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Educational attainment and obesity: A systematic review

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Abstract

Background—Although previous systematic reviews considered the relationship between socioeconomic status and obesity, almost 200 peer-reviewed articles have been published since the last review on that topic, and this paper focuses specifically on education, which has different implications.

Methods—The authors systematically review the peer-reviewed literature from around the world considering the association between educational attainment and obesity. Databases from public health and medicine, education, psychology, economics, and other social sciences were searched, and articles published in English, French, Portuguese, and Spanish were included.

Results—This paper includes 289 articles that report on 410 populations in 91 countries. The relationship between educational attainment and obesity was modified by both gender and the country's economic development level: an inverse association was more common in studies of higher-income countries and a positive association was more common in lower-income countries, with stronger social patterning among women. Relatively few studies reported on lower-income countries, controlled for a comprehensive set of potential confounding variables, and/or attempted to assess causality through the use of quasi-experimental designs.

Conclusions—Future research should address these gaps to understand if the relationship between educational attainment and obesity may be causal, thus supporting education policy as a tool for obesity prevention.

Keywords

educational status; overweight; obesity; social class; review

Introduction

Education has been shown to be associated with health outcomes in developed countries since at least the latter half of the 20th century[1,2], and it is often used as an indicator of socioeconomic position[3]. However, there is interest in the causal relationship between education and health (e.g., [4]), because education can be improved through policy

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channels[5,6]. Education may be associated with health via adult socioeconomic status (e.g. income and occupation[4,7]), but also via health literacy and health behaviors[4,7-10] and sense of control and empowerment[11]. There is also the possibility of reverse causation, that children with health problems may attain less education[12] and that education modifies the effect of other social determinants of health, like income[13]. These general education and health trends may also apply to obesity.

Reviews of the relationship between socioeconomic status and obesity[14,15] include studies that use education as a proxy for socioeconomic status but conflate them with other measures of socioeconomic status when reporting findings, with only one review separately considering the socioeconomic status and obesity relationship by how socioeconomic status was measured (including education)[16]. Different socioeconomic measures[14,17] appear to have different relationships with weight change[18] and obesity[16]. No reviews to date have critically examined education as a conceptually unique predictor of obesity. Additionally, a substantial body of research has accumulated in the eight years since McLaren's review, which only included articles published between 1988 and 2004[16].

This paper systematically reviews the literature to examine the relationship between an individual's educational status and obesity: in particular, if an association (direct or inverse) exists and if there is evidence of a causal relationship in either direction, using any type of study design. This study is different from McLaren's[16] review in its search scope: we used additional databases (e.g., Cochrane Library, EconLit, IBSS, LILACS) in more languages (e.g., French, Portuguese, and Spanish) and include articles published before 1988 and after 2004 (in our review, 10 analyses were from articles published before 1988 and 203 analyses were from articles published after 2004); our search terms also identified articles that focused on educational status and may not have also been classified using a socioeconomic status-related keyword. This review is different from Parsons et al's study[14] primarily because we do not restrict studies to having two measures of obesity, one from childhood and one from at least one year later. This review also offers a substantive update to Sobal and Stunkard's 1989 review[15], given the burst of research conducted in the decades since, and because their article, like Parsons et al's[14] conflated all measures of socioeconomic status when reviewing the relationship between socioeconomic status and obesity. Given that education as a potential social determinant of obesity is of great policy relevance, an updated review dedicated particularly to education is needed.

Methods

In conducting and reporting the results of our systematic review, we relied upon guidelines established by consensus groups[19-21].

Inclusion and exclusion criteria

Research examining the relationship between educational status and obesity can be found in several fields: public health, psychology, education, and other social sciences (economics, sociology, and demography). As such, multiple databases were searched: PubMed, the Cochrane Library, and LILACS (public health), PsycINFO (psychology), ERIC (education), IBSS (International Bibliography of the Social Sciences), Social Sciences Citation Index, Social Services Abstracts, Sociological Abstracts, and EconLit. Cohen and Rai performed the literature searches. Table 1 shows the search terms used for each database and the corresponding number of papers collected on June 26, 2012 (note: many of these were duplicates), and figure 1 documents the flow chart of inclusion and exclusion. Cohen and Rai reviewed the abstracts and full papers for inclusion/exclusion decisions; when Cohen and Rai disagreed about inclusion/exclusion of a particular study, all four authors discussed until a consensus was reached. Articles in all languages were included in the search, and all articles that were in English, French, Portuguese, or Spanish were included in the literature review. In addition, for each of the articles deemed relevant from the systematic search, the reference lists for each article were also reviewed to identify any additional relevant articles that had not been picked up in the search, leading to the addition of 41 articles. All human participant populations and research designs were eligible for inclusion in the review. The time period for which studies needed to be done was limited only by the databases searched; we included articles in our review published from 1977 to 2012. Inclusion criteria were: peer-reviewed, measured an individual's own educational status (rather than parents' education), and there was variability in educational attainment and obesity within the study population (e.g., if no variation existed because all subjects were overweight[22], the paper would be excluded). If articles were not available through library or inter-library services, authors were contacted directly, with success (i.e., [23]).

