A Systematic Review of Psychosocial Explanations for the Relationship Between Socioeconomic Status and Body Mass Index

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Abstract

A negative association between socioeconomic status (SES) and levels of overweight/obesity is consistently found in high- and middle-income countries. Yet, there is little conclusive evidence about the mechanisms driving this association. In this systematic review, we discuss and compare the results of 22 studies that examine the role of psychosocial mediators in the association between lower SES and BMI in diverse population samples. These include factors related to resources and constraints in one's external neighborhood, social resources, and psychological factors such as stress. The findings support theoretical models indicating that SES influences BMI partially through environmental and psychological factors. Importantly, SES remains a significant determinant of weight status, indicating the importance of also addressing structural antecedents in order to improve health among low-SES people. We thoroughly discuss the quality and limitations of current study designs and mediation testing and provide recommendations for future research.

Keywords: socioeconomic status, obesity, BMI, psychosocial, systematic review

Levels of overweight and obesity have reached alarming numbers worldwide. In 2016, 39% of adults were overweight and 13% were obese (WHO, 2017b). Data from 2015 shows that obesity prevalence was highest in the US: 35% for adult men and 40% for adult women (OECD, 2017), and 15% within EU countries in 2014 (Eurostat, 2014). People who are overweight are at increased risk of suffering from cardiovascular diseases (CVDs), diabetes, musculoskeletal disorders and some cancers, with CVDs being the leading cause of death globally, responsible for an estimated 17.7 million deaths in 2015 (WHO, 2017a).

Socioeconomic status (SES) is negatively correlated with weight status in high- and middle-income countries (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012; Robertson, Lobstein, & Knai, 2007; Wang & Beydoun, 2007). Food production and availability is more advanced in relatively wealthier countries, and people with lower incomes can afford high-calorie foods (Pampel, Denney, & Krueger, 2012), leading to an excess of calorie intake, with higher risk of becoming overweight or obese (Tanumihardjo et al., 2007). A systematic review in 2010 indicated that whereas the obesity epidemic is leveling off in some countries, this is less the case for individuals with lower SES (Rokholm, Baker, & Sørensen, 2010).

Scholars commonly point to limited access to healthy foods as the cause of higher obesity rates among lower SES people. Material deprivation is seen as the primary cause, with limited financial resources and limited food availability restricting access to healthier diets (Aggarwal, Monsivais, Cook, & Drewnowski, 2011; Story, Kaphingst, Robinson-O'brien, & Glanz, 2008). However, a nutritious diet does not need to cost more than a less nutritious diet, notably in European countries (Carlson & Frazão, 2014; Primavesi, Caccavelli, Ciliberto, & Pauze, 2015), and programs reducing the financial cost of healthy foods through food vouchers or tax reductions show unsubstantial effects on nutrition and weight outcomes (Capacci et al., 2012; Powell & Chaloupka, 2009; McFadden et al., 2014). Likewise, supermarket density is high in Europe making a variety of food outlets easily

accessible (Black & Macinko, 2008; Cummins & Macintyre, 2006; Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011). And two recent publications showed that in the U.S., neither actual nor perceived availability of (fast) food outlets was related to fast food consumption (Oexle, Barnes, Blake, Bell, & Liese, 2015) or BMI (Mejia, Lightstone, Basurto-Davila, Morales, & Sturm, 2015).

These findings suggest that there must be other factors besides those directly associated with material deprivation that influence the weight status of people with lower SES. Previous reviews examining SES-weight associations find more evidence for a social gradient in obesity among women than among men, and suggest explanations related to cultural and symbolic values of body shape (McLaren, 2007; Sobal & Stunkard, 1989). The pressure to be thin is highest for women on the top end of the SES spectrum: While larger female body shapes are subject to stigmatization, larger sizes in men are associated with power and dominance (Fikkan & Rothblum, 2012; McLaren, 2007). This is, for instance, apparent in work settings where men with higher incomes work more hours and exercise less, whereas women with higher incomes exercise more often (Godley & McLaren, 2010).

Furthermore, the stigmatization of one's lower social status as well as the stigma associated with a larger body size can result in more negative emotions and cortisol secretion which promote the intake of high-calorie foods (Tomiyama, 2014; Vartanian & Porter, 2016). This is also evident in epidemiological findings indicating that regardless of absolute income levels, obesity prevalence is higher in countries with more income inequality (Pickett, Kelly, Brunner, Lobstein, & Wilksinon, 2005). And recent research shows that mere activation of lower relative social position leads to higher calorie intake (Cheon & Hong, 2017; Sim, Lim, Forde, & Cheon, 2018). Stress-induced weight gain due to insecure economic conditions has been proposed as one of the central mechanisms through which lower SES leads to increased body weight. For instance, restricted food access (in early life) is associated with metabolic

changes that encourage the storage of body fat (Nettle, Andrews, & Baton, 2017). Similar

bodily changes, as well as shifts towards a preference for high-calorie foods, occur due to

chronically elevated stress levels associated with financial insecurity (Baum, Garofalo, &

Yali, 1991; Moore & Cunningham, 2012).

The work discussed above addresses possible pathways through which a social

gradient influences weight. However, to date there is a lack of a comprehensive review on

such mediating pathways. The current contribution was aimed to fill this gap by providing a

systematic review of psychosocial mediators of the SES-BMI relation.

Broader theoretical models on the SES-health link can provide us with a framework

for clarifying pathways linking SES with weight status. Such models describe pathways by

which macro-level contexts, social environments, and individual psychological and biological

characteristics increase risk of illness (Adler & Ostrove, 1999; Gallo & Matthews, 2003;

Martikainen, Bartley, & Lahelma, 2002). According to these models, individuals with lower

SES experience more environmental and social disadvantage which are constraints to health

and well-being (pathway A in Figure 1). Financial stress lowers psychological resources to

cope with adversity which in turn impedes health (pathway B in Figure 1). Furthermore,

environmental demands and social resources can shape cognitive and affective tendencies,

thereby determining the extent to which an individual will experience stress in response to

subsequent stressors (see pathway C in Figure 1; Adler & Ostrove, 1999; Adler & Snibbe,

2003). Both environmental and psychological factors then influence illness through

biological responses, exposure to health risks, and health behavior performance. Review

papers have illustrated that the pathways suggested by these models indeed partially explain

social gradients in health such as mortality and cardiovascular health (e.g., Gallo &

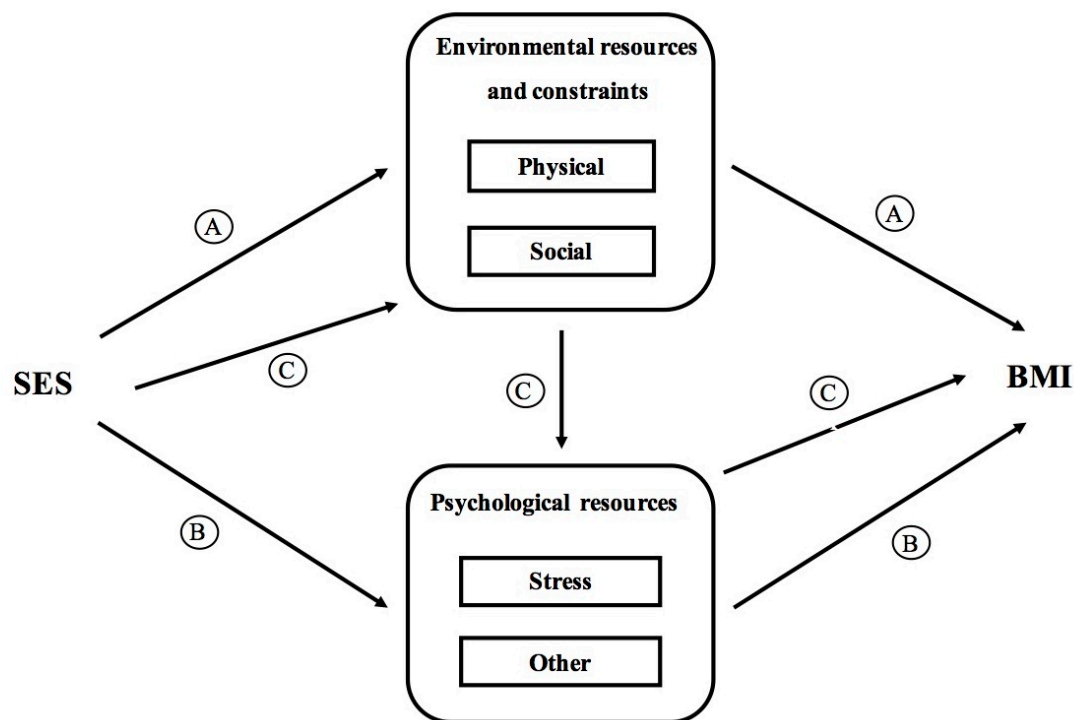Matthews, 2003; Matthews, Gallo, & Taylor, 2010).

