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Social Determinants as Moderators of the Effectiveness of Health Behaviour Change Interventions: Scientific Gaps and Opportunities

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Abstract

Social determinants of health (SDOH) refer to the broad range of social, economic, political, and psychosocial factors that directly or indirectly shape health outcomes and contribute to health disparities. There is a growing and concerted effort to address SDOH worldwide. However, the application of SDOH to health behaviour change intervention research is unknown. We reviewed the synthesis literature on health behaviour change interventions targeting self-regulation to: (a) describe the sociodemographic characteristics, (b) determine which types of social determinants were tested as moderators of health behaviour change interventions, (c) evaluate the methodological quality of the meta-analytic evidence, and (d) discuss scientific gaps and opportunities. Thirty (45.4%) of 66 articles examined heterogeneity of treatment effects by SDOH. There was a lack of racial/ethnic, immigrant, sexual/gender minority, and lifecourse sample diversity. Overall, 73.5% of SDOH moderator analyses tested heterogeneity of treatment effects by gender, race/ethnicity, and intervention setting; none examined neighbourhood factors. Methodological quality was negatively correlated with number of SDOH analyses. Most SDOH moderator analyses were atheoretical and indicated statistically non-significant differences. We provide an integrated SDOH and science of behaviour change framework and discuss scientific opportunities for intervention research on health behaviour change to improve health equity.

Keywords

health disparities; behavioural interventions; psychosocial; health risk behaviours; social determinants; heterogeneity of treatment effects

Seven out of 10 deaths and 37% of premature deaths worldwide are attributable to noncommunicable diseases (NCDs) such as cardiovascular disease, diabetes, cancer, respiratory diseases, and mental illness (World Health Organization “Noncommunicable diseases,” 2018). In 2015, behavioural and lifestyle-related metabolic risk factors for NCDs, such as smoking, alcohol use, high sodium, high body mass index, high fasting plasma glucose, high systolic blood pressure, and high total cholesterol, were among the top 10 leading global risk factors for disability adjusted life-years and death (Forouzanfar et al., 2016). Social disadvantage and marginalisation (e.g., poverty, unemployment) significantly increase the risk of death, NCDs, and NCD-related health risk behaviours (Braveman, Egerter, & Williams, 2011; Solar & Irwin, 2010). These social factors are not evenly distributed across the population and result in health disparities—defined as avoidable, unfair, unjust and systematic differences in health between population groups that are predicated on the risks and resources conferred by their social (dis)advantages (Braveman, 2006; CSDH, 2008; Marmot, 2005). Newer definitions differentiate the causes from the outcomes that result in a health disparity (Duran & Perez-Stable, 2019).

Social determinants of health (SDOH) refer to the broad range of social, economic, political, psychosocial and behavioural factors that directly or indirectly shape health outcomes, which in turn contribute to health disparities (Braveman, 2006; Braveman et al., 2011; Marmot, 2005; Solar & Irwin, 2010). A global and concerted effort to address the SDOH that drive health inequities was launched in the 21st century and advanced most notably by the World Health Organization (WHO) and its Commission on Social Determinants of Health (CSDH), which called for closing the health gap in a generation (CSDH, 2008). These efforts led to a proliferation of health equity and social justice centered interventions and policies that address the upstream determinants or root causes of health disparities (CSDH, 2008). While a SDOH framework is commonly used to understand the social distribution of disease, its application to behaviour change science and intervention research is unknown. This leaves many unanswered questions about what types of health behaviour change interventions are effective and for whom, and under what social conditions they are efficient.

We utilized the WHO CSDH conceptual model as an organizing framework to consider how structural factors (i.e., macro-economic social and public policies, culture and societal values) configure people’s health trajectories according to their position within the social hierarchy or their socioeconomic position, which reflects the relative power, prestige, and resources afforded by one’s social identities, including but not limited to one’s race, ethnicity, education, occupation, income, and gender (Solar & Irwin, 2010). In turn, it is these structural factors and people’s socioeconomic positions rather than innate predispositions to ill or good health that shape direct or intermediary pathways (i.e., psychosocial and behavioural, cultural, biological, environmental, health care systems, and