Articles were excluded for several reasons. Despite efforts to include articles in non-English languages, we still had to exclude 9 articles that were in languages other than English, French, Portuguese, and Spanish: one Turkish[24], two Czech[25,26], two Polish[27,28], two German[29,30], and one Icelandic[31]. Other articles were excluded because they noted that education was an effect measure modifier (e.g., [32,33]) or confounder (e.g., [34]) of the relationship between an exposure of interest and obesity, or that obesity mediated the association between education and another outcome (e.g., [35]), but did not provide any information quantifying this effect. When our searches led us to narrative review articles that were related to a piece of our research question (e.g., [36]), we identified relevant articles from the references cited to include in our systematic review but did not include the review itself when reporting our findings.

Data abstraction

We used standardized data extraction forms and repeated coding of papers, as well as review of each entry by Cohen, to ensure intra- and inter-coder consistent abstraction. When papers reported several effect estimates for the same population, we abstracted the analysis that most closely estimated direct effects and adjusted for the largest number of covariates because this was typically the result the authors of the papers focused on and because we were interested in the extent to which the relationship between education and obesity persisted after controlling for both confounders and mediators. Body mass index or obesity (as defined by body mass index ≥30) was the preferred outcome if several measures of obesity were provided, but all measures of obesity and adiposity were acceptable.

Articles often reported effect estimates for several different study populations. If the paper stratified its results by year and/or country, we considered a “study population” to be year-specific and/or country-specific. These articles were split into as many data points as there were study populations, because each population had a unique estimation of the education-obesity relationship. For example, one paper[37] reported on data collected in 9 different countries, and so was split into 9 data points. Another article[38] reported on data from one country (Switzerland) that was collected in 1992, 1997, 2002, and 2007. This study stratified results by year, and was split into four data points (i.e., four study populations). Most notably, three papers[39-41] were split into 37, 34, and 19 data points, respectively. For qualities related to the study, we use the article as the unit of analysis (N = 289), but when characteristics vary within papers, our unit of analysis was the country-specific and year-specific study population (N= 410). This method is consistent with a related systematic review[16].

The relationships between education and obesity were coded as *directly associated* (as education increases, so does odds or risk of obesity), *inversely associated* (as education decreases, odds or risk of obesity increases), *null* (no statistically significant relationship observed between education and obesity (*P*<0.05)), or *U-shaped* (if there appeared to be a curved relationship to the data). This was done manually by Cohen and Rai in consultation, since different studies employed different variations of exposures and outcomes.

We developed a study quality score to acknowledge and account for the spectrum of analyses reviewed inspired by other systematic reviews[13,42-45] and refined for the specific context of these articles (for example, no apparent conflicts of interest were discerned, so this criterion was not used to differentiate articles), in an attempt to identify the highest quality articles from among those reviewed. A total score of up to 7 was possible, with points awarded as following: *high response rate* (1 point if response rate ≥70%, 0.5 if response rate 50-70%, 0 if response rate <50% or not reported); *nationally representative study population* (1 point; 0.5 points if clearly stated cohort but not necessarily externally valid to nation; 0 points if other or not reported); *large sample size* (1 point for n ≥10 000, 0.5 for 1000 ≤n<10 000, 0 if n<1000 or not reported); *weight measured by trained person* (1 point; 0 points if self-reported); *statistical test conducted* (1 point if analysis allowed for assessment of statistically significant associations; 0 points otherwise); *controlling for confounders* (1 point if controlled for any confounders or considered any effect measure modifiers in addition to gender; 0 if only did bivariate analysis); and *stratifying results by gender* (1 point if stratified results or specifically stated that a test had been done and gender was not an effect measure modifier in the population studied; 0 points if did not discuss).

Results

These 289 articles reported on 410 populations in 91 countries around the world, with each of the six populated continents represented (figure 2A identifies which countries were represented by at least one article, and figure 2B identifies countries based on number of articles).

The vast majority (92%) of the articles (N=289) included in this review were in public health and/or medical journals, with 7% from other social science journals (sociology, economics, education, or psychology) and 1% from other disciplines (e.g., transportation).

All of the studies were observational in design. The majority (88%) of the study populations (N=410) were cross-sectional (from one point in time, or pooled cross-sectional data from multiple time points). Ten percent had prospective longitudinal data, and the rest used case-control (<1%) or ecological (1%) designs. Studies on the subject of education and obesity became increasingly common in the 1990s and 2000s, with cross-sectional studies appearing to peak in the 1990s, and longitudinal studies becoming more common over time (data available upon request). The data in the cross-sectional studies span from 1969 to 2010, and the data in the longitudinal cohort studies collected data as early as 1946 and as late as 2008.

Education was measured in several ways, including years of educational attainment, degree completion (e.g., high school degree, college degree), and achievement in school. There were also several weight-related measures used in these papers, including body mass index (a continuous variable), overweight (typically, but not uniformly, measured as 25 ≤body mass index<30), and obesity (typically, but again not uniformly, measured as body mass index ≥30), as well as measures of skin-fold thickness and waist-hip ratio. A majority (64%) of the associations (N=410) used body mass index that had been measured by a trained observer (clinician, interviewer, etc) as compared to self-reported data. While the direction of the relationship between education and obesity in general was similar regardless of the specific measure used, some papers analyzed multiple measures (e.g., for education: years of education, degrees attained; for weight: continuous body mass index, categorical obesity, waist circumference, waist-hip ratio, percent body fat). Most papers found a consistent relationship between education and obesity that was robust to whichever measure of obesity[46-60] or education[61,62] was used. However, a few papers found different (and sometimes opposite) relationships depending on how obesity[17,63-65] and education[18,66] were measured. For example, the relationship between educational attainment and obesity sometimes differed depending on whether obesity was measured using body mass index cut-offs or waist circumference[63].