Figure 1. Model of suggested pathways from socioeconomic status to BMI. Adapted from

Adler and Ostrove (1999). Pathway A links SES with BMI through environmental factors,

pathway B through psychological factors, and pathway C through a combination of

environmental and psychological factors.

Objective of the Current Review

The main objective of this article is to provide a review of existing publications

examining psychosocial pathways underlying the relationship between SES and weight

status. In line with the theoretical propositions described above, the broad term *psychosocial*

refers to individual-level environmental and psychological factors (Adler & Ostrove, 1999;

Martikainen et al., 2002). Identifying the pathways that link SES with weight status allows

targeted interventions for public health improvement to be developed. Beyond examining the

contribution of suspected mediators, the present review will also systematically discuss the

strengths and weaknesses of current research in this health domain. More specifically, this

review will propose an assessment of the conclusiveness of designs and statistical tests used

for examining these psychosocial pathways. This assessment, in turn, will allow making

recommendations for future research, as proposed in the general discussion.

Method

This review followed the Preferred Reporting Items for Systematic Reviews and

Meta-Analyses (PRISMA; 2009) guidelines for systematic reviews. The search strategy was

pre-registered in PROSPERO (International Prospective Register of Ongoing Systematic

Reviews, http://www.crd.york.ac.uk/prospero) under registration number:

CRD42017068926).

Search Strategy

In order to find relevant published research examining psychosocial explanations of

the relationship between lower SES and weight status, we searched Scopus and PsycINFO

databases. We created a string of search terms related to SES, psychosocial factors, and

weight. To make sure the studies included examination of a psychosocial pathway, we

restricted our search to articles that also included the terms 'psychosocial' or 'psychology'.

The complete search string was ('socioeconomic' or 'income' or 'education' or 'poverty' or

'inequalit*' or 'depriv*' or 'disadvantage*' or 'social class' or 'poor' or 'rich') AND

('psycholog*' or 'psychosocial' or 'psycho-social') AND ('obes*' or 'BMI' or 'weight'). We

restricted the search to terms appearing in the title, abstract, and keywords of publications.

Inclusion and Exclusion Criteria

A systematic review of the relevant literature was conducted according to the

following inclusion and exclusion parameters. Studies were only included if they included a

measure of SES, a psychosocial measure of environmental or psychological nature (e.g., food

availability, a measure of stress), and a measure of BMI.

SES (independent variable): In our selection of articles, we considered both objective

SES indicators such as income and occupation, and subjective measures of SES such as

perceived social position. We included studies that used an indicator of SES as an

independent variable, comparing differences between SES groups, and excluded those that

exclusively focused on low SES groups (no mediation could be possibly tested in these

studies due to a lack of variance in the predictor) and those that merely controlled for SES.

Psychosocial resources and constraints (mediator): these are addressed in the next

section.

BMI (dependent variable): The studies needed to assess weight status using BMI as

an indicator. The study was also included if obesity status was used as a dependent variable,

as long as this status was determined by a measure of BMI. BMI is derived from an

individual's weight and height (kg/m^2). A person is considered overweight if his or her BMI

falls between 25 and 30, and obese if this value is above 30 (standards used by the National

Institutes of Health, 2000). It is the most commonly used measure, easily derived and

considered an adequate measure for clinical purposes (Mooney, Baecker, & Rundle, 2013).

We included studies using the following designs and methods of mediation testing.

Design: Different study designs allow for testing causal and mediational relationships

between variables. We included articles using one of the following methods: 1) manipulation

of a psychosocial factor that is typically assumed to be influenced by SES, followed by a

measure of BMI and SES. This provides the best causal evidence (Bullock, Green, & Ha,

2010; Spencer, Zanna, & Fong, 2005), or random assignment to different SES groups,

followed by a measure of a psychosocial factor and BMI, 2) cross-lagged panel design with

repeated measures at different time points to control for changes over time and to allow for

more precise inferences about the direction of causation (Cole & Maxwell, 2003; Selig &

Preacher, 2009), 3) longitudinal design without repeated measures across time points (i.e., not

cross-lagged), 4) cross-sectional design (See Figure 2 for a graphical presentation of this

ranking of designs).

Studies examining other relationships between these variables, for instance, the

moderating role of SES, or the influence of BMI on psychosocial factors and SES were

excluded. On the other hand, studies whose results allowed for interpreting mediational

pathways linking SES and BMI were included even if this was not the focus of the study.

Time
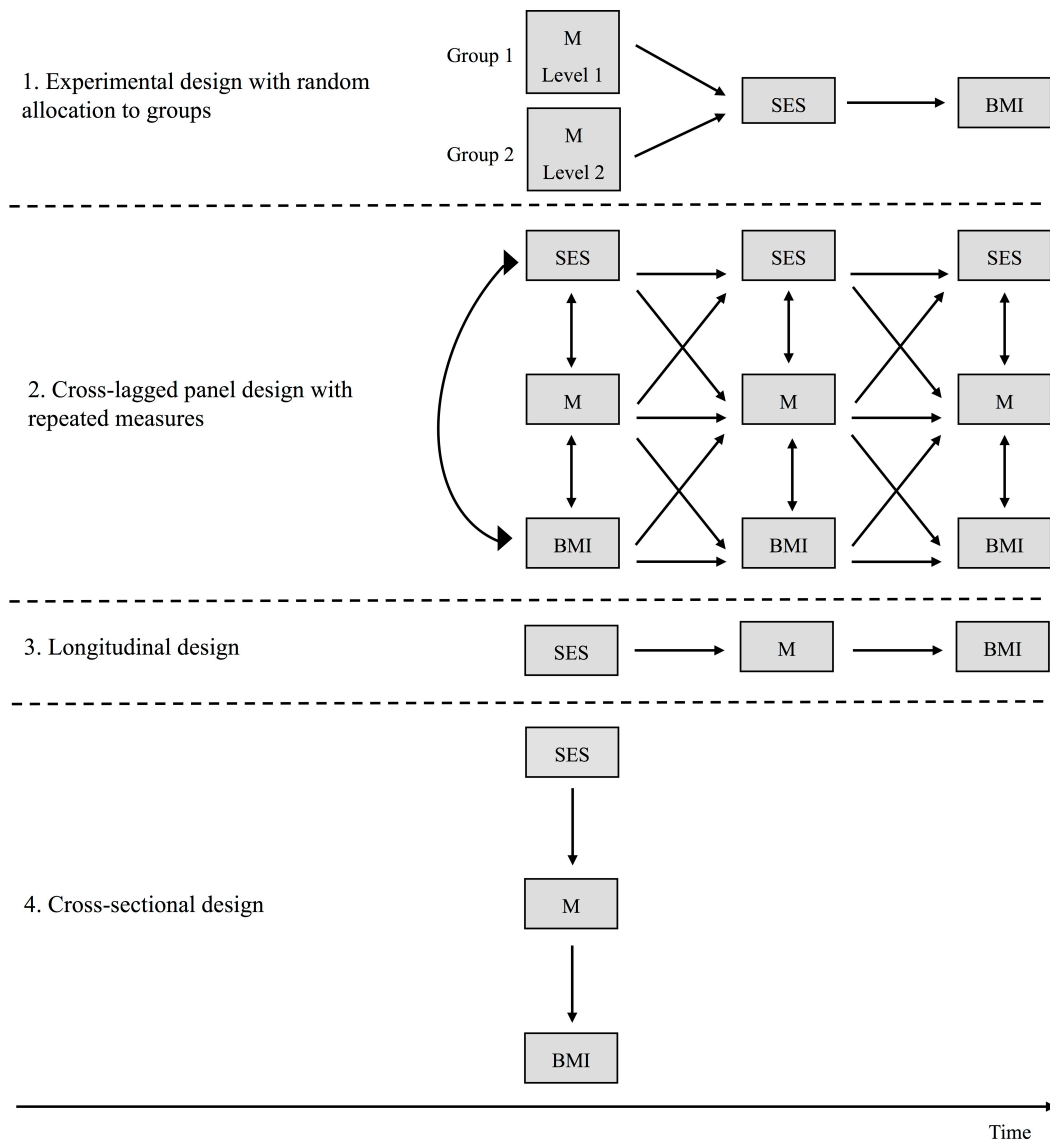
Figure 2. Criteria for inclusion of study designs and level of experimental rigor. Variations