material circumstances) to health by influencing the extent of exposure to intermediary factors or vulnerability to health risks (Solar & Irwin, 2010). By extension, we posit that these same structural-level and individual-level factors may moderate the effectiveness of health behaviour change interventions, or behaviour change techniques (BCTs) aimed at altering intermediary pathways. Herein, we reviewed the synthesis literature on health behaviour change interventions targeting self-regulation summarized in Hennessey et al. (in press) to: (a) describe the representativeness of the meta-review with respect to SDOH categories (% minority race/ethnicity, % gender, % immigrant), (b) determine which types of SDOH categories were tested as moderators, (c) evaluate the evidence for social determinants as moderators of health behaviour change intervention effectiveness, and (d) discuss scientific gaps and opportunities. Hennessey et al.'s (in press) meta-review was chosen as a point of departure for our review because this represents, to our knowledge, the first contemporary attempt to use standardized reporting tools to synthesize and evaluate the quality of all the meta-analytic evidence to date on how and whether health behaviour change interventions linked to various chronic diseases and related intervention components impact self-regulation, one of the most commonly implicated mechanisms in behaviour change.

Methods

Two of three review authors (SVD, LGC) independently extracted key study, SDOH moderator characteristics and findings after a period of calibration. This included a joint review of 30 out of 66 articles in Hennessey et al.'s (in press) review. All discrepancies were resolved through consensus with a third review author (CA). Study characteristics included % racial/ethnic minority/aboriginal, % women, % immigrant, average age, age group, health condition, country/region, primary outcomes, type of intervention, type and number of SDOH moderator analyses. SDOH moderator types included % race/ethnicity (or % non-Hispanic White), income, education, % women, housing, intervention, setting (clinic, community), occupation, unemployment, rural/urban setting, sexual/gender minority status, linguistic minority, access to health care, and discrimination. While not exhaustive, these SDOH categories capture common structural or root causes of health disparities as well as individual-level intermediary factors of health disparities including those related to one's socioeconomic position (Solar & Irwin, 2010; Alvidrez et al., 2019). We also included information extracted from Hennessey et al. (in press) about the BCT framework used and the methodological quality of the meta-analyses measured with the AMSTAR-2 (Shea et al., 2017), an indicator of the proportion of completed standardized reporting items. Given the exploratory aim, we used an AMSTAR-2 score of 0.5 as a cut-off to discuss SDOH moderator results (tested in meta-regressions or subgroup analyses).

Results

Sociodemographic Diversity of Meta-Analytic Samples in Synthesis Review

The average percentage of racial/ethnic minorities in the meta-analyses was 12.96% (Supplemental Table 1). Only 21 out of 66 meta-analytic studies reported data on racial/ethnic or minority sample composition. The average percentage of women participants

was 40.17%. The average age was 46.12 (SD=16.76). Of the 66 articles, 56.06% focused only on adults, 4.55% focused only on children or adolescents, and 3.03% on older adults (Supplemental Table 2). The meta-analyses were global; 42.42% included studies conducted in two or more countries.

Social Determinants of Health as Moderators of Health Behaviour Change Interventions

Thirty meta-analyses or 45.45% conducted at least one SDOH moderator analysis (mode: 1, range: 1 to 6; Table 1). One meta-analysis conducted SDOH moderator analyses in children, but none focused on older adults. In total, there were 68 different types of SDOH moderator analyses conducted. These analyses examined heterogeneity of treatment effects according to gender (33.82%), intervention setting (clinic vs. community) (20.59%), race/ethnicity/aboriginal (19.12%), income (10.29%), other category (8.82%) (e.g., study location [region]), education (5.88%), and housing (1.47%). None of the moderator analyses examined heterogeneity of treatment effects by occupation, unemployment status, rural vs. urban setting, sexual/gender minority status, linguistic minority status, access to care (e.g., health insurance), or exposure to discrimination. The most common outcomes for the SDOH moderator analyses were medication adherence (23.33%), physical activity (20%), blood pressure (16.67%), weight status (13.33%), and alcohol consumption (10%) (Supplemental Table 3). Twenty-three of SDOH moderator articles (76.7%) did not use an established behaviour change framework or classification system.