Many discussions of the relationship between education and obesity included hypotheses about potential confounders or effect modifiers. For these analyses, covariates that were explicitly included in analytic models and covariates that were implicit based on study design (e.g., cohort of white women aged 40-50 would be considered to include gender, race, and age as effect modifiers) were counted. A majority (91%) of the 410 country-year analyses included gender in their model as a confounder or effect measure modifier. Gender emerged as a clear effect modifier: 34.9% of the 232 country-year analyses that considered both genders reported different directions of the association between education and obesity depending on gender (e.g., inverse for one gender and null for the other, or positive for one gender and inverse for the other). Age was another common covariate included in analyses: 62% of the 410 country-year analyses included age in their model. However, there was much more variation in the other types of explanatory variables that were included as covariates in the analyses. We identified the following categories of potential confounders or effect modifiers. Only 26% of the 410 country-year analyses considered socio-economic factors, including income, wealth, and occupation. A similarly low percentage (16%) controlled for race or ethnicity, either as a confounder or effect modifier. Measures of region and urbanicity were included in 16% of analyses. Other potential confounders included parental factors (including parental education or socioeconomic status) (1%), and intelligence (2%). In attempts to understand only the direct relationship between education and obesity, sometimes mediators were also included in multivariate models. Health behaviors were sometimes included: 5% controlled for nutrition-related factors, 14% controlled for physical activity (work-related and/or leisure-time), and 30% included other health-related factors (often tobacco or alcohol use). Other potential mediators sometimes included were marital status (12%) and parity (5%). Twenty nine percent of analyses included additional covariates, including year of data collection, school absenteeism, religion, self-esteem, and number of people in the household. However, articles only used approximately 3 (mean=2.8, median=3, range: 0-9) domains of covariates in their analyses out of the several outlined here.

Studies varied substantially in quality, so we now focus on a sub-analysis of the studies we determined to be of highest quality. When we calculated our study quality score for each study, only 55 out of 410 study populations included in this systematic review scored a six or higher (locations mapped in figure 3; study details provided in table 2)[38,41,54,60,61,63,67-102].

Out of the 55 high quality study populations identified, the relationship between education and obesity varied by gender and by country. An inverse association between education and obesity was observed for women in Argentina[63], Australia[81,82] (although one[82] found no difference in obesity between high school graduates versus university graduates), Brazil[77,85], Canada[88], Chile[63], Czech Republic[98], Ecuador[63], Finland[54,96], Greece (although there was a null association between education and overweight)[78], Iran[92], Italy[41], Korea[60,75], Mexico[63,69,70], Norway[74], Peru[63], Portugal[41,61,73], Poland[98], Russia[98], Spain[71,90,93,97], Sweden[86], Switzerland[38,79], Thailand[68], one United Kingdom study[94], and the United States[89,91]. A null association was observed in Colombia[63], Germany[72], Papua New Guinea[83], another United Kingdom study[100], for non-Hispanic black women in the United States during some time periods[91], another United States study[95], and Venezuela[63].

A positive association between education and obesity was observed in Bahrain[80], India[87], and another Mexico study[103].

For men, there was much more variation, including within the same country. An inverse association was observed in Argentina[63], Australia[81,82], more developed regions of Brazil[85], Canada[88], Czech Republic[98], Finland[54,96], Iran[92], Italy[41], one Korea study[75], Norway[74], Poland[98], five Portugal studies[41,61,73,102], Spain[71,90,93,97], Sweden[84,86], Switzerland[38,79], one United Kingdom study[94], and the United States[89,91]. A null association was observed in less developed regions of Brazil[85], Chile[63], Colombia[63], Ecuador[63], Greece[78], Kuwait[67], Mexico[63,69,70,103], another Korea study[60], Peru[63], Russia[98], other United Kingdom studies[99,100], non-Hispanic black men in the United States[91], another United States study[95], and Venezuela[63]. Positive associations were observed in Bahrain[80], other Brazil studies[77], Germany[72], India[87], rural Mexico[69], Papua New Guinea[83], two other Portugal studies[76,101], and Thailand[68].

In addition to considering trends by quality, we also report trends by each study country's level of development. The association between educational attainment and obesity appeared to have a different direction depending on the economic development of the country for women and men (table 3): an inverse association was more common in studies of higher-income countries and a positive association was more common in lower-income countries. We observed similar trends among the subset of high-quality studies. Most of the studies have been done in higher-income countries, and there was only one high-quality study in a lower-income country.

Discussion

Our review agrees with other papers[16,39,63] that the relationship between measures of socioeconomic status like educational attainment and obesity depends on the country's level of development, such that inverse associations are more common in more developed countries and positive associations are more common in less developed countries. Furthermore, within countries, the relationship between educational attainment and obesity often appears to differ by gender such that the association is often further from the null among women (if the association is more inverse or more positive may depend on the level of development in the country), which also supports findings of previous reviews of socioeconomic status and obesity[16]. This also highlights the importance of considering how other measures of socioeconomic position at both the individual and area levels may modify the association between educational attainment and obesity.

Around the world, many studies have found an inverse relationship between educational attainment and obesity, although direct, null, and U-shape associations have also been observed. The whole set of the studies reviewed has similar trends as the subset of studies we identified as high quality, but we posit that the high-quality studies provide more informative and accurate point estimates of the association. We also note that only two "high quality" studies[83,87] were done of low-income countries (as defined by the World Bank), and only four studies[39,63,104,105] have been done in low-income countries in general (one of which[39] contributed thirteen country-year analyses).

