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Health Literacy, Social Cognition Constructs, and Health Behaviors and Outcomes: A Meta-Analysis

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Abstract

Objective: Observed disparities in health behaviors and outcomes may be associated with socio-structural variables and individuals' beliefs concerning health behaviors. We proposed and tested a model in which effects of health literacy, an independent predictor, on two target outcomes, health behavior participation and health-related outcomes, were mediated by belief-based constructs from social cognition theories.

Method: Studies (*k*=203, *N*=210,622) reporting relations between health literacy, social cognition constructs (attitudes, self-efficacy, knowledge, risk perceptions), and health behaviors and outcomes were identified in a systematic database search. Relations among proposed model variables, including indirect effects of health literacy on health behavior and outcomes mediated by social cognition constructs, were tested using random effects multi-level meta-analysis and meta-analytic structural equation modeling.

Results: The analysis revealed non-zero averaged correlations between health literacy, social cognition constructs, and health behavior and outcomes with small-to-medium effect sizes. Structural equation modeling indicated that self-efficacy and attitudes partially mediated the relationship between health literacy and health behavior and outcomes. Sensitivity analyses revealed that model effects did not vary substantively when omitting studies targeting health risk behavior, studies using comprehension measures of health literacy, and studies in countries with high education provision.

Conclusion: Findings indicate that relations between health literacy and health behavior and outcomes are partly accounted for by health behavior beliefs suggesting a potential mechanism by which health literacy may relate to health behavior and outcomes. Given these findings are based on correlational data, further corroboration is needed in studies adopting longitudinal or experimental designs.

Keywords: health literacy; health behavior; self-efficacy; attitudes; meta-analytic structural equation modeling

Health Literacy, Social Cognition Constructs, and Health Behaviors and Outcomes: A Meta-Analysis

Health literacy, a socio-structural variable defined as the degree to which individuals have the capacity to obtain, process, and understand basic health information (Baker et al., 2006), has been linked with poorer health outcomes including increased risk of chronic disease and higher rates of mortality (Mayberry et al., 2018; Peterson et al., 2011; Wolf et al., 2005). Individuals with 'adequate' health literacy possess competency to comprehend and utilize health information when making health-related decisions, while those with 'inadequate' health literacy have difficulty understanding and acting on health information (Beauchamp et al., 2015; Sentell et al., 2014). Although health literacy often correlates with other socio-structural variables associated with disparities in health outcomes (e.g., socioeconomic status, education level), it explains unique variance in outcomes when controlling for the effects of these other variables (Chang, 2011; Wolf et al., 2005). Inadequate health literacy is, therefore, considered an independent correlate of poor health outcomes and a risk factor for health disparities.

Inadequate health literacy is also associated with lower levels of health behavior participation (e.g., physical activity, healthy eating, refraining from smoking, drinking alcohol only in moderation), increased chronic disease risk, and poorer health outcomes (Cha et al., 2014; Husson et al., 2015; Lim et al., 2021; Zhang et al., 2014). Analogously, research has demonstrated that relations between inadequate health literacy and health outcomes is mediated by health behaviors participation (Mayberry et al., 2018; Stringhini et al., 2010). This means that observed poorer health outcomes among individuals with inadequate health literacy can be partially attributed to deficits in health behavior participation. These data have catalyzed interest in research focused on identifying the mechanisms by which health literacy relates to health behaviors and health outcomes with the goal of developing an evidence base that may inform interventions aimed at addressing observed disparities in health behavior participation and health outcomes (Hagger, Cameron et al., 2020; Hagger, Moyers et al., 2020).

A candidate mechanism that may explain the effect of health literacy on health behavior participation relates to the role of individuals' beliefs regarding their future performance of health behaviors. This potential mechanism stems from research demonstrating that behavior-related beliefs partially mediate effects of socio-structural variables on participation in health behaviors (Godin et al., 2010; Hagger & Hamilton, 2021; Orbell et al. 2017). This research demonstrates that disparities in health behavior participation, as indicated by effects of socio-structural variables that represent disparity (e.g., socio-economic status, education), on behavior participation are partially explained by beliefs directly implicated in their decisions to participate in health behavior. These data have been generated in research integrating socio-structural constructs in tests of social cognition theories, a preeminent approach to examining belief-based health behavior determinants, to identify candidate belief-based mediators of the effects of socio-structural variables on behavior (Godin et al., 2010; Hagger & Hamilton, 2021; Orbell et al., 2017). In the current research, we extended this approach to investigate a potential mediating mechanism for health literacy effects on health behavior and health outcomes in a meta-analytic synthesis of studies reporting data on these effects. Our analysis is expected to yield important information that may inform strategies to manage disparities in health behavior participation attributable to inadequate health literacy, and, ultimately, promote better health outcomes.

Social Cognition Theories and Health Behavior Determinants

Social cognition theories have been featured prominently in research aimed at identifying candidate determinants of health behavior and the processes involved. A key assumption of these theories is that individuals' beliefs regarding a given target health behavior are instrumental in forming their intention toward, and actual participation in, the behavior in the future (Conner & Norman, 2015; Fishbein et al., 2001). A number of social cognition theories have been applied to predict behavior in health contexts such as the health belief model (Rosenstock, 1974), the theory of planned behavior (Ajzen, 1991), and the health action process approach (Schwarzer, 2008). Meta-analyses of research applying these theories have demonstrated consistent associations between social cognition constructs such as attitudes, self-efficacy, social norms, and risk perceptions with health behavior intentions and participation (e.g., Brewer et al., 2007; Sheeran et al., 2016; Zhang et al., 2019). Importantly, a key assumption of these theories is that effects of extraneous contextual (e.g., availability of resources) and intrapersonal (e.g., personality) variables on health behavior participation are accounted for by belief-based behavioral determinants because those extraneous variables have an informational function. That is, individuals' estimates of their beliefs regarding future performance of health behaviors are, in part, informed by their context and intrapersonal dispositions, and they estimate their beliefs and intentions toward future behaviors, and enact subsequent behavioral responses accordingly.