Most SDOH moderator analyses (73.5%) indicated statistically non-significant differences. Out of the 68 SDOH moderator analyses, 14 reported larger effect sizes for racial/ethnic minorities/aboriginals, women, low income, low education [limited literacy], clinical settings, and geographic regions (e.g., developing countries). Twelve reported smaller effect sizes for those who were homeless, in community settings, and in geographic regions outside of Asia, America, and Europe. The average AMSTAR-2 score was 0.44, and the range was 0.08–0.88. The correlation between the AMSTAR-2 score and the number of SDOH moderator analyses was $r(28) = -47, p < 0.01$. Ten articles had an AMSTAR-2 score of 0.5 or higher. In these articles, heterogeneity of treatment effects according to race/ethnicity, income, gender, intervention setting or study location were examined, and are described below.

Medication Adherence.—Neither % women (Demonceau et al., 2013; Ruppap, Dunbar-Jacob, Mehr, Lewis, & Conn, 2017) nor race (% Black) significantly predicted intervention effectiveness on medication adherence (Ruppap et al., 2017).

Smoking.—Psychosocial interventions effect sizes on smoking abstinence in late pregnancy did not differ by SES (Chamberlain et al., 2017). While Chamberlain et al. (2017) described the results of RCTs that targeted specific racial/ethnic groups or conducted subgroup analyses, there was insufficient evidence from which to draw firm conclusions.

Glycemic Control.—Gender did not predict intervention effectiveness on glycemic control in patients with type-2 diabetes (Farmer et al. (2012)). Similarly, intervention setting (diabetes clinic vs. primary care clinic) did not modify the effectiveness of patient activation

interventions on hemoglobin A1c (HbA1c) levels (Bolen et al., 2014). While Zhu et al. (2016) did not find that studies in Asia vs. America-Europe differed in the effectiveness of self-monitoring of blood glucose on HbA1c levels, Bolen et al. (2014) found larger group differences in A1C in study locations outside of the US, Europe, or Canada (Bolen et al., 2014).

Physical activity.—Gender did not moderate the effect sizes of goal setting interventions on physical activity (McEwan et al. (2015). Interventions delivered in primary care or medical centers had larger effect sizes than those delivered at home (in-person, telephone, or mobile/ Internet); work-place delivered interventions were the least effective (McEwan et al., 2015).

Weight status.—Effectiveness of lifestyle interventions on postpartum body weight loss did not differ by intervention setting (home based or center-based care) (Lim et al., 2015).

Alcohol use.—Health behaviour change interventions targeting frequency of heavy drinking were less effective with increasing proportion of Blacks (Scott-Sheldon, Carey, Elliott, Garey, & Carey, 2014). Gender did not moderate intervention effectiveness.

Health Related Behaviour and Intentions.—Gender and race/ethnicity did not moderate the effectiveness of health behaviour change interventions that targeted attitudes, norms, and self-efficacy on health related behaviour and intentions (Sheeran et al., 2016).

Discussion

Our aim was to evaluate the heterogeneity of treatment effects by SDOH categories across the 66 articles included in Hennessey et al.'s (in press) review on health behaviour change interventions targeting self-regulation. Thirty articles (45%) conducted SDOH analyses, and ten were of high methodological quality. Below we discuss the scientific gaps that emerged from this review followed by a discussion of the scientific opportunities and new directions.

Scientific Gaps

Atheoretical designs and lack of sociodemographic and lifecourse diversity.—While nearly half of the articles examined heterogeneity of treatment effects by SDOH categories, among them, roughly 77% did not utilize a BCT framework, and none made explicit mention to a SDOH framework. Overall, racial/ethnic minority/aboriginal groups (12.96%), and immigrants (0%) were underrepresented. No articles examined differences in intervention effectiveness by sexual/gender minority status or linguistic minority status. In addition, only one meta-analysis of RCTs of children conducted SDOH moderator analyses while none was done for older adults.

Disproportionate focus on individual level factors and not root causes of health disparities.—Nearly 74% of the SDOH moderator analyses performed were concerned with the effect of individual-level intermediary SDOH factors (race/ethnicity, gender, intervention setting) and not with the effect of structural or root causes of health disparities. The one exception was housing (Conn & Ruppap, 2017). Relatedly, none of

the SDOH moderator analyses tested heterogeneity of treatment effects by occupation, unemployment status, rural, vs. urban setting, access to care (e.g., health insurance), or exposure to discrimination/racism.