within designs are possible. SES = socioeconomic status, M = psychosocial mediator, BMI =

Body Mass Index.

Mediation test: The studies examining psychosocial explanations of the relationship

between SES and BMI needed to test for mediational pathways between these variables.

There are different ways of testing mediation and we included studies that, as a minimum,

used coefficient testing (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). Figure 3

shows an overview of different levels of analysis that can be used to test for mediation.

Level	
1	Coefficient tests: comparing the influence of SES on BMI before and after inclusion of a mediator (e.g., MacKinnon et al., 2002).
2	Causal steps approach: at least testing two steps, including the influence of SES on the mediator and the mediator on BMI (Baron & Kenny, 1986; Cohen & Cohen, 1983).
3	Testing statistical significance of the indirect path (e.g., product of coefficients approach; Sobel, 1982, bootstrapping; MacKinnon, Lockwood, & Williams, 2004).
4	Examining alternative mediators by comparing different indirect effects (e.g., Preacher & Hayes, 2008a).
5	Testing alternative order of variables to establish causality (e.g., Smith, 1982).

Figure 3. Ordering of least to most reliable analysis for establishing mediation. The levels are

cumulative.

Included articles were published within the last 20 years (from 1997) and were written

in English. Excluded were studies that focused on undernutrition or studies carried out in

countries where a positive relationship between SES and BMI is found (typically in lower-

income countries; Dinsa et al., 2012). Additional exclusion criteria were non-human or

clinical samples (e.g., anorexia, diabetes, pregnancy, but obesity studies were included), and

studies involving children because the association between their SES and weight status is dependent on their parents' behaviors (Shrewsbury & Wardle, 2008). However, longitudinal studies in which measurements were taken during adulthood as well as during childhood were included.

Identification of Relevant Publications

Article screening followed the PRISMA guidelines (Moher, Liberati, Tekzlaff, & Altman, 2009; see Figure A1 in Appendix A1 in the Supplemental Online Material for a flow-diagram and Table A2 in Appendix A2 for the PRISMA statement). The searches yielded 3015 hits. After removing the duplicates, 2631 were left. We first screened titles for relevant publications, 875 remained. Next, we screened abstracts, eliminating another 552 and leaving 323. After reading the full-text articles, 22 were selected for inclusion in the review. Reasons for discarding the articles after reading the full-text were mostly due to not using BMI as a dependent variable, or not assessing mediation (for both reasons 26% of articles were discarded). The reference list of reviews found through this search was searched laterally but this did not yield any relevant hits.

Classification of Mediators and Assessment of Mediation

Two independent researchers classified the measures used in the included articles according to the categories proposed by the theoretical models discussing psychosocial explanations for the relationship between SES and health (e.g., Adler & Ostrove, 1999): environmental and psychological resources and constraints. Environmental factors included those associated with 1) the external and physical environment such as perceptions of environmental disorder and control, and 2) the social environment, such as social support and community involvement. Psychological factors included 1) affective, and 2) cognitive processes. In our classification we did not distinguish between affective and cognitive factors because their components overlap (e.g., Oatley, Keltner, & Jenkins, 2006). Nevertheless, we

classified factors as "stress-related" if they measured perceived stress or negative emotions, and "other" if assessing other psychological resources and constraints. Psychological factors were included if they were assessed with questionnaire-based methods and not by physiological measurements. For instance, stress was considered a psychosocial mediator if assessed by a question regarding an individuals' experience of stress in the past 30 days, but not by a measure of blood cortisol level, which we consider a physiological factor. Discrepancies in the classification of factors by the two researchers were resolved through discussion, with the help of a third researcher when necessary.

Assessment of Empirical Conclusiveness

Each of the studies included in this review was subjected to an assessment for drawing reliable conclusions about the existence of mediation. We developed a scoring system based on the different levels of design and levels of mediation test outlined in the inclusion/exclusion criteria. Based on these levels, studies could score four points for design (D1_4), and five for mediation test (M1_5). Table 1 shows the classification of the included studies according to these criteria. For points regarding M1_5, please note that these were taken as cumulative: A score of M5 means that criteria M1 to M4 have been met.

Due to the small number of studies assessing statistical significance of mediation, we did not require this as evidence for supporting mediation. Moreover, we concluded that there was support for mediation regardless of whether there was complete or partial mediation, and regardless of whether the direct effect of SES on BMI was significant (Mackinnon, Krull, & Lockwood, 2000; Zhao, Lynch Jr., & Chen, 2010). The results were analyzed in terms of support for mediation of the relationship between SES and BMI through the different psychosocial pathways proposed by the theoretical models (see pathways A, B and C in Figure 1). Some studies measured psychosocial factors which were not tested as mediators

(i.e., such as in path analysis models in which a specific factor was not allowed to predict

BMI directly). If mediation was not assessed, it was not discussed in our result section.

[Insert Table 1 about here]

Results

A total of 22 studies that met the criteria were identified. The studies differed in the

types of mediators tested, with 60% of them examining both an environmental and a

psychosocial factor, 32% - a psychosocial factor, and 9% - an environmental factor (the

classification of factors measured in each study can be found in Appendix C1 in the

Supplemental Online Material, and Table D1 in Appendix D1 in the Supplemental Online

Material provides a summary of the important characteristics of the included studies).

The studies reviewed revealed distinct associations between SES, psychosocial

factors, and BMI across genders. Firstly, when considering all different SES indicators

assessed across studies, in 67% of cases these indicators were significantly related to

women's weight. Among men, this was the case for 51% of the indicators used. A significant

association between income and weight was more often found among women (89% vs. 44%

among men, in the articles that assessed income as an indicator of SES). In contrast, among

both genders, education was frequently related to weight (66% among men and 75% among

women) while employment status was not (around 20% for both genders)[1]. This corroborates

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[1] These results need to be taken with caution as not all articles assessed the influence of the

predictors on BMI without simultaneously controlling for other predictors, and not all articles

specified results for men and women separately. It should also be noted that in some studies

the relationship between SES and BMI did not follow a linear function (e.g., Guthrie, Lessl,

Ochi, & Ward, 2013 - #9), while others found a positive relationship between SES and

weight (e.g., in men; Matheson et al., 2008 - #14).

findings in the literature showing that the relationship between SES and weight status is negative and consistent among women, but inconsistent or non-significant among men, depending on the SES indicator used (Mclaren, 2007; Sobal & Stunkard, 1989).