Extending this assumption, researchers have adopted social cognition theories to provide a mechanistic explanation of relations between the socio-structural variables that indicate disadvantage and health behavior participation. This is predicated on the premise that observed variability in health behavior participation and health outcomes in underserved populations may be a function of the beliefs individuals in these populations hold about health behaviors. For example, disadvantage represented by lower socioeconomic status or education level has been shown to be related to individuals' perceptions of the health risk associated with not engaging in a particular health promoting behavior, or to their perceived efficacy of the behavior in promoting health outcomes (Adams et al., 2013; Orbell et al., 2017). These effects may indicate that individuals from disadvantaged groups have limited access to information concerning, or means to engage in, health behaviors, which manifest in their beliefs with respect to future health behavior participation (e.g., risk perceptions, beliefs regarding health behavior efficacy) and, ultimately, their behavioral enactment. These findings imply a mechanism by which social cognition variables account for the relationship between socio-structural variables representing disparity and health behavior participation (McKinley et al., 2020).

Consequently, researchers have proposed models in which relations between socio-structural variables and health behavior participation are mediated by social cognition constructs (e.g., Hagger & Hamilton, 2021; Orbell et al., 2017). For example, Orbell and colleagues demonstrated that relations between membership of minority South-Asian ethnic groups and colorectal cancer screening attendance was mediated by self-efficacy beliefs and the perceived costs. Individuals from these groups may have lower perceived capacity and higher perceived costs due to their experience of disenfranchisement from the healthcare system, and concerns over stigma and employment loss, as a result of their screening participation. Similarly, Hagger and Hamilton (2021) demonstrated that effects of socioeconomic status on health behavior participation were mediated by perceived behavioral control. Individuals from economically disadvantaged backgrounds may perceive they have lower capacity to perform health behaviors through lack of prior experience of success or positive reinforcement. These studies offer initial support for candidate mechanistic explanations for observed disparities in health behavior.

Mediators of Health Literacy Effects on Health Behavior

Extrapolating these findings, social cognition constructs may also offer a potential explanation for the association between inadequate health literacy and lower health behavior participation and poorer health outcomes. Individuals with inadequate levels of health literacy may hold beliefs associated with reduced propensity to participate in health behavior, reducing their likelihood of participating in those behaviors in future (Adams et al., 2013; Peterson et al, 2007). For example, individuals with inadequate health literacy may lack the knowledge or skills to interpret risk-related information such as information linking health with behavior (e.g., linking foods labeled high in dietary fat or sugar with heart disease risk). This will then be reflected in their evaluations of risk (e.g., risk perceptions) and utility (e.g., attitudes) with respect to their dietary choices. Consistent with theory, these beliefs will be implicated in their decisions to participate in dietary behaviors. Long term, this may also impact health outcomes (e.g., heart disease risk). We therefore propose a mediational model in which the effect of health literacy on health behavior and health outcomes is mediated by belief-based constructs from social cognition theories.

Few studies to date have formally studied the potential for social cognition constructs to mediate effects of socio-structural variables that indicate disparity, such as health literacy, on health behavior participation and outcomes. However, an emerging body of research has tested associations among health literacy, social cognition constructs, and health behavior participation and outcomes. For example, Adams and colleagues (2013) demonstrated that relations between health literacy and participation in health behaviors (cigarette smoking, fruit and vegetable consumption, physical activity) were mediated by risk perceptions. This affords the opportunity to address this knowledge gap by synthesizing correlations among the variables from these studies and using them to evaluate the tenability of our proposed mediation model using meta-analysis. The value of this research lies in its potential to demonstrate empirically the potential for social cognition constructs to provide a mechanistic explanation for the effect of health literacy on health behavior and health outcomes.

The Present Study

The purpose of the present study was to synthesize relations among health literacy, social cognition constructs, and health behaviors and outcomes using meta-analysis, and use the synthesized relations among these constructs to test our proposed model in which effects of health literacy on health behavior and outcomes are mediated by social cognition constructs. Our analysis was conducted in two stages. In the first stage of our research, correlations among health literacy, social cognition constructs, and health behaviors and outcomes across studies were synthesized using meta-analysis. To do so, we conducted a systematic literature to identify studies that included measures of health literacy, social cognition constructs, and health behaviors and outcomes. Next, we extracted effect size data for relations among these variables from the identified studies and estimated averaged bias-corrected correlations among them using meta-analysis. We hypothesized non-zero correlations among health literacy, social cognition, health behavior and health outcomes. Finally, we evaluated the predictions of our proposed mediation model using the synthesized correlation matrices among health literacy, social cognition, health behavior and health outcomes using meta-analytic structural equation modeling. The proposed model is presented in Figure 1a.

We also assumed that studies included in the proposed analysis were likely to have been conducted in multiple behaviors and populations, and to have adopted different measures of study variables. As a consequence, we expected substantive heterogeneity in effects among the constructs and variables in the proposed model across studies. We therefore aimed to investigate effects of a series of candidate moderator variables on model effects to evaluate the extent to which they might resolve the expected heterogeneity. Candidate moderators were: behavior type, behavior measure type, sample education level, and type of health literacy scale used. We expected model effects may vary according to behavior type given previous research that has indicated variation in associations between health literacy and behavior associations (Levin-Zamir et al., 2016), and between social cognition constructs and health behavior and outcomes (Sheeran et al., 2016), across behaviors. However, we still expected the pattern of model effects to generalize across behaviors, consistent with the premises of social cognition theorists (e.g., Ajzen, 1991). As the numbers of studies for specific behaviors was expected to be low, we classified studies into broad health risk (e.g., smoking, alcohol consumption) or health promoting (e.g., physical activity, screening behaviors) behaviors for the purposes of this analysis. Consistent with the broader research on health behaviors, we also expected studies to use a broad range of behavior measures, including previously-validated instruments with good psychometric integrity (e.g., The Health Behaviors Questionnaire, the Morisky Medication Adherence Scale) as well as idiosyncratic, bespoke measures with little or no prior validity data (e.g., single-item behavior measures: “How often do you brush your teeth?”). Use of such measures may introduce substantive method variance in research examining relations between behavior and other outcome variables, and result in an attenuation of effect size estimates. We therefore hypothesized that behavioral effects involving behavior in studies adopting validated behavior measures would be larger relative to those adopting bespoke measures.

We also tested whether sample education level, indicated by national education statistics from the study country of origin, would moderate model effects. Those with lower education levels were expected to attach less value to health behavior as they may have lower expectations of risk or knowledge of perceived benefits (Beauchamp et al., 2015). In addition, we tested the effect of health literacy measure type on model relations, as different measures have been shown to have varying effects on health outcomes (Rudd, 2015). We expected health literacy measures focused on individuals' estimates of their confidence in responding to health information would exhibit larger effects of health literacy on social cognition constructs and health behaviors and outcomes across studies compared to measures testing health knowledge. This pattern was expected because confidence measures are more likely to align with beliefs such as attitudes and self-efficacy with respect to performing the behavior in future. Finally, we controlled for effects of key demographic and study design covariates in our model tests: sample gender and age, sample type (clinical or non-clinical), study design, and study quality.