Variable methodological quality of meta-analyses.—Among the 30 articles testing SDOH moderators, only ten had an AMSTAR-2 score of 0.5 or higher, indicating coverage of 50% of standard meta-analytic reporting items (e.g., protocol registration, literature search, assessment of risk of bias, publication bias, etc.). The correlation between methodological quality and the number of SDOH analyses was negative and statistically significant, which may reflect a tendency for suboptimal reporting of meta-analytic study procedures to correspond with investigator likelihood to conduct post hoc SDOH analyses, or limitations of the AMSTAR-2 standardized reporting tool, though further research is warranted. Only one meta-analysis satisfied 70% of the AMSTAR-2 items (Chamberlain et al., 2017); the cut-off that Hennessey et al. (in press) used to indicate high quality. The variable methodological quality as well as the differential findings by type of health outcome obfuscate our ability to make conclusions about the extent to which SDOH moderators impact intervention effectiveness. Relatedly, moderation according to race/ethnicity was often tested in meta-regressions as percentage of racial/ethnic minority in the sample, but this approach does not adequately compare treatment effects across racial/ethnic categories and may have contributed to the observed non-significant effects.

Scientific Opportunities

The increasing focus on SDOH and community-level interventions, as well as advances in digital health technologies offer scientific opportunities for intervention science on health behaviour change to improve health equity. Below we discuss four of such promising directions for future research, which have great potential to simultaneously enhance methodological rigor, increase sample representativeness, and to shift the focus from the individual to the community.

Integrate SDOH and Science of Behaviour Change (SOBC) frameworks and methodologies.—In order to design multi-level health behaviour change interventions to reduce morbidity and mortality from NCDs for all, an integrated SDOH and SOBC framework is needed. Building off Hennessey et al.'s (in press) logic model, an integrated framework requires investigators to consider from the outset of the research process how SDOH shape the intervention/prevention strategies, target mechanisms of action, proximal or intermediary outcomes, behaviours, or indicators, and long-term health outcomes. This ensures that questions regarding the heterogeneity of treatment effects by SDOH, how SDOH may affect BCTs, and how they may target mechanisms of action (i.e., self-regulation) are not an afterthought.

In Table 2, we present a heuristic to help facilitate the integration of SDOH and SOBC (<https://commonfund.nih.gov/behaviorchange>) theoretical frameworks and list key questions to guide investigators at each stage of the research process from hypothesis generation, sampling, operationalisation, analysis, to interpretation of results, and implications. This framework calls on investigators to use multi-level models of moderators and mediators

to consider: (a) for whom and under what social conditions are health behaviour change interventions effective and efficient? (b) for whom and under what social conditions do BCTs alter health behaviours and engage target mechanisms of action? (c) is the sample diverse and reflective of the SDOH categories hypothesized to alter outcomes and target mechanisms? (d) are the measures of target mechanisms of action valid across subpopulations? (e) is the study sufficiently powered to test these hypotheses? (f) are target mechanisms informed by SDOH? (g) are contextual barriers to intervention uptake addressed (e.g., transportation, health literacy, cultural beliefs)? An integrated framework may promote awareness of the need for diversity in the representation of the populations enrolled in interventions. This integrated framework also underscores health equity, and calls for an explicit consideration of the extent to which interventions widen or narrow health disparities and the implications for the development of upstream interventions and community engagement. Importantly, interventions can be more impactful for the individuals that are enrolled when community engagement and awareness of community strengths and resources are central in the design and implementation such that the interventions that are developed and tested are acceptable and sustainable in the target communities (Koh et al., 2010). To illustrate, an RCT of a psychosocial intervention targeting smoking in pregnancy re-designed from an integrated SDOH and SOBC framework would be concerned not only with determining how (e.g., feedback, social support, tailoring) and why (e.g., improved self-efficacy, self-regulation) such health behaviour interventions work, but also with understanding how the conditions where pregnant women “work, live, and play” result in differential exposure to social determinants that subsequently alter the pathways through which BCT techniques might impact purported mechanisms of action, and ultimate intervention effectiveness. Indeed, RCTs designed from an integrated perspective might test whether motivational interviewing impacts smoking cessation and self-efficacy equally in pregnant women with and without a reported history of early life adversity (e.g., poverty, maltreatment) particularly given the effect of adversity on mechanisms of action (stress reactivity, self-regulation) in behaviour change. Relatedly, RCTs of behavioural counseling for smoking cessation in pregnancy re-designed from an integrated SDOH and SOBC framework would require active contention with the policy relevant conditions and implications of their findings from the outset. Investigators would need to answer questions such as how does variation in state policies in Medicaid expansion affect who does and does not have access to behavioural counseling for smoking cessation and in turn how does the siloed implementation of behavioural counseling in higher income communities widen health disparities among those with and without access to Medicaid coverage. An integrated framework places equal weight on understanding the how and why a health behaviour intervention works with understanding the social conditions, settings, and contextual factors that affect for whom an intervention is effective. While this integrated framework may be most useful at the intervention design stage for primary studies, it is possible that these key questions could be integrated into extant standardized reporting tools and applied toward the evaluation of meta-analytic evidence for core SDOH considerations.