The empirical conclusiveness scores for the studies were considerably low, with 27% of studies falling in the weakest category (D1*M1; see Table 1). The types of designs and mediation tests used both contributed to this relatively low score. Thirty-two percent of studies used a longitudinal (but never a cross-lagged) design, and 68% used a cross-sectional design. Moreover, among the included studies, 36% performed coefficient testing, and 63% assessed (at least) the relationship between SES and a psychosocial mediator, and the relationship between a mediator and BMI. However, only 35% among those assessed statistical significance of mediation or compared the relative strength of direct and indirect pathways linking SES and BMI[2].

In 51% of the studies, there was support for (partial) mediation of the relationship between SES and BMI through psychosocial factors. Of the studies examining environmental factors (pathway A), 44% found support for (partial) mediation, which was lower than that for psychological factors (57%; pathway B). Based on the included studies, the results provided the most support for mediation through psychological factors (unrelated to stress). Seventy-eight percent of these studies found support for (partial) mediation (versus 36% -

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[2] Important to note, however, is that the scoring was based on the analysis performed regarding the relationship of interest to the current paper. For instance, some studies scored only M1 for their mediation test of the SES-BMI relationship, whereas they did test for the significance of a different mediation pathway (associated with a score M3). These studies were, for instance, interested in pathways linking SES with disease inflammation markers, through psychosocial factors and BMI.

57% for physical, social, and stress-related factors). Furthermore, 60% of the studies

examining the influence of both environmental and psychological factors (pathway C) in the

relationship between SES and BMI found support for (partial) mediation. See Figure 4 for a

graphical representation of the percentage of suggested support for mediation across studies.
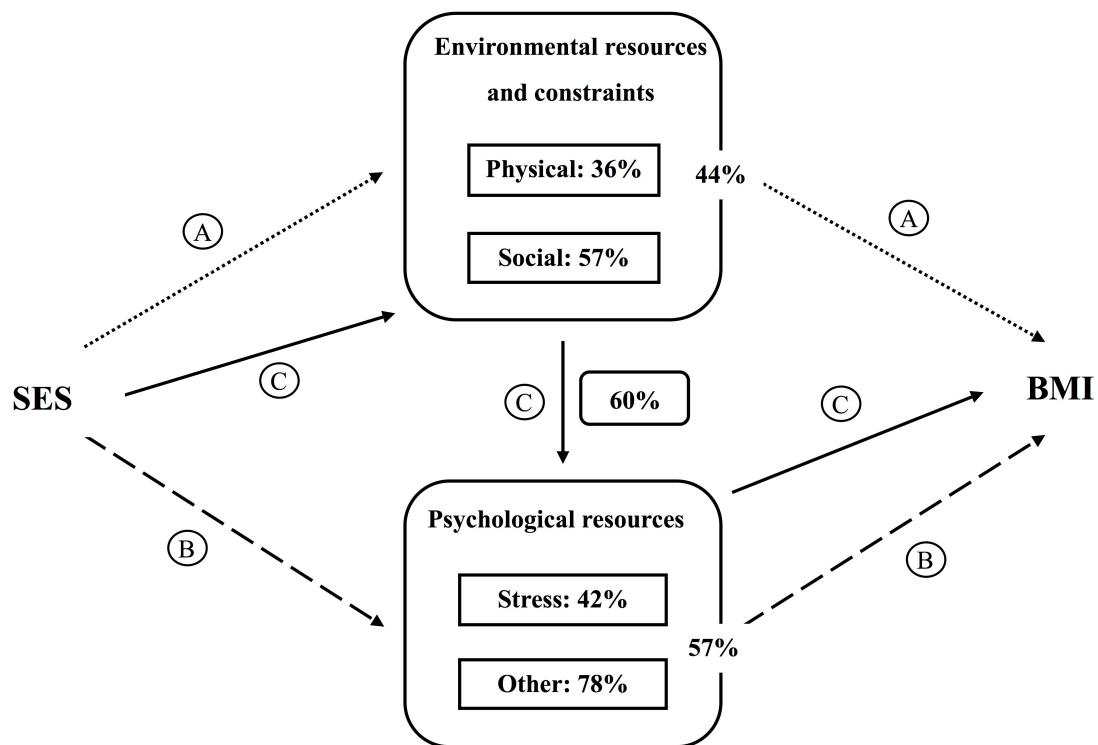
Figure 4. Overview of the percentage (%) of support for each pathway and psychosocial

mediator assessed in the reviewed studies. The more dashed the line, the less consistent the

evidence.

Results of Pathways Linking SES with BMI

      Studies examining environmental resources and constraints (pathway A). Ten

studies included in this review examined environmental factors as mediators of the

relationship between SES and BMI. Among these, eight assessed physical factors, and seven

social resources.

Physical factors. Five studies examined factors related to their neighborhood or community (#4, #11, #12, #16, #17) and one - food insecurity (#3). Furthermore, three studies assessed job factors (#2, #15, #20), and four - stress related to the home and school environment in young adulthood (#13, #15, #18, #21).

From the five studies examining the mediating role of neighborhood factors, one found no support for mediation (#17), and two only through indirect pathways with social support (#11, #12; see results for social factors), or with negative affect (#12; see results for pathway C). Among the studies that did find support for mediation, a cross-sectional multilevel analysis (D1*D1) of objectively measured community disadvantage showed that more disadvantage was related to higher BMI in women and that it slightly reduced the association between lower income and BMI, but not that between lower education and BMI (#16). However, this study scored low on our assessment of empirical conclusiveness and assessed self-reported, not measured, BMI. A longitudinal study (D2*M4) found that poorer neighborhood quality was related to higher BMI and obesity and that it reduced the association between subjective SES and overweight, simultaneously controlling for objective measures of SES (#4). Nevertheless, addition of childhood SES factors, which included adolescent neighborhood quality, eliminated the significant association between low current neighborhood quality and BMI, and reduced that with obesity.

The study (D1*M4) examining the role of food insecurity found that SES was inversely associated with food insecurity. Food insecurity had no direct association with BMI, except through psychological factors (#3; see results for pathway C).

There was little evidence that work stressors, and childhood stressors related to home and school played a role in the relationship between SES and BMI. One study (D1*M2) showed that in a sample of women, lower social position was associated with higher job strain, and that higher job strain was associated with obesity although not with BMI (#20).

Job strain accounted for about 18% of the association between lower SES and obesity, but this was lower than the amount explained by two psychological resources (self-esteem and expectations for the future which individually accounted for 23% and 34%, respectively; see results for pathway B). The two other studies found no mediation by high job demands or low job control on the relationship between SES and BMI (#2, #15), although one study (D1*M1) did find that skill discretion (skill and creativity required and flexibility in using these skills at work) was inversely related to BMI (#2).

Another study (D2*M1) tested whether childhood stressors explained educational differences in overweight (#15). Among women but not among men, childhood stress related to home (parental divorce) and school (low control and unpopularity) reduced the association between lower education and overweight/obesity at age 30 by at least 10% (#15). Among men, only low parental social support in education explained a significant part (29%) of the association between lower education and later overweight risk in men. The other three studies examining childhood factors did this only in path analyses together with psychological factors (#13, #18, #21; see results for pathway C).

Social factors. Evidence for social resources as a mediator in the relationship between SES and BMI was inconclusive based on the findings from seven studies that found mixed results in terms of type of social factors assessed, the strength of the mediation, and the direction of the relationship between social resources and BMI. Most studies examined social support as number of close friends, or satisfaction with one's social relations (#1, #11, #12, #15, #16, #20). Other measures used were sense of belonging (#14) and participation in social activities related to an association (#15).

Three out of seven studies found no evidence that social factors mediated the association between SES and BMI (#14, #16, #20). One study (D1*M1) found that weak versus strong community sense of belonging was related to higher BMI but had no influence

on the association between lower education and BMI (#14). Four studies did find that social

support mediated (part of) the association between SES and BMI (#1, #11, #12, #15). Two of

these studies were carried out in the same laboratory (#11, #12). Using structural equation

modeling (SEM; D1*M4) they both found a significant indirect pathway showing that SES

was positively related to social support, and that there was a positive association between

social support and BMI. Furthermore, there was also a significant indirect relationship

including neighborhood disadvantage: SES was inversely associated with perceived

neighborhood disadvantage, which was in turn inversely associated with social support.