Method

Transparency and Openness

In this article, we followed PRISMA guidelines for conducting systematic reviews and meta-analyses (Page et al., 2020). Our review was pre-registered on the *Prospero* database of systematic reviews (#CRD42020177315). We provide supplemental materials that include the following: search strings for our database searches; a completed PRISMA checklist; a diagram summarizing the flow of articles through the search and screening procedures; additional details on methods used in data analysis; a summary table of included study characteristics and moderator variable coding; the study quality checklist used and its description with a table listing scores for each of included study; results of the multi-level multivariate meta-analysis; results of our sensitivity analyses for our meta-analytic structural equation models; results of our publication bias analyses for our multi-level meta-analysis; and results of multi-level meta-analytic structural equation model. Data files and data analysis scripts and output for each analysis are archived online: https://osf.io/va8zs/.

Search Strategy and Study Selection

We searched four digital databases (PubMed, Web of Science, Scopus, PsycInfo) for articles reporting associations among health literacy, social cognition variables (i.e., health beliefs), health behavior, and health outcomes. In addition to the database searches, reference sections of other health literacy meta-analyses were searched to ensure all relevant articles had been identified. We also contacted prominent authors in the field to request additional data for inclusion in our analyses. In response, we received some recently published datasets, but no unpublished data.

The initial pool of articles was screened for duplicates by four researchers. After duplicates (k = 9,222) were removed, the remaining pool of articles (k = 14,077) was screened according to title and abstract screening protocols. Articles remaining after title and abstract screening were subjected to a full-text screening by two researchers to examine their eligibility against a full-text inclusion criterion. Screening protocols were validated by having each researcher screen of a sub-set of the articles according to protocol and estimating agreement. At each stage, agreement between researchers was good (average Cohen's κ = .85). Disagreements were discussed and resolved among the group of researchers, and the screening protocol updated accordingly. When the researchers identified articles that satisfied inclusion criteria but did not report sufficient data to compute effect sizes for analysis, article authors were contacted by email to request the relevant data.

Inclusion Criteria

Studies were included in the current analysis if authors reported associations between a measure of health literacy and a measure of a social cognition construct, health behavior, or health outcome (e.g., health status, health related well-being). Health literacy measures were included if assessed using a valid scale. Studies utilizing proxy measures of health literacy (e.g., education level, socioeconomic status) were excluded. Qualitative studies, reviews including narrative and conceptual reviews, systematic reviews, and meta-analyses, study protocols, and editorials were excluded.

Included Studies and Study Characteristics

Article search and screening processes identified 365 articles meeting inclusion criteria. Articles (k = 162) that did not report sufficient data to compute effect sizes for analysis and for which data from study authors were unavailable were excluded, leaving 203 articles eligible for analysis. A number of studies reported data from multiple studies or samples, yielding additional independent samples for analysis (k = 6). The final pool of studies consisted of 209 samples and an overall sample size of 210,622. Behaviors were grouped into health promoting (k = 180; e.g., physical activity, screening behaviors) or health risk (k = 45; e.g., smoking, alcohol consumption) behaviors. Sixty-five percent of studies reported samples with approximately equal proportions of men and women, with 30% comprised predominantly women (> 75% women) and 5% comprised predominantly men (≤ 25% women). In addition, 63% of studies were on samples originating from countries classified as those with a high level of education according to national education ranking data (OECD, 2021).

Effect Size Data Extraction and Classification of Constructs

Data Extraction

Reported effect size data for relations between health literacy, social cognition constructs, health behaviors, and outcome variables were extracted from each included study. The zero-order correlation coefficient was identified as the effect size metric as data relevant to the current analysis were correlational. Where zero-order correlations among study variables were not reported, we computed zero-order correlations from other available effect size data (e.g., odds ratios, mean differences, chi-square tests) using relevant conversion formulae.

Construct Classification

A perennial problem in meta-analysis is ensuring that measures used in studies were sufficiently representative of the key variables included in the analysis. To address this, we applied a classification procedure to ensure measures of health literacy, social cognition constructs, and behaviors were equivalent across studies. Our classification procedure was informed by a priori definitions of study constructs based on theory and conceptual reviews of the relevant variables.

Health literacy. A number of health literacy measures have been adopted in previous research (for review see Mancuso, 2009). Due to the large number and variation in health literacy measures used in the included articles, the items used in each measure were subjected to a content analysis to identify congruences and variation in items across measures. Two broad categories of health literacy measure emerged: confidence and comprehension. Many commonly-used measures of health literacy prompt respondents to rate their confidence in understanding health-related information in medical contexts, or to complete health-related tasks and include the Health Literacy Questionnaire (Osborne et al., 2013) and Single Item Literacy Screener (Morris et al., 2006). Alternative approaches prompt completion of health comprehension tasks (i.e., identifying familiar health terms, responding to comprehension questions based on a short health passage). The Test of Functional Health Literacy in Adults (Parker et al., 1995) and Rapid Estimate of Adult Literacy in Medicine (Murphy et al., 1993) utilize these methods to assess health literacy. Health literacy measures were therefore coded into *confidence* or *comprehension* categories based on their item content. Comprehension measures were used in 44% of the included studies and confidence measures were used in 56% of the studies.

Social cognition constructs. We screened studies to identify available measures used to tap constructs from prominent social cognition theories including social cognitive theory (Bandura, 1977), the health belief model (Rosenstock, 1974), protection motivation theory (Rogers, 1975), and the theories of reasoned action and planned behavior (Ajzen, 1991). We also identified constructs that were measured using bespoke measures that were not developed according to specific guidelines or were utilized in integrated theoretical approaches. Alongside the extraction of measures, we developed a set of definitions of key social cognition constructs informed top-down by prior classification systems used to develop ‘core’ sets of social cognition constructs from leading theories (e.g., Hagger et al., 2017; McMillan & Conner, 2007) and bottom-up by the reported measures of social cognition constructs from the included studies and the theories on which they were based. The classification system was then used to develop a coding system, which was used to assign measures of social cognition constructs from each study to a defined construct in the classification. Assignment was based on the content of the measures rather than the terms used to describe the constructs, as researchers’ construct definitions do not necessarily align with the content of the items in the measure (Block, 1995; Hagger, 2014). Coding of study measures in accordance with the classification protocol was conducted by one researcher with a sub-sample of studies independently coded by a second researcher to confirm validity of the coding protocol. Inter-coder agreement was high (Cohen’s $\kappa = .89$). A majority of studies included measures of specific constructs from typical social cognition constructs with measures of self-efficacy ($k = 32$), knowledge ($k = 42$), attitudes ($k = 3$), and risk perceptions ($k = 8$) occurring most frequently.