Explore intersecting SDOH categories.—Most SDOH moderator analyses were of sociodemographic categories (e.g., gender, race/ethnicity, income, education), and often these were examined in isolation. However, as contemporary research on intersectionality

and health has shown, individuals occupy multiple social identities, or social positions, that reflect interconnected systems of power and privilege; these systems configure access to risks and resources, which ultimately shape health disparities (Bowleg, 2012; Cole, 2009; Evans, Williams, Onnela, & Subramanian, 2018). As a result, explorations of differences in treatment effectiveness by a single sociodemographic category or social position, without consideration of the other social positions may be a limitation of the work thus far and present an area for future research. While results of SDOH moderator analyses overwhelming found non-statistically significant differences, it is possible that an intersectional lens would yield different findings.

Highlight Timing and the Developmental Lifecourse Perspective.—Meta-analytic studies of health behaviour change interventions targeting self-regulation in children or older adults were disproportionately underrepresented among studies with SDOH moderator analyses. Further, most of the measures of SDOH exposures were snapshots of an individual's social position in a moment in time (e.g., household income in adulthood, housing status in adulthood). While these findings generally point to the need for more research on the science of behaviour change across the lifecourse, they also highlight the need for a developmental life course approach to the study of health disparities and intervention science to address these inequities (Gee, Hing, Mohammed, Tabor, & Williams, 2019; Jones et al., 2019; Rosenthal et al., 2015). A developmental life course approach emphasises how early life adversity and exposure to social determinants (e.g., racism, poverty, marginalization) unfold over time, the importance of the timing of these exposures relative to developmental stage, and the impact of cumulative social and environmental exposures, as well as their intergenerational transmission (Gee et al., 2019; Jones et al., 2019; Rosenthal et al., 2015). This is particularly important for health behaviour change interventions targeting self-regulation skills, which are developed initially in childhood and impacted by social determinants such as poverty (Blair, 2010). Indeed, the National Institutes of Health funded a research network focused on reversibility of early life adversity, which suggested pathways forward to provide interventions in adulthood that could reverse or remediate effects of early life SDOH such as poverty, abuse or neglect (Reiss et al., 2019). To that end, Mindfulness-Based Cognitive Therapy, which targets self-regulation, shows replicated greater effects on preventing depression relapse in adults exposed to early life abuse vs. those not exposed (Kuyken et al., 2015; J. M. Williams et al., 2014). Future research should draw from developmental research on target mechanisms of action and SDOH to hypothesise and test for whom, under what social conditions, and when would SDOH impact BCT's engagement of target mechanisms and health outcomes. Importantly, there were no moderator analyses by exposure to racism/discrimination despite the increasing recognition that racism is a pernicious SDOH with sustained adverse health effects across the lifecourse (Trent, Dooley, & Dougé, 2019; D. R. Williams & Mohammed, 2013). This is also a critical area for future research.