On the contrary, a study (D2*M1) examining the cumulative influence of adverse

circumstances in adolescence and young adulthood on adult BMI, found that perceived

availability of a social network and social support did not explain any variance in the

relationship between education and overweight (#15). However, not participating in social

activities at age 30 explained 29% of the increased risk in overweight of lower educated men.

OR adjustments were tested separately for each mediator and then together in a cumulative

model showing that parental support in adolescence was a more important factor than

participation in social activities.

Surprisingly, several studies revealed that possessing greater social resources was

associated with higher levels of BMI/obesity (#1, #11, #12, #14). For instance, whereas in an

overweight/obese sample, support for exercise was inversely associated with BMI, there was

a positive association between support for healthy eating and BMI (#1). However, social

support was inversely associated with calorie consumption, which suggests a reverse causal

pathway between social support and weight: The more obese individuals receive more

support from their social environment, rather than their weight being influenced by the

amount of social support they receive. Table 2 shows an overview of the findings regarding

environmental factors.

[Insert Table 2 about here]

Studies examining psychological resources and constraints (pathway B). Eighteen studies examined the influence of psychological factors in the relationship between SES and BMI. Thirteen among these examined stress-related factors and seven other psychological processes.

Stress-related factors. Thirteen studies examined the influence of perceived stress, negative affect, or a combination of both, of which one only in SEM models together with environmental factors (#21; see results for pathway C). The factors examined were, among others, negative life events, negative affect, and depressive symptoms.

Five studies out of twelve found that factors related to stress mediated (part of) the relationship between SES and BMI (#4, #5, #8, #10, #22). The others did not (#11, #13, #14, #16, #17), or only in an indirect pathway with environmental factors (#3, #12; see results for pathway C).

Two studies found a negative relationship between stress and BMI. One study (D2*M4) showed that higher stress experienced in the last 30 days, simultaneously controlling for depressive symptoms, was related to lower BMI and obesity and explained a statistically significant 18.2% of the relationship between subjective social status and BMI (#4). Depressive symptoms were not associated with BMI. Results were identical with obesity status as a dichotomous dependent variable. The second study (D2*M2) examined associations between childhood and adult SES on BMI, and assessed a composite measure reflecting stress related to environmental, social, psychological and physical domains (#10). There was a significant negative association between SES and stress, and SES and BMI, but stress was not associated with BMI.

The other studies found that experiencing more stress was associated with higher BMI (#3, #5, #8, #21, #22). One of these studies (D1*M3) showed that of the three stress measures

assessed, two partially mediated the association between low income and obesity, although

the mediation was not statistically significant and the reduction was minimal: 3.3 - 5.1% (#8).

This was similar to the 5% reduction found in another study (D1*M1; #5). Two other studies

revealed that controlling for stress in a linear regression model reduced the strength of

association between income and BMI/obesity in women, but not in men (#8, #22).

Other psychological factors. Seven studies examined the influence of other

psychological resources and constrains, including time perspective/future expectations (#9,

#20), eating motivation and control (#1, #7), personal control (#4, #19, #20), and personality

characteristics (#4, #6).

People differ in the extent to which they are more focused on their present or future,

with low SES being associated with a present-oriented focus (Fieulaine & Apostolidis, 2015).

A present-oriented time perspective is associated with unhealthier behaviors and heavier

weight status (Daugherty & Brase, 2010; Dassen, Houben, & Jansen, 2015). In one of the

studies included in this review (D1*M2), neither present nor future time orientations

mediated the relationship between education and overweight/obesity, nor were they

associated with BMI (#9). The second study (D1*M2) assessed people's expectations of the

future by showing them a ten-grade ladder with the lower rung representing the worst

possible expectation, and the 10th rung the best possible expectation for the future (#20). The

researchers found that expectations of poor quality in one's future life accounted for

approximately 34% of the association between low SES and obesity. Both studies were

carried out in small samples (n < 301).

Two studies found that part of the association between SES and BMI was accounted

for by attitudes and motivations towards eating (#1, #7). In a study with an obese sample

(D1*M2), motivation for healthy eating was positively associated with BMI, but self-efficacy

for exercise and healthy eating, assessed by questions regarding one's intentions to exercise

and one's ability to control their eating, were not related to BMI (#1). Another study

(D1*M2) examined *eating restraint*, the extent to which people restrict their food intake to

lose or maintain weight, *eating disinhibition*, a loss of eating restraint, and the extent to

which one regularly experiences hunger (#7). Only scores on the hunger scale (measured

with items such as "I am always hungry enough to eat at any time"), but not on the restraint

and disinhibition scale, differed across employment grades. Adjusting for hunger scores

attenuated the mean difference in BMI across low vs. high employment grade by 8.4%.

Evidence for the influence of personal control was mixed. In two studies, skills to

cope with school/work responsibilities and social difficulties, or dealing with scarce financial

situations were not associated with BMI or obesity (#19, #20). In the latter study (D1*M2),

however, it was found that women with lower social positions reported less self-esteem, and

this explained approximately 23% of the SES gradient in BMI, but this was not as much as

negative expectations about one's future life which individually explained 34%. Contrary to

these findings, another study (D2*M4) found a positive association between mastery and

BMI and obesity. Simultaneously controlling for personality characteristics in a regression

model, these factors slightly reduced the coefficient of subjective SES as a predictor of

BMI/obesity, although this reduction was not statistically significant (#4).

Neither of the two studies examining personality characteristics found strong support

for mediation, and the associations of each personality characteristic with BMI and obesity

were different. Personality characteristics were assessed with the Big Five scales which

consist of subscales assessing five different characteristics (Barrick & Mount, 1991). The

conclusion that can be drawn from these two studies is that personality characteristics are

associated with weight status in different ways among men and women: For instance, in one

study (D2*M1), higher scores on the agreeableness sub-scale, which assesses one's

consideration of others, was related to higher BMI and obesity among men but not among

women (#6). On the contrary, in the other study (D2*M4) there was a negative association between agreeableness and BMI but not obesity (#4). Furthermore, in both studies higher conscientiousness, one's tendency to be self-disciplined, was related to lower BMI/obesity among both men and women, reflecting the positive influence greater self-discipline can exert on health. These results, however, need to be interpreted cautiously since in both studies the internal consistency for the conscientiousness dimension was poor or questionable. Table 3 provides an overview of the results.

[Insert Table 3 about here]

Studies examining psychological resources and constraints as a mediating pathway between SES, environmental resources and constraints and BMI (pathway C). Thirteen studies measured both environmental and psychological factors, among which eight assessed mediation of the association between lower SES, environmental factors, and BMI (#3, #4, #11, #12, #13, #16, #18, #21). Six among those used SEM or path analyses to examine significant pathways linking SES with BMI.

Results regarding the associations assessed were mixed with studies finding support for and against mediation of the relationship between SES, environmental factors and weight. For instance, a life-course analysis (D2*M2) illustrated that cumulative adversity in adolescence was positively associated to BMI in adulthood (#21). This association was partially explained by a chain starting with parental rejection, depressive symptoms, and precocious life events during adolescent years (e.g., onset of sexual intercourse before 16 years). Yet, in another study (D2*M2), path analyses indicated that although material disadvantage in early life was positively associated with psychological distress through the quality of one's parental relationship at age 16, there was no significant association between psychological distress and BMI (#13). The study concluded that material factors were more important than psychosocial factors in translating childhood SES into poor health later in life.

Another study using SEM (D1*M4) found that neighborhood disadvantage and social

support mediated part of the influence of SES on BMI through negative affect (#12).