Behavior measures. We identified the target behavior or behaviors of each study and classified them into health-promoting and health risk categories based on prior research (McEachan et al., 2011). The most frequently reported health-promoting behaviors were physical activity, nutrition, medication adherence, illness management behaviors, oral health behaviors, and other general preventive health behaviors (i.e., preventive screening). The most frequently reported health risk behaviors were smoking and alcohol consumption. A number of studies reported multiple target behaviors ($k = 38$). The vast majority of studies measured behavior using self-report methods ($k = 245$) and few adopted non-self-report measures ($k = 43$). Behavior measures were assessed by standardized validated scales in some cases, but many studies adopted bespoke, single-item frequency measures.

Health outcome measures. Our construct classification procedure identified two broad categories of health outcome: health status (*k* = 95) and well-being (*k* = 18). Measures were classified into the health status outcome category if they assessed a physical health outcome, while measures were classified into the well-being outcome category if they assessed outcomes relating to psychological well-being (e.g., health-related quality of life). Our health status outcome encompassed self-report and non-self-report assessments of health status. Examples of non-self-report measures included glycosylated hemoglobin (HbA1C) in diabetics, blood pressure for hypertension, modified diet for renal function (MDRF) for kidney function, or verified presence or absence of an illness or condition. Examples of self-reported health status included general perceived health status or pain level. Our well-being outcome category comprised exclusively of self-report measures of health-related quality of life, including disease-specific measures (e.g., the Asthma Quality of Life scale). Self-report measures included validated measures of physical and psychological well-being such as the RAND-36 scale (Hays et al., 1993) and the Quality of Life in Epilepsy Inventory (Cramer et al., 1998). Validated measures of self-rated health included the Short Form 12 Health Survey (Ware et al., 1996), the Addiction Severity Index (McLellan et al., 1992), and the CAGE Questionnaire (Ewing, 1984).

Moderator and Covariate Coding

We coded four candidate moderator variables for the current analysis: health behavior type (protective or risk behavior), health behavior measure type (validated or non-validated), country of origin (based on country's education level; high or low education), and health literacy measure type (coded as: comprehension or confidence measures). In addition, study sample and demographic characteristics were coded for inclusion as covariates in our proposed model. The conceptual basis for moderator and covariate coding is outlined next.

Moderator Variables

Health behavior type. Included studies targeted multiple health behaviors, and these were classified into health promoting (*k* = 180) and health risk (*k* = 45) behaviors for our moderator analysis, consistent with previous research (McEachan et al., 2011). Health promoting behaviors were defined as those expected to lead to improvement in health outcomes (e.g., physical activity engagement, healthy eating behaviors, medication adherence, screening attendance), and health risk behaviors were defined as those likely to have deleterious health consequences (e.g., tobacco smoking, excessive alcohol consumption, sedentary behavior).

Health behavior measure type. Included studies adopting health behavior measures with prior validity data were classified into a 'valid behavior measure' category (*k* = 376), while those adopting bespoke behavior measures without prior data on validity were classified into a 'non-validated' category (*k* = 460) for this moderator analysis. Validated measures included self-report questionnaires, often comprising multiple items, with prior data on their psychometric properties (e.g., Morisky Medication Adherence Scale, Health Promoting Lifestyle Profile II), while non-validated measures included idiosyncratic measures, often comprising single items.

Education level. Our initial goal for the education level moderator variable was to classify the included studies according to reported sample-level statistics on education. However, this proved challenging given that study authors adopted different metrics or criteria when reporting education level, and, in some cases, did not report education level at all. Coding our education moderator variable according to this procedure meant that almost a third of the studies (k = 83) had to be excluded. We therefore inferred sample education level from national statistics and used it to code our education level moderator variable. Specifically, we coded studies according to the national education level ranking of the study sample country of origin based on the global education data (OECD, 2021). Samples were assigned to a *high* or *low* education category if the country of origin appeared top or bottom 50% of OECD global education rankings, respectively. We recognize the lack of fidelity in the coding of this moderator – population education level may not reflect education level of the sample with high precision – so our results should be interpreted in light of this limitation.

Health literacy measure type. Multiple measures of health literacy were adopted in the present sample of studies, with the Short Test of Functional Health Literacy in Adults (Baker et al., 1999) and the Rapid Estimate of Adult Literacy in Medicine (Murphy et al., 1993) measures the most frequently adopted. Content analysis of items used in these measures identified two broad categories: confidence (*k* = 88) and comprehension (*k* =121) measures, as outlined in the construct classification section.

Covariates

Demographic characteristics. Each sample included in the analysis was assessed for demographic characteristics that were included as covariates in the final analysis*.* Samples were classified as *older* (*k* = 45) if the reported average age of the sample was 40 years or above with a standard deviation below 15, *younger* (*k* = 54) if the average sample age was under 40 years with a standard deviation less than 15. Studies with samples with a high range or variability in the age of the included participants were coded as *balanced* in age profile. Consistent with previous meta-analyses (Hamilton et al., 2020), samples were coded as majority female (>=75% female; *k* = 52), majority male (<=25% female; *k* = 14), or balanced gender profile (>25% female and < 75% female; *k* = 138).

Sample characteristics. Samples of the included studies were classified as clinical (*k* = 109) if the sample comprised participants with a clinically diagnosed health condition (e.g., diabetes, heart disease). The samples of all other studies were classified as non-clinical (*k* = 94).

Study quality. The methodological quality of each included study was assessed using the Quality Assessment Checklist for Survey Studies in Psychology (Q-SSP) checklist (Protogerou & Hagger, 2020). The Q-SSP is a twenty-item checklist assessing the quality of reporting of four different categories of the assessed study: introduction, participants, data, and ethics. For each item, expert raters awarded a score of 1 if the quality criterion was satisfied, and a score of 0 if it was not. Scores for each item are summed to yield an overall quality score out of 20 and aggregate scores for each quality category.