Leverage Precision Public Health and advances in digital technologies to design and test community-level health interventions.—Despite the growing and established evidence on the importance of place for health (Kind et al., 2014), none of the SDOH moderator analyses tested heterogeneity in treatment effectiveness by neighbourhood

or other place-level factors (e.g., urban vs. rural). Precision Public Health (PPH), a field which focuses on identifying and delivering the “right interventions in the right community at the right time” (Khoury, Iademarco, & Riley, 2016) has much to offer the science of behaviour change. PPH expands the attention from individual health, genetics, and precision medicine to population health, the environment, and community-level health interventions (Chowkwanyun, Bayer, & Galea, 2018; Khoury et al., 2016). The opportunity to use PPH approaches to design health behaviour change interventions intended for specific places, communities, or postal codes, and to assess how these interventions alter health behaviour outcomes and mechanisms at the community or neighbourhood level is an exciting new research direction. There are recent global examples of these setting or community interventions (Newman, Baum, Javanparast, O’Rourke, & Carlon, 2015). Further, the digital revolution has brought advances in population-level data collection, and the capacity to collect real-time health behaviour data that can be aggregated to the community-level (Shah, Steyerberg, & Kent, 2018). Researchers may soon be able to simultaneously use big data strategies and predictive analytics (that use SDOH data captured in the electronic health record) to design targeted, community-level interventions, and then they could subsequently map individual-level changes in biological markers (e.g., cortisol, insulin resistance) that are in response to such interventions and then aggregate these to the neighbourhood-level. This is a nascent area with unresolved challenges (e.g., standardisation, uneven infrastructure across communities) and ethical questions (Cantor & Thorpe, 2018; Garg, Homer, & Dworkin, 2019; Khoury et al., 2016).

Conclusion

There is a growing and concerted effort to address SDOH worldwide. To our knowledge, our review is the first contemporary characterization of heterogeneity of treatment effects by SDOH for health behaviour change interventions targeting self-regulation. Overall, 45% of studies tested SDOH moderators, and yet, most studies were atheoretical, lacked sample and lifecourse diversity, were of poor methodological quality, and were focused at the individual-level. More diverse, high quality, theoretically-informed, and adequately powered interventions are needed to determine if SDOH moderators are effective in health behaviour change interventions. We present an integrated SDOH and SOBC framework for primary intervention research on health behaviour change, the first of its kind, that offers great promise in understanding the effect of social determinants on intervention effectiveness, BCTs, health outcomes, and mechanisms of action while simultaneously centering health equity, social justice, and community health.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1. Results of Meta-Analyses Testing Heterogeneity of Treatment Effects by Social Determinants of Health (SDOH) (*N* = 30)

Articles	No. SDOH Moderator Analyses	AMSTAR-2	Outcome	Race/Ethnicity	Income	Education	Gender	Housing	Intervention Setting	Other
<i>93 BCT version (Michie et al., 2013)</i>										
Harkin et al., 2016	1	0.47	HB, Goal attainment				NS, NS			
<i>26 BCT version (Abraham & Michie, 2008)</i>										
McEwan et al., 2016	1	0.63	PA				NS		-	
Michie et al., 2009	4	0.47	PA, Diet		NS		NS		NS	Location ^d , NS
Tyson et al., 2014	2	0.39	Condom use, Attitudes				NS, NS			Location ^b , NS,+
Dombrowski et al., 2012	1	0.38	Weight						+	
<i>Communication-Based Influence Components Model (Cugelman et al.)</i>										
Cugelman et al., 2011	1	0.31	HB				+			
<i>Other BCT version</i>										
Bartlett et al., 2014	1	0.44	Smoking						-	
<i>No BCT version utilized</i>										
Chamberlain et al., 2017	1	0.88	Smoking					NS		
Farmer et al., 2012	1	0.69	Glycemic control				NS			
Demonceau et al., 2013	1	0.66	MED ADH				NS			
Zhu et al., 2016	1	0.66	Glucose							Location ^c , NS
Bolen et al., 2014	2	0.63	HBA1c						NS	Location ^d , +
Ruppar et al., 2017	2	0.59	MED ADH	NS			NS			
Lim et al., 2015	1	0.56	Weight						NS	
Scott-Sheldon et al., 2014	2	0.53	Alcohol	-			NS			