Whereas there was no direct effect of perceived neighborhood disadvantage on BMI, there

was a significant indirect effect through social support and through negative affect, as well as

an indirect effect including both social support and negative affect: Perceived neighborhood

disadvantage was inversely associated with social support, and social support was inversely

associated with negative affect. Negative affect was positively associated with BMI. The

estimated coefficient was highest for the pathway from SES through social support to BMI

(although overall the direct effect of SES on BMI remained the strongest). A comparable

pattern of results was found in a similar study (D1*M4), but the pathways reached only

marginal significance (#11). Similar results were found in a study (D1*M4) examining food

insecurity, the insecurity and anxiety associated with accessing adequate food (#3). The

direct effect of SES on BMI remained the strongest, although a significant pathway was

found through food insecurity and depression. SES was inversely related to food insecurity,

food insecurity with depression, depression with BMI. These results were only found among

women. Among men, SES was inversely related to food insecurity but food insecurity was

not related to depression nor BMI.

Two studies using stepwise regressions showed that the association between

neighborhood deprivation and BMI/obesity was not attenuated after inclusion of factors

related to stress and depression (#4, #16). One of these studies (D2*M4) did find that

psychological resources such as personal control and conscientiousness reduced the

association by 20% (#4). Another study (D2*M2) found that childhood SES was inversely

related to riskier family environment, riskier family environment was inversely related to

psychosocial functioning (as indicated by a composite score of depression, mastery, and low

positive/high negative social contacts), and psychosocial functioning was inversely related to

BMI (#18). Table 4 provides an overview of the results.

[Insert Table 4 about here]

Conclusion and discussion

This contribution offers a systematic review of existing publications that examined

psychosocial explanations for the SES gradient in BMI. Overall, the findings provide

inconclusive evidence due to significant limitations in research designs and mediation testing,

the limited amount of studies per psychosocial factor, and the mixed results as a consequence

of inconsistent use of types of samples, SES indicators, and measures across studies (see

Table C1 in Appendix C in the Supplemental Material with a detailed overview of measures

used in each included study). However, a few conclusions may be cautiously drawn.

First, the findings tend to corroborate the theoretical pathways proposed by, among

others, Adler and Ostrove (1999). Support for environmental factors was relatively weaker

than that found for the collective role of environmental and psychological factors in

explaining associations between SES and weight status. The studies that found (partial)

mediation of the SES-BMI association by neighborhood factors, were solely studies that used

objective indicators of environmental conditions (Bradshaw, Kent, Henderson, & Setar, 2017

- #4, Robert & Reither, 2004 - #16). Objective environmental factors are more proximal to

SES and concern structural constraints in one's environment that can directly lead to weight

gain (e.g., lower access to physical activity resources and nutritious food; Carlson & Frazão,

2014; Estabrooks, Lee, & Gyurcsik, 2003), whereas environmental perceptions may capture

psychological states related to lower SES, influencing weight through factors such as

increased stress levels (Burdette & Hill, 2008 - #5; Kendzor et al., 2013 - #12).

Although four out of seven studies (57%) found support for mediation by social

resources, there were also significant pathways through neighborhood perceptions and

negative affect (Kendzor et al., 2013 - #12), and through childhood support (Novak, Ahlgren, C., & Hammarström, 2006 - #15) which was relatively more important. The inconsistencies in the findings regarding the social environment suggest different functions of, and different importance accorded to social support across genders and ethnicities. For instance, in the U.S., social support related to one's neighborhood was more important for people with Latino ethnicity than for other ethnic groups (Kendzor et al., 2013 - #12). Moreover, women may use social support as a way to improve their self-esteem and body acceptance (Augustus-Horvath & Tylka, 2011; Bacon, Stern, Van Loan, & Keim, 2005; Puhl & Heur, 2009) whereas for men, social resources may be protective in an indirect manner, for instance, when engaging in exercise during social activities (Novak et al., 2006 - #15).

Second, the findings indicate a substantial role of psychological factors (unrelated to stress) in the association between SES and BMI. It is important, however, to note that some of these factors were measured with several measures of which only some mediated (part of) the SES-BMI link (e.g., see the results regarding eating motivation/control). Moreover, there is a lack of consistency among the measures used to assess psychological factors. More specifically, whereas the measured factors related to stress (encompassing perceived stress, negative affect, depression) can be considered a generally unified construct, there is a lot of variance in the other psychological factors assessed. Too few studies examined each factor for drawing generalizable conclusions. For instance, a study examining the influence of time perspective found no significant association with obesity (Guthrie et al., 2009 - #9). Comparisons with similar studies that did find associations between SES and time perspective, or time perspective and BMI (e.g., Adams & White, 2009; Barlow, Reeves, McKee, Galea, & Stuckler, 2016), suggests that results vary depending on the age composition of the samples and the scales used to assess time perspective (Crockett, Weinman, Hankins, & Marteau, 2009).

Contrary to theories proposing perceived control as a central predictor of health behaviors and weight status (e.g., Bandura, 2004), perceptions of control or self-esteem did not play a key role in the studies included in this review. Similarly, control over eating did not contribute to explaining the association between SES and BMI. The findings related to eating motivation and control suggest that dietary interventions for low-SES individuals should focus on changing eating motivations rather than boosting self-control regarding eating (Dykes, Brunner, Martikainen, & Wardle, 2004 - #7; Baughman et al., 2003 - #1). Possibly this could overcome food intake regardless of one's level of satiation or hunger which has been associated with lower SES (Hill, Prokosch, DelPriore, Griskevicius, & Kramer, 2016).

Third, support was slightly higher for the pathway through both environmental and psychological factors (pathway C) than the other pathways. A large amount of the studies examining pathway C used longitudinal designs and SEM models comparing different mediating pathways. Although support was found for the influence of environmental and psychological constraints and resources in the SES-BMI link, SES itself often remained the most significant predictor (e.g., Kendzor et al., 2013 - #12; Beydoun & Wang, 2010; #3). For instance, the study with the highest level of design and analysis, tested a final model including all variables. This model explained 59.5% of this association between subjective SES and BMI. Childhood and adult SES and environmental factors explained 48.6% while psychological and health factors explained an additional 10.9%.

Lastly, although psychological stress is often proposed as an explanation in the association between SES and BMI, less than half of the studies testing stress as a mediator find support for it. This finding is consistent with the inconsistencies found in studies examining the influence of emotions on eating behavior and weight (Ball, Schoenaker, Mishra, 2017; Bongers, de Graaff, & Jansen, 2016; Dallman, 2010). Gender differences are a

possible explanation for these inconsistent findings. For instance, Beydoun and Wang (2010 - #3) found that men with depression were less likely to be overweight or morbidly obese, whereas women with depression were three times more likely to be morbidly obese. Yang, Matthews, and Chen (2014 - #22) found a positive relationship between stress and BMI for both genders but the difference in BMI between low and highly stressed participants was 1.5 times larger among women. Men may have different coping mechanisms for dealing with negative emotions (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008), or, alternatively, may report and experience less negative emotions due to lower awareness of their internal bodily sensations (Gersten, 2008).

Furthermore, gender differences in acute and chronic experiences of stress may be another reason for the inconsistent findings (Torres & Nowson, 2007). For instance, Wickrama, O'Neal, and Oshri (2014a - #21) found that accumulation of adverse childhood experiences was positively related to BMI later in life among women, but not among men, which is consistent with other research findings (Chapman, 2009 - #6; Solís et al., 2015). Likewise, Hill, Rodeheffer, DelPriore, and Butterfield (2013) showed that environmental harshness in childhood as well as experimentally manipulated harshness cues were related to increased caloric intake and less weight concern for women. Increased vulnerability to chronic stressors may offer an explanation for why the SES-BMI link is more consistently found among women than among men and for the finding that more support is found for stress as a mediator in the SES-BMI association for women than for men (e.g., Gebreab et al., 2012 - #8). Accumulation of stressful experiences related to SES adapts psychological responses to stressful triggers and can cause neurobiological changes in appetite and motivation, leading to unhealthier eating patterns and propensity to weight gain (Adam & Epel, 2007; Dallman et al., 2003; Yau & Potenza, 2013).