The papers reviewed consistently identified gender as an a priori effect measure modifier, but other effect measure modifiers have not been as thoroughly investigated. For example, the potential of race/ethnicity was explored in only a few studies (and primarily in the United States) and merits further inquiry. One study[106] found a linear relationship between education and obesity for white women but a curvilinear relationship for black women. Such effect measure modification could occur if members of certain racial or ethnic groups received, on average, lower quality education[107]. Additionally, other measures of socioeconomic status—especially poverty—may modify the effect. A more pronounced education-obesity association was observed among lower occupations than higher-status occupations[54,108] and in high poverty school districts as compared to low-poverty districts[109]. This is aligned with Mirowsky and Ross's[11] hypothesis that education exhibits a greater effect when other socioeconomic resources are low. However, in more extreme poverty situations, nutrition and physical activity may have a role. In one study of women in multiple developing countries[39], a positive association was observed for the lower-income countries and an inverse association was observed among the higher-income countries. Differences in parity, which is associated with both educational attainment and obesity, by country's level of development could also play a role[110]. We also posit that there may be age, period, or cohort effects for the relationship between education and obesity. However, in order to systematically understand if these phenomena may be occurring, researchers will need to use similar analytic strategies across comparable populations within countries. For example, a closer look at the studies in Spain suggests that trends there have been relatively consistent across recent decades[111].

While the relationship between education and obesity appeared to be largely robust to the measures used, there were a few studies that found different results depending on how they measured education and/or obesity. It is possible that these different measures are capturing different underlying constructs. This could also suggest that the assumption of linearity for both obesity and education should be checked, and both linear models and non-linear models should be considered when modeling the relationship between education and obesity. This may be especially an issue when there is a particularly large range in educational attainment. For example, some studies noted that illiterate groups and highly educated groups had the lowest prevalence of obesity[112]; this is hypothesized to be due to different physical labor patterns among the illiterate and obesity-preventing health behaviors among the highly educated. Only a few studies considered the possibility of a U-shaped (non-linear) relationship between educational attainment and obesity, leaving open the possibility of other studies finding non-significant results due to incorrect functional form specification. This is a hypothesis that merits further exploration, especially since obesity may not be linearly related to other health outcomes, including mortality[113]. Empirical work has shown a stronger association with degree than years of education for mortality, but it is unknown whether this same relationship exists for obesity or body mass index[114].

We also encourage researchers to consider when obesity and educational attainment are measured: for example, one previous review has found a relatively weak association between childhood obesity and academic attainment,[309] whereas other prior reviews have focused on adult obesity and educational attainment.[14-16] Since the underlying causal processes for the education-obesity relationship likely differ between children and adults, we encourage future researchers with cohort studies to assess if different associations exist depending on whether obesity is measured in childhood, adolescence, or adulthood.

Two studies that analyze the same data with both ordinary least squares regression and fixed effects merit individual mention. When Lawlor et al[115] analyze their full cohort using standard regression, they find an inverse association between education and obesity, but when they analyze a subsample of their cohort to consider within-sibling pairs using fixed effects, they find a null association. In a study of adolescents with data at multiple time points over the course of their schooling[116], significant associations between education and obesity in ordinary least squares regression are null under fixed effects with the exception of the relationship between education and obesity among white females, for which an inverse (and larger) association remains. We encourage future researchers to use designs like these that attempt to control for unmeasured confounders to further understand the potentially causal relationship between educational attainment and obesity.

Self-reported weight and height data have been found to be systematically biased, with overweight and obese (as defined by measured body mass index) people more likely to underreport weight, certain gender and racial/ethnic groups more likely to overreport height, and those who were more highly educated more likely to underestimate weight[117]. Although several papers included in this review operated under the assumption that everyone would equally underreport weight and overreport height, thereby creating a bias towards the null, more recent evidence suggests this is an inappropriate assumption, and self-reported data should be calibrated to account for such potential biases[118,119].

Our systematic review identified twelve common categories of covariates for which different studies controlled, yet studies in our review only controlled for covariates from 2-3 of those categories on average. Some of the articles reviewed note that associations between education and obesity appeared to be explained away when additional confounders (e.g., childhood socioeconomic status[120]) were added to the model. Other sets of covariates, such as nutrition and physical activity (for which a small proportion of studies reviewed controlled), are likely mediators, and therefore are not needed to assess the total effect of education on obesity but are relevant for assessing the direct effect. Additionally, the relationship between intelligence and obesity has been reviewed[121], but intelligence and educational attainment are distinct concepts[122]. Yet intelligence and educational attainment are still very much related, and adjusting for intelligence when considering the role of educational attainment would add to the body of research. We encourage future researchers to acknowledge and attempt to measure a wide array of potential confounders in their future work. By doing so, we will be able to better understand the major hypothesized pathways linking education and obesity that these papers identified—via income/wealth and/or health behaviors—but that we were unable to quantify systematically due to the heterogeneity of the individual papers' analytic techniques.

Notably, we scored studies as being of “high quality” regarding confounders if they controlled for any covariates besides gender, since many studies did not comply with this simple measure. An additional stratum of papers only adjusted for age and gender. The relationship between educational attainment and obesity is likely to be confounded by a number of other characteristics, and we encourage researchers to include these in their future analyses to better understand the unconfounded relationship between educational attainment and obesity. The limited extent to which even the higher-quality papers controlled for confounding may help explain why the trends observed in table 3 did not vary dramatically between the subset of high-quality studies and the set of all studies.