The average quality score for the sample of included studies was 12.26 (*SD* = 2.01) with an average of 61.25% of checklist items scoring 1 across studies. Only 11.83% of studies met the suggested guideline value of 15 (70%) or greater to be considered of 'acceptable' quality. Focusing on the individual quality domains, average scores did not meet the 'acceptable' guideline values for any of the domains. However, average scores exceeded the hypothetical scale midpoint for the introduction, participants, and data categories, but below the midpoint for the ethics category (see Table E1, Supplemental Materials). Focusing on average scores on individual Q-SSP items, studies exceeded the guideline criterion for ten of the items. In particular, studies achieved 'acceptable' quality on items assessing the provision of a study rationale, description of recruitment strategies, justification of methods used, and confinement of findings to the study sample. By contrast, very few studies scored 1 on items 8 ("Was the attrition rate provided?"), 9 ("Was a method of treating attrition provided?"), and 19 ("Were participants debriefed at the end of data collection?"), indicating key areas of deficiency.

Study design. All data used in this meta-analysis were correlational in design. The majority of studies were classified as adopting a cross-sectional design in which all variables were measured on a single occasion (*k* = 187). A minority of studies were classified as adopting a longitudinal design, which included a time lag between collection of data on measures of health literacy or social cognition constructs and health behavior or outcome (*k* = 16).

Data Analysis

In the first stage of the analysis, we estimated the averaged bias-corrected correlations among the health literacy, the social cognition constructs, and health behavior and health outcome measures across studies using random-effects multi-level meta-analysis. The analysis yielded bias-corrected point estimates for each correlation with 95% confidence intervals, variability estimates for each analysis level (Cheung, 2014), and total variability (τ^2 coefficient) and heterogeneity (Cochran's *Q*) estimates.

Next, we tested the predictions of our proposed model using meta-analytic structural equation modeling (MASEM; Cheung, 2015a, 2015b). The analysis used the pooled matrix of correlations of model constructs as input for estimating a model specifying the proposed relations among them using Wilson et al.'s procedure to correct each correlation in the matrices used in the MASEM analysis using multi-level meta-analysis and for our covariates. The analysis yielded overall model fit indices and standardized parameter estimates with 95% Wald confidence intervals for each proposed effect. The analysis was implemented using two-stage multi-level MASEM using the metafor (Viechtbauer, 2010) and metaSEM (Cheung, 2015b) packages in R.

We also tested the effects of the candidate moderator variables (behavior type, behavior measure type, health literacy measure type, country of origin) on the averaged zero-order bias-corrected correlations among each of the study constructs from the multi-level meta-analysis in a series of meta-regression analyses. In these analyses, each correlation was simultaneously regressed on the set of candidate moderators controlled for covariates. Comparisons between the meta-regression model and the meta-analytic model excluding moderators was made using likelihood ratio test (Viechtbauer, 2010). Effects of moderator variables on the effects in our proposed model were tested by estimating separate multi-level MASEM models in groups of studies at each level of the moderator. Differences in the standardized parameter estimates for model effects was tested using the standard difference in the estimates across models at each level of the moderator (Schenker & Gentleman, 2001). Where numbers of studies in the synthesized correlation matrices precluded model estimation in some moderator groups, we conducted sensitivity analyses instead to determine whether our conclusions changed when the studies at a specific level of the moderator were omitted from the analysis.

Finally, the extent of selection bias for each correlation in our analysis was evaluated using a series of bias correction methods based on the funnel plot (Begg & Mazamdar, 1994; Duval & Tweedie, 2000; Sterne et al., 2001) and selection methods (Vevea & Hedges, 1995; Simonsohn et al., 2014; Van

Aert, 2020). Each analysis provided an estimate of the extent of bias, and some provide corrected effect size estimates after correcting for bias.

Results

Meta-Analysis of Correlations

Averaged bias-corrected zero-order correlations and corresponding variability statistics from the multi-level multivariate meta-analysis among health literacy, social cognition constructs, and health behavior and outcomes are presented in Table 1. In all cases, correlations were non-zero and most were small-to-medium in size (r range = .060 to .309, ps < .034) with moderate-to-high heterogeneity in most cases and statistically significant Q-values. The largest correlations were between health literacy and knowledge and well-being, between self-efficacy and knowledge, attitudes, risk perceptions, and health behavior, and between risk perceptions and attitudes (rs > .200, ps < .001). There were insufficient studies in the current sample to estimate averaged correlations between the social cognition constructs and well-being, and between risk perceptions and health status.

Tests of the Proposed Model

We estimated our proposed model using the multi-level MASEM procedure using the matrix of correlations among study constructs for which we had sufficient effect sizes as input. The absence of effect sizes for psychological well-being and treatment beliefs, as noted in the previous section, resulted in empty cells in the matrix for these variables and precluded their inclusion in the model tests. As a consequence, our model excluded treatment beliefs as a mediator and well-being as an outcome. Standardized parameter estimates and 95% confidence intervals for the direct and indirect effects the proposed model from the multi-level meta-analytic structural equation model for the full sample of studies are presented in Table 2 and summarized in Figure 1b. We noted no statistically significant differences in the effect sizes in the models adjusted and unadjusted for covariates - we report the coefficients from the unadjusted models here but provide the adjusted coefficients in the table for comparison. Focusing on the direct effects, we found non-zero effects of health literacy on the self-efficacy ($\beta = .228$, $p < .001$), knowledge ($\beta = .299$, $p < .001$), attitudes ($\beta = .167$, $p < .001$), and risk perceptions ($\beta = .175$, $p < .001$) constructs with small-to-medium effect sizes. There were also non-zero effects of the self-efficacy ($\beta = .218$, $p < .001$) and attitudes ($\beta = .124$, $p < .001$) constructs on behavior with small-to-medium effect sizes, while the effect of the knowledge and risk perceptions constructs on behavior were no different from zero. In addition, effects of all of the social cognition constructs on health status were no different from zero (β range = .030 to .200, *p*s > .116). Finally, there were non-zero effects of health literacy on both behavior ($\beta = .064$, $p < .001$) and health status ($\beta = .074$, $p < .001$).