Limitations and Suggestions for Future Research

One of the limitations is the relatively small amount of articles examining mediational pathways linking SES and BMI. In our selection of articles, we only included studies using designs that could establish causal inference. Methodological soundness was deemed more important for the objective of this review than widening the inclusion parameters to include more articles. However, it is possible that some important factors are absent in this overview. For instance, none of the included articles examined factors related to stigmatization of low SES individuals, or to weight-related stigma (McLaren, 2007). Moreover, a recent paper suggests that cultural influences and the symbolic value of foods should also be considered when explaining social gradients in diets. Fielding-Singh (2017) showed that the meaning parents attach to food, and the way in which these meanings affect the food they purchase for their children, differs across SES level.

One approach for increasing the number of articles found would be to include search terms related to specific psychosocial mediators such as 'stress' (for an example, see Matthews and colleagues, 2010). We specifically did not choose this approach because we believed this would bias the article search towards findings consistent with our individual preconceptions about pathways underlying the SES-BMI link. We chose to search for keywords related to the main key concepts according to proposed methodologies for systematic reviews (e.g., Mertens, 2014). This search already led to a large number of articles. Nonetheless, future work could certainly provide a focused exploration of the role of specific factors in the link between SES and BMI.

Another limitation of the relatively small selection of studies is that more systematic research is warranted examining the influence of various combinations of SES and psychosocial indicators, to reveal potential distinctive associations. For instance, the association between employment and BMI may be explained by perceived job control, whereas that of income and BMI may not (Sobal, 1991). Moreover, previous studies suggest

differences in the relative importance of SES indicators. For instance, low SES in early life

may set out a path towards psychosocial characteristics and unhealthy behaviors that is more

predictive of illness than low SES in adulthood (Simpson, Griskevicius, Kuo, Sung, &

Collins, 2012; Lynch, Kaplan, & Salonen, 1997). Scholars also emphasize the importance of

distinguishing between the instrumental function of financial resources and relative

deprivation (i.e., the subjective experience of dissatisfaction that can lead to feelings of

resentment and anger), which can help clarify the processes underlying SES-BMI

associations (Bernstein & Crosby, 1980; Boyce, Brown, & Moore, 2010; Goudeau, Autin, &

Croizet, 2017). Whereas recent studies suggest that relative income and perceptions of

relative deprivation show a greater association with BMI and obesity than absolute or

objective measures of income (Daly, Boyce, & Wood, 2015; Davillas & Benzeval, 2016),

only one study included in this review included it as a measure, showing that lower

subjective SES was for more than 50% associated to BMI and obesity, independent of

childhood and adult SES (Bradshaw et al., 2017 - #4).

A major limitation of the research under examination is the limited use of designs and

analyses that allow for strong causal inferences and for quantifying the mediational role of

psychosocial factors in the relationship between SES and BMI. Most published studies

concerned with psychosocial mediations were cross-sectional. And, among the limited

number of longitudinal studies that addressed this pathway, none relied on a cross-lagged

design that would have allowed for stronger inferences. Regarding the mediation tests, very

few tested for statistical significance of the indirect pathway of interest and many were not

principally interested in examining mediation. None of them tested for alternative directions

of pathways (which is necessary to establish mediation: Fiedler, Schott, & Meiser, 2011). The

low scores for empirical conclusiveness in nearly all studies made it impossible to conclude

on the support for or against mediation by comparing the relative strength of the studies.

Moreover, the current studies use different measures or questionnaires to assess similar factors, often included in models simultaneously with other factors. Whereas this could provide information about the relative strength of a predictor compared to another, these analyses are often carried out with little theoretical justification. In addition, they often do not allow assessing the relative importance of one factor over another due to simultaneous addition of variables in a model, or due to the use of non-standardized coefficients (e.g., Baughman et al., 2003 - #1).

Significant empirical advances need to be achieved in order to better address the causal pathways between SES and weight, using study designs that make it possible to infer causality (Burkholder & Harlow, 2003; Kearney, 2017; Mulatu & Schooler, 2002). Some studies suggest a bi-directional relationship between SES and weight. For instance, obesity might lower a person's chances of being hired for a job, or increase the risk of discrimination in the health care system, thereby leading to lower SES (Nobles, Weintraub, & Adler, 2013; Agerström & Rooth, 2011; Puhl & Heuer, 2009). Random assignment of participants to different SES conditions would be ideal but, although possible (e.g., Sim, Lim, Leow, & Cheon, 2017; Spears, 2011), is problematic for practical and ethical reasons. Manipulating a psychosocial mediator is a reasonable method but is hard to carry out in a field study. As an additional issue, mediation has to be demonstrated in the first place, before conceptually intervening on a mediational factor. As we have seen, evidence for mediation is only suggestive at this stage. Nevertheless, effect size of a mediator and pragmatic value do not necessarily overlap (i.e. less powerful mediators may be easier to intervene on, for ethical, or practical reasons). An alternative method would be to manipulate perceptions of, for instance, subjective status or psychological stress, and examine the influence on health behaviors rather than on weight change. For instance, using this approach, Bratanova, Loughnan, Klein,

Claassen, and Wood (2016) showed that social anxiety mediated associations between lower SES (both self-reported and manipulated) and caloric intake.

The lack of intervention or trial studies in the adult population is unfortunate given the practical limitations of experimental designs to test changes in BMI as a function of status differences. We found one intervention study in an adult, low-income sample in Brazil. This study consisted of workshops aimed at improving autonomous decision-making and overcoming barriers related to desired dietary change. The intervention led to a significant amount of weight loss during the 6-month intervention (a reduction in BMI of -0.44 ±1.06; de Menezes, Mingoti, Cardoso, de Deus Mendonça, & Lopes, 2015). No significant weight loss occurred in participants in the control condition, who participated in exercise and nutrition education sessions, which were also followed by the participants in the intervention group. Although all participants were of low family income (<\$292 per capita), and cost was not a focus in the intervention, income was one of the factors associated with weight loss in the intervention group, besides dietary change. Future work should keep into consideration that even within SES groups, and especially so among lower SES ones, there is large variability. Given the fact that SES remained a significant predictor alongside psychosocial factors in many of the studies examined, it is important to examine variability even within specific SES groups.

Another limitation of the literature is the focus on BMI as the sole indicator of weight status, specifically in the context of gender and ethnic differences. On average, men tended to be heavier than women when comparing BMIs (Matheson et al., 2008; - #14; Novak et al., 2006 - #15), but more women were classified as (morbidly) obese (Beydoun & Wang, 2010 - #3; Baughman et al., 2003 - #1). Men have a heavier muscle and bone mass and a higher density of fat free body mass than women (Gallagher et al., 1996), yet the same BMI cut-off values are used to classify men and women into obesity classes. The same problem holds for

ethnic differences in body types and fat distribution (Deurenberg, Yap, & Van Staveren, 1998). This may lead to misrepresentation of findings. We recommend future studies to measure weight rather than relying on self-reported weight, and to include several indicators such as BMI, waist circumference, or percent body fat (Davillas & Benzeval, 2016; Tomiyama, Hunger, Nguyen-Cuu, & Wells, 2016). Some of the studies discussed in this review used alternative obesity-indicators alongside BMI and found distinct results depending on the measure examined. For instance, Schulz and colleagues (2008 - #17) found no influence of income on BMI in an ethnically diverse sample, but did find that lower income was related to higher waist circumference (which had different cut-off values for men and women) and that this relationship was mediated by stressful life events.

Theoretical and Policy Implications

Based on the findings of this systematic review, several suggestions can be formulated for future interventions and policies. First of all, the findings tend to provide support for the theoretical models proposed by authors such as Adler and Ostrove (1999). SES is associated with BMI through environmental and psychological factors individually, but support is also found for a pathway through which environmental factors influence psychological processes that affect weight status. This highlights the importance of taking into consideration (social) environmental and contextual situations alongside SES factors when targeting health interventions to specific groups or people (Chen & Paterson, 2006).