We acknowledge several limitations to this study. Most importantly, the heterogeneity in the way articles measured education and obesity and reported measures of association hampered our ability to summarize across the studies beyond direction of association, especially since some of the measures of association may have reported total effects and others reported only direct effects. An additional issue when considering the studies that reported direct effects is that none adjusted for all possible mediators, and these analyses, which adjusted for mediators using more traditional approaches, could actually lead to additional sources of bias.[308] While expansive, our search strategy was also limited in two important ways. First, including articles in Portuguese especially but also Spanish and French widened the number of articles captured, but we were still forced to exclude articles in other world languages (Czech, German, Polish, Turkish, Icelandic). Second, some of the articles captured in our search of the reference lists of our original set of articles had used education as a measure of socioeconomic status but had discussed it purely within the context of socioeconomic status, never education, and were therefore not detected in our search teams, and it is possible that other articles remain undetected for this reason. For example, in PubMed, MeSH terms varied in ways that limited our ability to identify articles (for some[123,124], 'social class' was the relevant MeSH term; for others[106,125-127], the MeSH term used was 'socioeconomic factors'; one[128] had no MeSH terms referring to education or socioeconomic status, or had no MeSH terms listed at all[129]). Fortunately, this was relatively rare (only 13% of the articles included in our review were identified through references rather than through our search terms), likely in part due to our use of multiple databases and several combinations of key words, but this also emphasizes that education is sometimes considered to be no different from other measures of socioeconomic position in the public health literature. We also note that this approach may be biased against the inclusion of more recent papers[130] that did not have appropriate keywords to be captured in our systematic search and were not yet cited in other papers we reviewed to be captured through searching references but nevertheless provide information on educational attainment and obesity.

Limitations aside, we note that education as a social determinant of obesity has clinical relevance. Cutler and Lleras-Muney[7] note that the education gradient in health may be strongest when there are known methods to prevent or treat the health outcome. Given that obesity is a widely prevalent[131] and widely-recognized health problem with well-known prevention approaches, it follows that a strong gradient is likely. For example, one study found that receiving dietary information as a way to reduce obesity was more effective among those with a higher education[132]. Alternatively, socioeconomic status may mediate the education-obesity relationship; most studies have not isolated the effects of education separately from other socioeconomic measures, including measures of income that may also be associated with obesity[133].

Conclusion

Our systematic review has highlighted a major gap in the extensive literature studying the relationship between educational attainment and obesity: while many studies account for gender and age, a majority fail to adjust for other potential confounders and effect modifiers, such as race/ethnicity, that may influence results. Only 10% of articles reviewed (N=289) fully or almost fully met our seven criteria for quality. However, there appears to be movement in the right direction: 76% of the study populations we scored as high quality (N = 55) in our review were published in 2005 or later. However, most of these high-quality studies controlled for a small and basic set of confounders. Future studies considering social determinants of obesity should include a wide array of covariates, including other measures of socioeconomic position and a wider range of potential mediators, along with more advanced mediation analysis techniques (e.g., [308]) to better elucidate the direct and indirect effects of educational attainment on obesity.

Others have called for better understanding the causal nature of social determinants of health[2]. There are many possible mechanisms by which educational attainment may affect health outcomes, and these mechanisms may change over time[134]. Policy interventions could range from mandatory schooling policies[135] to increasing educational quality[107]. Innovative causal modeling work has begun to be done looking at the relationship between education and health status (e.g., [4,10]), but a comparable body of literature does not yet exist considering the relationship between education and obesity based on the studies reviewed here.

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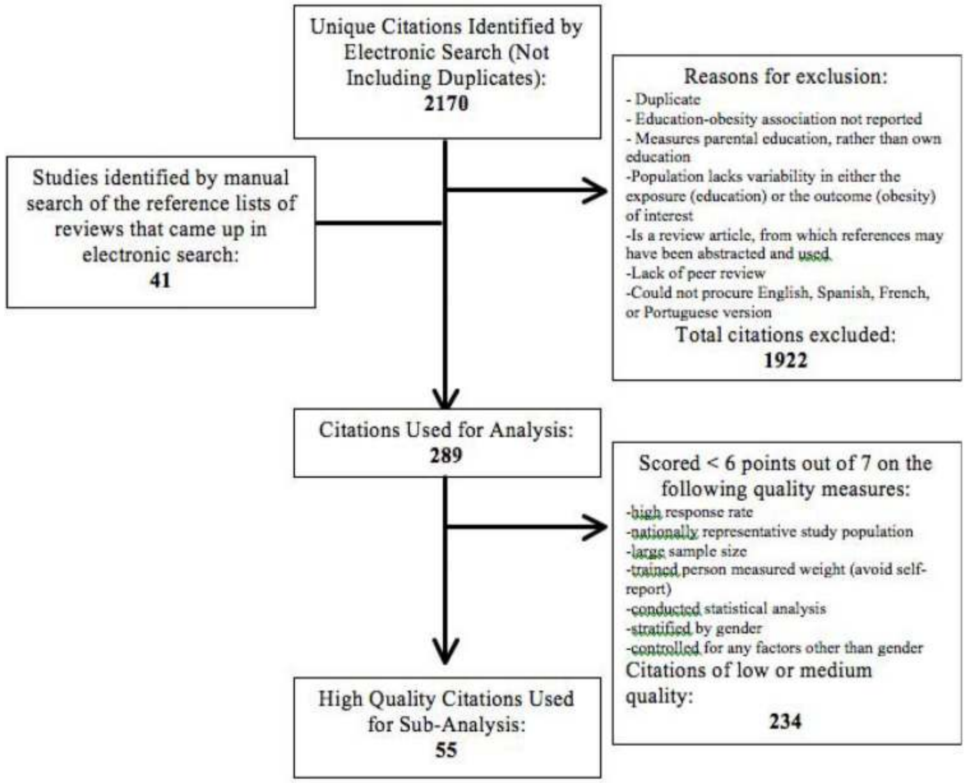

Figure 1.