Turning to indirect effects, there were non-zero indirect effects of health literacy on behavior mediated by self-efficacy ($\beta = .050$, $p < .001$) and attitudes ($\beta = .021$, $p < .001$). The non-zero direct, residual effect of health literacy on health behavior indicated that the indirect effects of health literacy on behavior through self-efficacy and attitudes represented partial mediation. However, the sum of indirect effects of health literacy on health behavior ($\beta = .089$, $p < .001$) accounted for a substantive proportion of the total effect of health literacy on health behavior. The mediation proportion statistic (P_M; Ditlevsen et al., 2005), which provides ratio of the total effect to a mediated effect, indicated that the sum of indirect effects of health literacy on behavior through these social cognition constructs accounted for over half of the total effect of health literacy on health behavior ($P_M = .569$).

By contrast, indirect effects of health literacy on health status through each social cognition construct were no different from zero. However, we found a non-zero sum of indirect effects of health literacy on health status through all social cognition constructs ($\beta = .050$, $p = .016$). Although each specific indirect effect was no different from zero, when combined they yielded a non-zero total indirect effect. In fact, the sum of indirect effects of health literacy on health status through social cognition constructs accounted for over one-third of the total effect of health literacy on health status ($P_M = .391$).

These findings indicate that while health literacy contributes uniquely to health status, social cognition constructs account for a substantive proportion of the variance in this effect.

Analysis of Moderators

Our meta-regression analyses testing effects of our moderators on the zero-order correlations among the study constructs from the multi-level meta-analysis revealed significant moderator effects for the correlation between health literacy and behavior. Examining the effects of each moderator for this relationship revealed a statistically significant effect of health behavior type, such that the health literacy-behavior correlation was larger in studies targeting health risk behavior relative to those targeting protective behaviors (β = -.057, p < .001). There was also a statistically significant effect for behavior measure type, where larger correlations between self-efficacy (β = .189, p = .025) and behavior, and between knowledge and behavior (β = .125, p = .037), were observed in studies using validated measures of behavior as opposed to studies utilizing idiosyncratic, non-validated measures. We found no other significant moderator effects in our meta-regression models.

For the meta-analytic structural equation model, we aimed to estimate our model separately in groups of samples at each level of the moderator and compare the coefficients for model effects across the analysis in each moderator group. However, insufficient studies at some levels of the moderator analyses resulted in empty cells in the pooled matrix of correlations used as input for the meta-analytic structural equation model. We were unable to estimate the model in groups of studies targeting health risk behavior for the behavior type moderator; studies using comprehension measures of health literacy for the health literacy measure moderator; and studies conducted in countries classified as high education provision for the country-of-origin moderator. As an alternative, we conducted sensitivity analyses to evaluate the extent to which excluding studies in each of these moderator groups from the analysis affected our conclusions on model effects when compared to the analysis in the overall sample. As not all studies measured behavior, there were substantive empty cells in the input correlation matrices at each level of the behavior type moderator precluding both moderator and sensitivity analyses for this moderator. Our tests of this moderator were therefore confined examining its effects on the zero order correlations from the multi-level meta-analysis using meta-regression. Finally, we only expected effects of the behavior measure type moderator on relations involving behavior, accordingly, we confined our meta-regression analyses to these correlations.

For the health literacy measure type analysis, results indicated larger effects of health literacy on self-efficacy ($\beta = .281$, $p < .001$) and knowledge ($\beta = .374$, $p < .001$), and larger indirect ($\beta = .145$, $p < .001$) and total ($\beta = .194$, $p < .001$) effects of health literacy on behavior, when studies using comprehension measures of health literacy were omitted from the analysis. For the education level analysis, results revealed a smaller effect of health literacy on knowledge ($\beta = .230$, $p < .001$) when studies from countries classified as higher education were omitted from the analysis. In addition, the indirect effect of health literacy on behavior through self-efficacy ($\beta = .026$, p < .001), and the sums of indirect ($\beta = .048$, $p < .001$) and total effects ($\beta = .105$, $p < .001$) of health literacy on behavior, were smaller in this analysis. Finally, for the behavior type analysis, we found no differences in model parameter estimates in the model excluding health risk behavior relative to the model estimated in the overall sample. Overall, high heterogeneity was observed in all models in the sensitivity analyses based on statistically significant Q-values and I^2 values greater than 50%.

Assessment of Publication Bias

The profile of estimates across the panel of bias analyses suggests limited evidence of systematic bias in the correlations in the present study. Only a small number of instances of non-zero bias was identified, and bias corrected correlations from these analyses were also not appreciably different from the correlations reported in the original analysis. It is also important to note that substantive heterogeneity was observed in most of the averaged correlations, and many of these bias detection methods do not provide precise estimates under conditions of high heterogeneity.

Discussion

In the present study we synthesized relations between health literacy, belief-based constructs from social cognition theories (attitudes, self-efficacy, risk perceptions, treatment beliefs), health behaviors, and health outcomes (health status, psychological well-being) across samples using meta-analysis. We also tested a proposed model in which relations between health literacy and health behavior and outcomes were mediated by social cognition constructs using meta-analytic structural equation modeling. We found non-zero averaged correlations between health literacy and health behavior and outcomes, corroborating findings of previous studies examining relations between these variables, such as research indicating associations between adequate health literacy and better diet quality and food label use (Cha et al., 2014), decreased smoking incidence (Husson et al., 2015), and greater physical activity participation (Husson et al., 2015). Our research extends these findings by demonstrating that adequate health literacy is associated with increased participation in behaviors that promote health (e.g., physical activity, healthy eating, screening attendance) across studies.

In addition, we found positive non-zero averaged correlations between adequate health literacy and health status across studies consistent with previous research that has shown associations between adequate health literacy and better health outcomes such as subjective reports of health, and lower incidence of, or effective management of, chronic conditions (Kim, 2009). Our findings indicate that individuals with reduced capacity to comprehend or interpret health-related information are less likely to participate in behaviors likely to promote health, and more likely to report poorer health outcomes and lower levels of psychological well-being. Our findings corroborate previously-observed disparities in health behavior participation and health outcomes, particularly in populations with lower income and education levels (Crook & Peters, 2008; Mackenbach et al., 2008).

Our results also indicate that adequate levels of health literacy were associated with increased self-efficacy, knowledge, and attitudes, and lower risk perceptions, with respect to health behavior participation across studies. This implies that individuals with inadequate health literacy may be less likely to express beliefs with respect to the utility, risk, capacity, and know-how when it comes to health behaviors. The lower endorsement of these beliefs among individuals with inadequate health literacy may be attributable to inadequate provision of, and clarity in, health-related information by the health education systems or healthcare providers that serve these communities (Orbell et al., 2017).