Articles	No. SDOH Moderator Analyses	AMSTAR-2	Outcome	Race/ Ethnicity	Income	Education	Gender	Housing	Intervention Setting	Other
Tanner-Smith & Lipsey, 2015	3	0.47	Alcohol	+ ^e			NS		NS	
Bray et al., 2010	1	0.47	BP				NS			
Conn et al., 2015	4	0.44	MED ADH	NS	-		+		NS	
Conn et al., 2009	4	0.41	MED ADH		NS	NS ^f	+		NS	
Higgins et al., 2014	1	0.38	PA, Exercise				+,-			
Chase et al., 2016	5	0.33	MED ADH	NS	NS		NS		NS	Location ^g ; NS
Conn & Ruppap, 2017	6	0.31	MED ADH	NS	NS	NS ^f	NS	-		
Epton et al., 2015	2	0.31	Acceptance, Intentions, HB	NS, NS,+			NS,NS,NS			
Bravata et al., 2007	2	0.31	PA	NS			NS			
Conn et al., 2011	4	0.28	PA	NS		NS	NS		NS	
Conn et al., 2008	3	0.28	PA	NS	NS ^d		NS			
Albarracín et al., 2008	5	0.08	Condom use, HIV-related knowledge	-,-		-,+	-,+		Clinic ^h ; -,+ Community ^h ; NS, -	Location ⁱ : +, -
St Amand et al., 2008	2	0.08	Child sexual behavior	NS			NS			
<i>Blank</i>										
Sheeran et al., 2016	2	0.50	Intentions, HB	NS			NS			
Cristea et al., 2016	1	0.44	Alcohol, Smoking						NS	

Note. NS: No statistically significant differences between groups; +Larger effect sizes in SDOH category (minority group); - Smaller effect sizes in SDOH category (minority group). MED ADH= medication adherence; HB= health behaviors; HBA1c= Hemoglobin A1C. No analyses conducted for heterogeneity of treatment effects by occupation, unemployment status, rural/urban setting, sexual/gender minority status, linguistic minority, access to care, and discrimination/racism. Outcomes reflect primary outcomes for SDOH analyses.

^aStudy location specified as European country vs. All others; UK vs. All others; US vs. All others;

^bStudy location specified as developing country v. developed country;

^cStudy location specified as Asia v. Europe;

^dStudy location specified as US, Europe, or Canada vs all else.

^eThese findings were driven by four studies including only racial/ethnic minority youth.

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Literacy was used to identify level of education;
Study location specified as North America vs Not North America;
Results for samples comprised of 50% or more Latinos or Latin Americans;
Study location specified as Latin America v. U.S.

Table 2.

Key Questions to Guide Intervention Research Using an Integrated Social Determinants of Health (SDOH) and Science of Behavior Change (SOBC) Framework

Research Stage	SDOH Framework	SOBC Framework	Integrated SDOH and SOBC Framework
Hypothesis generation	How do SDOH affect the design, delivery, or effectiveness of the intervention?	What are the specific BCTs techniques that are linked to health behaviors and target mechanisms of action?	How do SDOH affect BCTs' effectiveness, impact on mechanisms of action, and intervention effectiveness? Are contextual barriers to intervention uptake addressed (e.g., transportation, health literacy, cultural beliefs)?
Sampling	Is the sample diverse and reflective of SDOH categories (e.g., race/ethnicity, gender, income, education, language, literacy level etc.)?	Is the sample representative of the target population?	Is the sample diverse, and reflective of the SDOH purported to affect intervention effectiveness, BCT effectiveness, and mechanisms of action?
Operationalization	Are SDOH measured? Are the measures valid across subpopulations?	Are BCTs measured? Are mechanisms of action measured?	Are the SDOH that are hypothesized to affect BCT effectiveness, and their impact on mechanisms of action, measured? Are the measures of target mechanisms valid across subpopulations? Are the target mechanisms informed by SDOH? Is the study sufficiently powered for SDOH moderator analyses?
Analysis and Interpretation	SDOH moderator analyses Are there differences in intervention effectiveness by SDOH categories?	BCT moderator analyses and mediational analyses Does intervention effectiveness differ by specific BCTs? Which BCTs are engaging target mechanisms of action?	Multi-level modeling of moderators and mediators For whom and under what social conditions are: (a) interventions effective, and (b) BCTs effective at altering health behavior and engaging target mechanisms?
Implications for Health Equity	Does the intervention narrow or widen health disparities? What are the implications for upstream interventions and community engagement?	Unclear	Does the intervention narrow or widen health disparities? What are the implications for upstream interventions and community engagement?

Note: Mechanisms of action refer to those identified by the SOBC Network (<https://commonfund.nih.gov/behaviorchange>): self-regulation, stress reactivity, stress resilience, and interpersonal and social processes.