Flow chart of inclusion and exclusion of articles collected in systematic review.

Figure 2A.

Articles from 91 countries (shaded) were included in this systematic review. Note: the following countries were represented by the following studies: Albania[136], Argentina[63,137], Australia[81,82,123,138-140], Austria[37], Bahrain[80], Bangladesh[105], Belgium[37,40,41,48,127,141], Benin[39], Bolivia[39,104], Botswana[142], Brazil[39,77,104,143,144], Burkina Faso[39,145], Cameroon[39], Canada[88,146-153], Central African Republic[39], Chile[63,154], China[39,40,155,156], Colombia[39,63,104,157], Cote d'Ivoire[39], Croatia[158], Czech Republic[40,41], Denmark[37,40,41,51,159-161], Dominican Republic[39,104], Ecuador[63], Egypt[39], Estonia[41,162], Finland[37,40,41,46,62,96,120,124,161-171], France[40,41,172-177], Germany[40,41,72,178,179], Ghana[39,145,180], Greece[37,64,181], Guatemala[39,104], Haiti[39,104], Honduras[104], Hungary[41], Iceland[40,182], India[39,126,183], Iran[59,87,92,112,128,184-187], Ireland[37,41], Israel[188], Italy[37,40,41,189], Jamaica[190], Japan[191], Jordan[39], Kazakhstan[39], Kenya[39,145], Kuwait[67,192], Kyrgyzstan[39], Latvia[41], Lithuania[41,162], Madagascar[39], Malawi[39,145], Malaysia[193], Mali[39], Mexico[39,63,69,70,103,104,194,195], Morocco[39,196,197], Namibia[39], Netherlands[41,50,198-202], New Zealand[203], Niger[39,145], Nigeria[39,204], Norway[41,74,205], Papua New Guinea[83], Peru[39,63,104,206], Poland[40,207-210], Portugal[37,41,61,73,211,212], Russia[40,213,214], Saudi Arabia[215-217], Senegal[39,145], Singapore[218], Slovakia[41], South Africa[39,219], South Korea[60,75], Spain[23,37,40,41,49,52,56,71,90,93,97,220-231], Sri Lanka[232], Sweden[40,41,84,129,233-241], Switzerland[38,40,55,79,108,242], Tanzania[39,145], Thailand[243], Tunisia[197], Turkey[39,244-246], Uganda[39], United Arab Emirates[247], United Kingdom[40,41,66,94,100,248-253], United States[7,40,47,57,65,91,95,104,106,125,191,194,254-303], Uzbekistan[39], Venezuela[63], Vietnam[39,304,305], Yugoslavia (at the time of the study)[40], Zambia[39], Zimbabwe[39].

Figure 2B.

Countries are shaded darker in proportion to how many articles in this systematic review included data from that country. Note: the number of data points for each country ranged from 0 to 76 (United States).

Figure 3.
The countries represented by the highest quality analyses (n=55); countries shaded darker in proportion to number of high quality analyses. The number of studies each country represented had ranged from 1-6.

Table 1

Databases searched, search terms used, and articles collected.

Database	Search term	Number of articles
Public health		
PubMed	Educational Status[Mesh] AND “Overweight ” [Mesh]	953
	Educational Status[Mesh] AND “Obesity ” [Mesh]	904
LILACS	[MH]“educational status” and [MH]“OVERWEIGHT”	6
	[MH]“educational status” and [MH]“OBESITY”	31
Cochrane Library	“educational status” AND “obesity” (in Title, Abstract, or Keywords)	22
	“educational status” AND “overweight” (in Title, Abstract, or Keywords)	6
Psychology		
PsycINFO	DE=(“educational attainment”) AND DE=obesity	20
	DE=(“educational background”) AND DE=obesity	10
Education		
ERIC	DE=(“educational attainment”) and DE=obesity	28
	DE=(“educational background”) AND DE=obesity	1
Social sciences		
IBSS	DE=(educational status) and DE=obesity	0
	DE=(“educational attainment”) and DE=obesity	0
	DE=(“educational attainment level”) AND DE=obesity	0
	DE=(“educational level”) and DE=obesity	0
Social Sciences Citation Index	Topic=(“educational status”) AND Topic=(obesity)	33
	Topic=(“educational attainment”) AND Topic=(obesity)	111
Social Services Abstracts	DE=(“educational attainment”) and DE=obesity	2
Sociological Abstracts	DE=(“educational attainment”) and DE=obesity	9
EconLit	DE=education and DE=obesity	34