Our analysis also indicated that self-efficacy, risk perceptions, knowledge, and attitudes were associated with participation in health behavior, supporting research indicating that these constructs consistently predict of health behavior (Brewer et al., 2007; McEachan et al., 2011; Zhang et al., 2019). Our findings are also consistent with research identifying attitudes and self-efficacy as having the largest effects on behavior, an indication that beliefs in behavioral utility in producing outcomes and capacity in performing behavior are central to decision-making for future behaviors. Further, we observed that self-efficacy and knowledge were correlated with health status, which corroborates prior research on links between social cognition constructs and health outcomes (Kumsar et al., 2021; Sarkar et al., 2007). Although not to be directly inferred from correlational evidence, we speculate, consistent with social cognition theory, that these belief-outcome associations are indicative of the beliefs lining up future participation in behaviors likely to be consequential, in the long run, to adaptive health outcomes.

A unique aspect of the current analysis is that it afforded us the opportunity to test a unique model in which social cognition constructs mediated relations between health literacy and health behaviors and outcomes across studies. We found that attitudes and self-efficacy mediated the health literacy-health behavior relationship and accounted for a substantive proportion of the effect, consistent with studies indicating that beliefs mediate the relationship between socio-structural variables including health literacy and participation in certain health behaviors (e.g., Adams et al., 2013; Orbell et al., 2017). These findings implicate beliefs relating to the utility of the behavior in producing outcomes (i.e., attitudes), and beliefs in capacity to perform it (i.e., self-efficacy), are instrumental to explaining this relationship. Individuals with adequate health literacy are more likely to be better equipped to access, interpret, and apply health information, such as messages linking health outcomes with behavior, and modify their beliefs and actions accordingly. By contrast, those with inadequate health literacy may not have the capacity to process health-related information, which is likely to be reflected in their beliefs with respect to health behaviors, such as valuing the behavior less or not having sufficient confidence to perform it, and their subsequent participation in health behaviors.

This pattern of effects extended to health outcomes: social cognition constructs mediated the relationship between health literacy and health status, although specific indirect effects were no different from the null. This finding demonstrates that individuals' beliefs about future participation in health behavior effectively account for the variance shared between health literacy and health outcomes (e.g., self-reported health status, HbA1c). Adequate levels of health literacy, or, adequate understanding of health information, is not only reflected in adaptive beliefs regarding health behaviors and actual participation in health behavior, but also in actual health outcomes, likely the consequence of health behavior participation. These are important findings given that explaining variance in health behavior participation does not necessarily imply concomitant explanation in health outcomes.

The current analysis also provided important information on the potential conditions that may determine the magnitude of effects in the proposed model. Sensitivity analyses revealed larger direct effects of health literacy on self-efficacy and knowledge, and larger indirect effects of health literacy on behavior through these variables and a larger total effect, when estimating the model in the sample of studies excluding comprehension measures of health literacy compared to when it was estimated in the full sample. These findings suggest a measurement artifact. Confidence-based health literacy measures prompt respondents to estimate their capacity to interpret and apply health-related information. As a result, they are likely to be closely aligned with general motivation toward health behavior, and with belief-based mediators of health literacy, particularly respondents' estimates of their capacity to perform health behaviors. This may explain the larger effects of health literacy on social cognition constructs relating to confidence, and effects on behavior through the belief-based mediators in the model. However, should be exercised when interpreting these findings as we were unable to directly compare model estimates with data from studies adopting comprehension measures of health literacy.

We also found a smaller effect of health literacy on knowledge, a smaller indirect effect of health literacy on behavior through self-efficacy, and a smaller sum of indirect effects and total effect of health literacy on behavior when studies conducted in countries with higher education level were excluded from our analysis. Individuals from lower education backgrounds may be more likely to discount, or be less reliant on, their capacity to understand health information when estimating their beliefs about health behaviors. This indicates the importance of accounting for general education when individuals are prompted to estimate their beliefs about health behaviors, and their future engagement in health behaviors. Finally, we found no differences in model effects when estimating the model in studies excluding health risk behaviors. This provides evidence that model effects are consistent across behaviors, and provide initial support for the premise that effects of belief-based constructs in social cognition theories represent a general decision-making process that precedes behavior (Ajzen, 1991).

Finally, our meta-regression analyses for the correlations among health literacy, the social cognition constructs, behavior, and outcomes also revealed notable effects. Most prominent among these was the finding that the type of behavior measure had an effect on relations between behavior and some of the constructs in our model, most notably, self-efficacy and knowledge. Limitations on the use of non-validated behavioral measures have been well-documented, and researchers in the domain of testing social cognition theories such as those in the current research should be advised to adopted measures that have been subject to sufficient psychometric testing to support their validity.

Contribution, Limitations, and Avenues for Future Research

The current study is the first to synthesize relations among health literacy, social cognition constructs, health behaviors and outcomes in the extant literature, and leverage these data to test effects of a model in which health literacy relates to health behavior mediated by social cognition variables. These findings have value because they contribute to the emerging evidence indicating that health literacy is not only related to health outcomes and health behavior participation, reflecting disparities in observed health, but also to the sets of beliefs that likely inform decisions to participate in health behavior based on social cognition theories. The research also contributes initial evidence of a potential mechanism by which health literacy is associated with health behavior and health outcomes.

Current findings should be interpreted in light of several limitations. One notable limitation was the relatively small number of included studies that reported relations between health literacy and treatment beliefs and well-being. Not only did this result in small sample sizes when estimating the averaged correlations for these variables, but also empty cells in the input matrix of correlations among study variables leading them to be dropped from the estimation of our proposed model. In addition, only small numbers of studies were available at each level of our proposed moderators which precluded full moderation analyses. Although the sensitivity analysis allowed us to make qualified inferences regarding the potential effects of each moderator, they prevented drawing definitive conclusions. As the research on relations among health literacy, social cognition constructs, and health behaviors and outcomes proliferates, future syntheses may permit complete moderator analyses.

A related limitation is the use of study-level data for coding some key moderator variables, which produced low fidelity variables and may have reduced the precision of our findings. For example, our education moderator variable was coded from the education statistics of the population from which the study sample was drawn. We adopted this approach as data on education level tended not to be systematically or precisely reported in the included studies, or was not reported at all in some cases. Similarly, our characterization of sample gender and age, as covariates in our analyses, used data taken at the sample level. The lack of fidelity in these moderator variables is likely to have introduced random error in our moderator analyses, reducing our power to identify differences. Reporting individual-level sample characteristics is, therefore, an important recommendation for future research, as better reporting may improve future syntheses of health literacy effects within social cognition models. An optimal solution would be for researchers to share their full data sets includes individual-level data on these characteristics maximizing precision in moderator analyses (see also Hagger, 2022).