Nevertheless, it is striking to see the relatively poor quality of designs and mediation tests of studies examining causal pathways through which SES influences weight status. Without convincing evidence about which specific psychosocial factor(s) mediate(s) the relationship between SES and BMI, it is not possible to create effective interventions targeting a factor that might play a role in the relationship. It is critical to establish which factors translate lower SES into increased weight. All intervention studies that we found were

carried out among children, adolescent populations, or only among lower SES people. In order to determine how to reduce socioeconomic inequalities, interventions should be carried out in broader populations as well.

The direct effect of SES on obesity remained statistically significant in many of the studies, indicating the importance of also addressing the structural antecedents of obesity (Link & Phelan, 1999). The same applies for factors regarding the physical and social environment which explained part of the association between low SES and BMI. Thus, besides targeting health interventions to individuals themselves, structural interventions or policy-changes such as environmental modifications, or food procurement policies need to be considered (Turrell & Vandevijvere, 2015).

Important to keep in mind are possible discrepancies between objectively measured economic or social constraints and subjective experiences of these constraints (Powell-Wiley et al., 2014). For instance, diminishing the amount of crime rates in a neighborhood may not lead to changes in the perception of the amount of crime rates in one's neighborhood. Moreover, a gap between one's level of personal wealth and the average wealth of people in one's neighborhood can have detrimental psychological and behavioral consequences due to upward comparisons to a possibly unattainable higher standard (Roy, Godfrey, & Rarick, 2016; Sanchez-Vaznaugh, Kawachi, Subramanian, Sanchez, & Acevdeo-Garcia, 2009). Structural changes should be accompanied by subjective evaluations provided by the targeted population.

Improving the conditions of physical and social environments can help decrease weight gains, or diminish weight increases among low SES individuals, through an indirect influence on more positive emotions and lowered stress experiences. Besides changing structural and environmental factors, lower SES people could also benefit from individually tailored interventions. These could, for instance, focus on improving self-esteem or changing

eating motivations towards healthier types of food (Lasikiewicz, Myrissa, Hoyland, &

Lawton, 2014).

The differences found among genders and ethnic groups, although not the focus in

this paper, highlight the importance of considering cultural differences in perceptions of

healthiness and body satisfaction, as well as addressing societal issues such as gendered

weight norms. Future studies should focus on examining subgroups of low and high SES

more closely, taking into account cultural and ideological differences regarding material

goods and status as well as beliefs and values about food (Sobal, 1991; Wang, Worsley, &

Cunningham, 2008). In particular, clarifying such racial/ethnic differences could help refine

SES-BMI pathways in men, which vary among racial or ethnic subgroups (Ogden, Lamb,

Carroll, & Flegal, 2010; Godley & McLaren, 2010).

The present review illustrates the possible role of psychological factors in translating

lower SES and environmental and social deprivation into higher BMI. Although the

statistically explained variances are small and both designs and statistical approaches are

problematic, the preliminary findings suggest potentially relevant mechanisms explaining the

relation between SES and weight status. The existing literature examining psychosocial

explanations of the SES-BMI relationship point to promising findings that bring us closer to

understanding the intricate workings of socioeconomic influences on psychologically

different individuals in social environments.

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Classification of included studies according to the empirical conclusiveness of their design and statistical approach to mediation testing. The color of the cell provides an indication of the overall strength of evidence, ranging from best (dark grey cells), to moderate (light grey cells), to low (plain cells).

		M1_5: MEDIATION TEST				
		M1 – Coefficient test	M2 – Causal steps approach	M3 – Statistical significance	M4 – Alternative mediators	M5 – Order of variables
D1_4: DESIGN	**D1 – Cross-sectional**	Bean (#2) Burdette (#5) Matheson (#14) Robert (#16) Veenstra (#19) Yang (#22)	Baughman (#1) Dykes (#7) Guthrie (#9) Schulz (#17) Wamala (#20)	Gebreab (#8)	Beydoun (#3) Kendzor (2009; #11) Kendzor (2013; #12)	
	D2 - Longitudinal	Chapman (#6) Novak (#15)	Hagger-Johnson (#10) Lacey (#13) Taylor (#18) Wickrama (#21)		Bradshaw (#4)	
	D3 – Cross-lagged					
	D4 - Experimental					

Table 2.

Studies examining environmental constraints and resources as a mediating pathway between SES and BMI (pathway A).

Study	SES indicator						Environmental factor				
							Physical				Social
	Income	Education	Employment	Composite	Childhood	Subjective	Neighborhood disadvantage	Food insecurity	Job stress	Stress/low control at home and school	Social resource
#1		•	•								✓ / ✗ (D1*M2)
#2	•		•						✗ (D1*M1)		
#3				•				✗ (D1*M4)			
#4	•	•			•	•	✓ (D2*M4)				
#11				•			✗ (D1*M4)				✓ (D1*M4)
#12				•			✗ (D1*M4)				✓ (D1*M4)
#14		•									✗ (D1*M1)
#15	•	•	•						✗ (D2*M1)	✓ / ✗ (D2*M1)	✓ / ✗ (D2*M1)
#16	•	•	•				✓ (f) / ✗ (D1*M1)				✗ (D1*M1)
#17	•	•					✗ (D1*M2)				
#20				•					✓ (f; D1*M2)		✗ (f; D1*M2)
#21				•						✗ (D2*M2)	

Note. ✓ = (partial) mediation, ✗ = no mediation, f = result only applies to females, m = result only applies to males. Empirical conclusiveness score between brackets.

Table 3.

Studies examining psychological constraints and resources as a mediating pathway between SES and BMI (pathway B).

| Study | SES indicator | | | | | | Psychological factor | | | | | |
| | | | | | | | Stress | | Other | | | |
	Income	Education	Employment	Composite	Childhood	Subjective	Perceived stress or negative affect	Composite	Time perspective	Eating motivation / control	Personal control	Big 5
#1		•	•							✓ / ✗ (D1*M2)		
#3				•			✗ (D1*M4)					
#4	•	•			•	•	✓ / ✗ (D2*M4)				✓ (D2*M4)	✓ / ✗ (D2*M4)
#5	•	•	•				✓ (D1*M1)					
#6	•	•	•		•							✓ / ✗ (D2*M1)
#7			•							✓ / ✗ (f; D1*M2)		
#8	•						✓ / ✗ (f; D1*M3)					
#9		•							✗ (D1*M2)			
#10							✓ (D2*M2)					
#11				•				✗ (D1*M4)				

Table 3 continued.

Study	Income	Education	Employment	Composite	Childhood	Subjective	Perceived stress or negative affect	Composite	Time perspective	Eating motivation / control	Personal control	Big 5
							Stress		**Other**			
#12				•				✗ (D1*M4)				
#13		•	•		•		✗ (D2*M2)					
#14		•					✗ (D1*M1)					
#16	•	•	•				✗ (D1*M1)					
#17	•	•					✗ (D1*M2)					
#19	•	•									✗ (D1*M1)	
#20				•					✓ (f; D1*M2)		✓ / ✗ (f; D1*M2)	
#22	•	•	•				✓ (f; D1*M1)					

Note. ✓ = (partial) mediation, ✗ = no mediation, f = result only applies to females, m = result only applies to males. Empirical conclusiveness score between brackets.

Table 4

Studies examining environmental and psychological factors as a mediating pathway between lower SES and obesity (pathway C).

| Study | Environmental factor | | | | Psychological factor | | | | Composite |
| | | | | | Stress | | Other | | |
	Neighborhood deprivation	Home environment	Food insecurity	Social support	Perceived stress or negative affect	Composite	Control	Big5	
#3			•		✓ (f; D1*M4)				
#4	•				✗ (D2*M4)		✓ (D2*M4)	✓ / ✗ (D2*M4)	
#11	•			•		✗ (D1*M4)			
#12	•			•		✓ (D1*M4)			
#13				•	✗ (D2*M2)				
#16	•			•	✗ (D1*M1)				
#18		•							✓ (D2*M2)
#21		•			✓ (D2*M2)				

Note. ✓ = (partial) mediation, ✗ = no mediation, f = result only applies to females, m = result only applies to males. Empirical conclusiveness score between brackets.