Table 2

Characteristics of high-quality studies

Country	Association observed (women)	Association observed (men)	Study population	Sample size	Response rate	Height and weight measured by trained personnel	Covariates in model	Stratified results by gender	Conducted statistical test
High-income economies									
Australia[81]	-	-	Systematic random sample of adults in each regional capital	19 315	75%	Y	Age	Y	Y
Australia[82]	-	-	Adults from randomly selected districts across the country	10 347	67% of those eligible completed initial survey; 55% of those surveyed were weighed	Y	age, smoking status, physical activity, television viewing, country of birth, weekly income, occupation skill level	Y	Y
Bahrain[80]	+	+	National systematic sample	2013	70%	Y	Age	Y	Y
Canada[88]	-	-	Multistage stratified cluster random sample of all non-institutionalized, civilian, not living in an Indian reserve Canadian adults	7590	76.50%	Y	Age	Y	Y
Czech Republic[98]	-	-	population based random sample of adults; baseline data of a longitudinal study	7081	not reported	Y	Age	Y	Y
Finland[96]	-	-	nationally representative sample of adolescents; pooled, repeated cross sectional	at least 42,000	66-88%	N	age, survey year	Y	Y
Finland[54]	-	-	Random sample of adults from Finland national population register	24 604	79.50%	Y	area, birth cohort	Y	Y
Germany[72]	0	+	German microcensus (1% of all Germans; participation is mandatory)	61 892	100%	N (self-report)	age, German nationality, state and cohort fixed effects	Y	Y
Greece[78]	-	0	Stratified random sample of all families with adolescents attending public schools	16 073	78.30%	Y	age	Y	Y
Italy[41]	-	-	population based random sample of adults	41,613	90%	N	age	Y	Y
Korea (South)[75]	-	-	Cluster random sample of Korean adolescents	60 643	94.80%	N (self-report)	grade level, physical activity (vigorous, moderate), sedentariness, diet (fruit, milk, fast-food, soft drink, routine breakfast consumption), weight control behavior, smoking, perceived stress, depressed mood, paternal education, maternal education, family affluence, subjective family economic status	Y	Y
Korea (South)[60]	-	0	Korean National Health and Nutrition Examination Survey (census-based sampling frame)	7962	90.80%	Y	age, area of residence, marital status, smoking, alcohol consumption, percentage of energy intake from fat, exercise, income	Y	Y
Kuwait[67]	n/a	0	Multistage cluster random sample of fifth-grade males in male public schools in all regions	1066	87.90%	Y	maternal educational attainment, paternal educational attainment, nationality	Y	Y
Norway[74]	-	-	Secondary data from multiple sources from multiple regions of the country	94 078	70%	Y	age	Y	N
Poland[98]	-	-	population based random sample of adults; baseline data of a longitudinal study	9170	not reported	Y	age	Y	Y

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Country	Association observed (women)	Association observed (men)	Study population	Sample size	Response rate	Height and weight measured by trained personnel	Covariates in model	Stratified results by gender	Conducted statistical test
Portugal[306]	n/a	+	military census of adult males	70858	100%	Y		Y	Y
Portugal[61]	-	-	Multistage proportional stratified sample nationwide	8116	80%	Y	age, civil status, gender, professionally active	Y	Y
Portugal[73]	-	-	National Health Survey	112 540	82%	N (self-report)	age, survey year	Y	Y
Portugal[41]	-	-	national population based random sample of adults	12297	80%	N	age	Y	Y
Portugal[102]	-	-	nationally representative sample of adults	20977 women, 18663 men	82%	0	age, physical activity, and potentially smoking	Y	Y
Portugal[76]	n/a	+	Mandatory examination of all males (for military service)	850 081	100%	Y	year of examination	Y	Y
Spain[71]	-	-	ENRICA study (representative of adult non-institutionalized population)	12 883	51%	Y	age	Y	Y
Spain[93]	-	-	national population based random sample of adults	30040	81%	0	physical activity at work, leisure time physical activity, tobacco consumption, presence of chronic condition, age, marital status, size of municipality of residence, time (1987 or 1993)	Y	Y
Spain[97]	-	-	population based random sample of adults in Murcia region of Spain	3091	61%	Y	age, employment situation, type of residence	Y	Y
Spain[90]	-	-	Random sample from official census population register	1200	80%	Y	age, marital status (for women, they also adjusted for frequent drinking, work related physical activity, and leisure physical activity)	Y	Y
Sweden[84]	-	-	national population based random sample of adult men	752283	67%	Y	intelligence, height, parental education, parental socioeconomic position, country of birth, conscription center, municipality	Y	Y
Sweden[86]	-	-	Stratified random sample of adults in one rural community	3365	75%	Y	age, leisure-time physical activity	Y	Y
Switzerland[307]	-	-	systematic population based random sample of major city	6635 men, 6558 women	57-65%	Y	age	Y	Y
Switzerland[38]	-	-	national population based random sample	53588	71%	0	age, year of survey, inflation-adjusted household income terciles, occupational class	Y	Y
Switzerland[79]	-	-	Population-based two-stage cluster sample in one region	5240	82%	Y	age	Y	Y
United Kingdom[100]	0	0	Population based systematic sample	8490	51%	Y	for OR's, included childhood variables (height at 10 years, maternal and paternal body mass index z scores, maternal education, and social class) and adult variables (height and social class) as potential confounding factors.	Y	Y
United Kingdom[99]	-	0	middle aged Caucasian sample, external validity possible	4598	73%	Y	obesity-related health behaviors: diet, physical activity, alcohol consumption, (ethnic minorities- excluded to avoid	Y	Y

