note that while we conceptualized analytic intercategorical intersectionality as an approach to identifying causes of inequalities in outcomes, it has the potential to contribute to causal explanation in the absence of an inequality. As with mediation generally, there is no requirement for a total effect to be decomposed, as components of effect can be in different directions, a situation Zhao et al. (2010) label "competitive mediation". We observed this situation for the Black non-SGM group in our demonstration analysis. Thus, interpretation of results with regard to intervention strategies should not be based solely on unadjusted differences in outcome or on total adjusted effects.

Intersectional mediation analysis offers opportunities to inform intervention strategies both for the population, and for specific intersections. Interventions may focus on changing the level of the mediator, or on altering its effect on the outcome. In our example, these could involve interventions to reduce day-to-day discrimination through policy, education or social media, or alternately to reduce its impact on psychological distress through building resiliency, respectively. For mediators that are likely to also have adverse effects on outcomes not under study (including those not yet identified), the former represents a broader intervention with greater potential. Additional work is needed to best direct intervention planning. Mulinari et al. (2015) have emphasized the importance of consideration of not only mean effects, but of within-group heterogeneity in guiding interventions. While their methods for discriminatory accuracy analysis do not map well onto mediation analysis, the general considerations are highly relevant: weighing out information on average effects, potential heterogeneity (here in outcome, mediator, and mediated effect), and intervention risks and benefits. Particularly relevant is their caution of the risks of stigmatizing an already-marginalized sub-group (here intersection) through targeting for intervention, in cases where many in that group would not benefit. Ultimately, true effects will not be known until interventions are implemented and evaluated.

7. Conclusion

We have introduced analytic intercategorical intersectionality as one way to counter some of the "flattening" (May, 2015) of intersectionality that has occurred with its move into quantitative research. Analytic intersectionality retains intersectionality's focus on power and examines intersectional heterogeneity in process as well as outcomes. The analytic approach we describe differentiates mediation effects due to unequal levels versus unequal effects of a mediator, providing a model that is applicable to a wide range of health-related inquiries. Moreover, it produces estimates of expected residual causal inequalities following an intervention to equalize the mediator for all intersections to that of the intersection with the most advantageous level. Ultimately, analytic intersectionality is intended to inform the identification of strategies for intervening on the processes that generate health and social inequalities between intersectional social groups.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.socscimed.2018.12.015.

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