Country	Association observed (women)	Association observed (men)	Study population	Sample size	Response rate	Height and weight measured by trained personnel	Covariates in model	Stratified results by gender	Conducted statistical test
							confounding), socioeconomic position in adulthood (employment grade), smoking		
United Kingdom[94]	-	-	middle aged Caucasian sample, external validity possible	4598 (3364 men and 1234 women)	73%	Y	0	Y	Y
United States[91]	- (0 for black women)	- (0 for black men)	National Health Examination and Nutrition Survey	21 504	(missing)	Y	race/ethnicity	Y	Y
United States[95]	0	0	nationally representative sample of children in 4th year of school	13 680	not reported	Y	SES (family income, parents' education, parents' occupation), maternal education, race/ethnicity	Y	Y
United States[89]	-	-	National Health Examination and Nutrition Follow-up Survey	4836	76%	Y	race, family income, marital status, age, BMI at baseline, smoking, physical activity, parity, rural or urban background, region of the country	Y	Y
Upper-middle-income economies									
Argentina[63]	-	-	Population-based sample in capital city	1482	66%	Y	age	Y	Y
Brazil[77]	-	+	Multistage nationwide random sample	54 353	74.50%	N (self-report)	age, marital status, physical activity, overweight status at age 20	Y	Y
Brazil[85]	-	- in more developed/0 in less developed	Probabilistic multistage stratified cluster random sample from northeastern and southeastern regions	9397	85%	Y	age, ethnicity, urban or rural status, income, region's developmental level	Y	Y
Brazil[101]	-	+	repeated cross sectional nationally representative random sample	89771 in 1975, 14602 in 1989, 11033 in 1997	not reported	Y	age (categorical- age ranges), region (Northeast or Southeast), and residential location (urban or rural)	Y	Y
Chile[63]	-	0	Population-based sample in capital city	1655	64%	Y	age	Y	Y
Colombia[63]	0	0	Population-based sample in capital city	1553	64%	Y	age	Y	Y
Ecuador[63]	-	0	Population-based sample in capital city	1638	61%	Y	age	Y	Y
Iran[92]	-	-	population based random sample in major city	300	90%	Y	physical activity	Y	Y
Mexico[69]	-	0 (+ for rural areas)	Probabilistic stratified multistage cluster sampling design with oversample of rural areas (national sample)	14 280	71%	Y	Age, early life social experience (toilet at age 12, born in city, stunted growth)	Y	Y
Mexico[63]	-	0	Population-based sample in capital city	1722	74%	Y	age	Y	Y
Mexico[103]	+	0	random sample of adults; representative of poorest sector of country	12873 (2015 men, 6778 women in full model)	not reported	Y	occupation, housing conditions, household assets, household income, subjective social status	Y	Y
Mexico[70]	-	0	Representative sample of Mexicans (ENSA study)	38 901	86%	Y	Urban/rural residence, household assets	Y	Y
Peru[63]	-	0	Population-based sample in capital city	1652	64%	Y	age	Y	Y
Russia[98]	-	0	population based random sample of adults; baseline data of a longitudinal study	9231	not reported	Y	age	Y	Y
Thailand[243]	- (not reported separately by gender)		random sampling of children in grades 3-6 in major city	1794	not reported	Y	gender, age, grades within the school itself, parental and family factors	N	Y

Country	Association observed (women)	Association observed (men)	Study population	Sample size	Response rate	Height and weight measured by trained personnel	Covariates in model	Stratified results by gender	Conducted statistical test
Thailand[68]	-	+	National multistage stratified cluster sample	22 531	79%	Y	Age, smoking status, marital status, geographic region	Y	Y
Venezuela[63]	-	0	Population-based sample in capital city	1848	90%	Y	age	Y	Y
Lower-middle-income economies									
India[87]	+	+	Within Mumbai, non-random selection of primary sampling unit (polling station); assumed complete electoral rolls	99 598	99%	Y	Age, tobacco use	Y	Y
Papua New Guinea[83]	0	+	national population based random sample of adults	1877	rates reported by community and gender, ranged from 46.8-88.5%	Y	type of housing, age, years in urban center, physical activity	Y	Y

Legend: - for inverse association, + for direct association, 0 for null (not statistically significant) association, n/a for not applicable (some studies were restricted to one gender). Y for yes, N for no.

Note: All of the papers in this table relied on self-reported educational attainment. The World Bank's economic classifications were used to organize the countries (see http://data.worldbank.org/about/country-classifications/country-and-lending-groups for full list). The World Bank also has a low-income economies category, but our review had no high-quality studies of education and obesity in low-income economies.

Table 3

Analyses of women

	High-income countries		Upper-middle-income countries		Lower-middle-income countries		Low-income countries	
	High-quality (n=18)	**All (n=203)**	**High-quality (n=12)**	**All (n=60)**	**High-quality (n=1)**	**All (n=24)**	**High-quality (n=0)**	**All (n=15)**
Inverse association	89%	87%	92%	77%	0%	13%	n/a	7%
Null association	6%	12%	8%	17%	0%	21%	n/a	0%
Positive association	6%	1%	0%	7%	100%	67%	n/a	93%
Analyses of men								
	High-income countries		Upper-middle-income countries		Lower-middle-income countries		Low-income countries	
	High-quality (n=20)	All (n=196)	High-quality (n=12)	All (n=37)	High-quality (n=1)	All (n=4)	High-quality (n=0)	All (n=0)
Inverse association	70%	64%	17%	19%	0%	0%	n/a	n/a
Null association	15%	29%	67%	62%	0%	50%	n/a	n/a
Positive association	15%	5%	17%	19%	100%	50%	n/a	n/a
Curvilinear (U-shaped) association	0%	2%	0%	0%	0%	0%	n/a	n/a

n/a means not applicable

Note: percents may not add up to 100% due to rounding.