An additional limitation of the current research is the sole reliance on correlational data, which precluded inference of causality in the predictions of our proposed model. The proposed directional relations among model constructs, and the associated mediated effects, are inferred from theory alone, and not the meta-analytic data. In addition, we cannot rule out the possibility that effects in the model, including the mediation relationship, could be attributed to other, unmeasured variables. Future researchers should prioritize well-designed longitudinal or experimental tests of the proposed model to better enable directional and causal inferences (Bullock & Green, 2021).

Conclusion

Our meta-analysis is the first to support relations between health literacy and health behavior and outcomes across the extant research literature and flag a potential mechanism by which health literacy relates to health behavior with social cognition constructs as mediators. Although this study alone does not provide sufficient evidence to definitively recommend intervention targets for behavior change, it provides impetus for future behavioral intervention studies (see Hagger, Cameron et al., 2020; Hagger, Moyers et al., 2020). Such research should seek to extend current findings to demonstrate that interventions not only lead to change in the targeted social cognition constructs and behavior and health outcomes, but also to partially mitigate the deleterious effects of socio-structural constructs that represent disadvantage on behavior and outcomes.

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Note. Articles marked with an asterisk ("") were included in the meta-analysis*

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Table 1

Results of Multi-Level Meta-Analysis of Zero-Order Correlations Among Study Variables Including and Excluding Moderators

Model[a]	*k*	*r*[b]	95% CI		σ² within	σ² between	*Q* (residual heterogeneity)	AIC	*I*²	var σ²		Moderator tests		ANOVA[c]
			LL	UL						L1	L2	*Q*	df	LRT
HL-SE	120	0.198***	0.165	0.231	.008	.002	392.591***	-139.955	69.59	53.01	16.58	-	-	-
		0.333***	0.140	0.524	.006	.001	263.518***	-138.634	63.73	54.97	8.75	17.561*	8	14.679
		0.336***	0.145	0.527	.006	.001	263.517***	-136.767	54.83	47.69	7.15	17.809*	9	14.811
HL-KN	78	0.296***	0.247	0.344	.003	.019	810.954***	-80.460	92.63	12.12	80.51			
		0.184	-0.152	0.520	.003	.014	566.263***	-73.524	91.27	15.84	75.44	10.493	8	9.064
		0.155	-0.217	0.527	.003	.013	535.906***	-71.644	89.71	15.73	73.98	10.713	9	9.184
HL-RP[a]	8	0.177**	0.068	0.286	.023	.000	116.135***	-0.927	93.43	93.43	0.00	-	-	-
HL-AT	50	0.144***	0.073	0.216	.007	.008	179.509***	-52.064	73.65	32.52	41.12	-	-	-
		1.101***	0.587	1.614	.003	.000	77.846**	-64.582	35.29	35.29	0.00	57.281***	6	24.518**
		1.190**	0.348	2.032	.003	.000	77.465**	-60.751	30.09	30.09	0.00	58.064***	8	24.687**
HL-TB[a]	9	0.144	-0.002	0.290	.005	.018	98.079***	-5.833	96.88	19.89	76.99	-	-	-
HL-BEH	570	0.150***	0.129	0.170	.006	.012	5475.542***	-747.697	93.66	31.84	61.82	-	-	-
		0.153*	0.021	0.285	.006	.010	4818.260***	-741.688	93.32	34.15	59.17	10.484	8	9.991
		0.156*	0.024	0.288	.006	.010	4535.567***	-748.754	92.61	33.79	58.83	22.030*	10	21.057*
		0.107	-0.027	0.240	.005	.010	3930.812***	-751.024	92.31	32.13	60.18	26.007*	11	-
HL-ST	447	0.117***	0.092	0.141	.006	.011	5767.179***	-642.838	94.64	32.19	62.44	-	-	-
		0.250**	0.089	0.411	.006	.010	5027.656***	-640.010	94.20	35.05	59.15	13.875	8	13.171
		0.245**	0.086	0.403	.006	.009	4185.609***	-639.885	93.50	35.59	57.91	18.276	10	17.047
HL-WB	26	0.228***	0.174	0.282	.000	.010	83.427***	-53.585	87.39	0.00	87.39	-	-	-
		-0.056	-0.475	0.363	.000	.007	71.975***	-42.739	87.36	0.00	87.36	5.840	8	5.154
		-0.006	-0.416	0.404	.000	.006	66.782***	-40.782	80.85	0.00	80.85	8.332	10	7.197
SE-KN[a]	10	0.220***	0.136	0.303	.012	.000	32.785***	-5.124	73.37	73.37	0.00	-	-	-
		1.455	-3.836	6.747	.005	.000	21.555**	1.184	73.21	73.21	0.00	4.849	5	3.692
SE-RP[a]	6	0.233***	0.181	0.286	.003	.000	14.822*	-11.683	59.52	59.52	0.00	-	-	-
SE-AT[a]	59	0.309**	0.120	0.498	.008	.042	217.577***	-51.719	88.40	13.85	74.55	-	-	-
		2.878**	0.987	4.769	.007	.014	158.976***	-48.539	77.54	27.25	50.29	9.518	5	6.820
SE-BEH	83	0.240***	0.190	0.290	.046	.000	886.930***	0.283	92.68	92.68	0.00	-	-	-
		0.141	-0.210	0.493	.041	.000	506.697***	6.243	92.45	92.45	0.00	8.482	7	8.040
		0.133	-0.305	0.572	.041	.000	506.153***	9.798	86.58	86.58	0.00	8.975	9	8.485
		-0.288	-0.850	0.274	.037	.000	461.496***	6.966	85.58	85.58	0.00	14.607	10	
SE-ST	69	0.156**	0.054	0.257	.010	.025	484.982***	-58.502	92.08	26.43	65.65	-	-	-
		0.921***	0.504	1.338	.010	.004	331.661***	-58.388	83.84	59.89	23.95	21.565**	6	11.887
		0.945***	0.510	1.380	.010	.004	331.657***	-56.570	81.94	57.89	24.05	21.484**	7	12.068
KN-RP[a]	6	0.128	-0.025	0.282	.035	.000	126.883***	1.200	95.27	95.27	0.00	-	-	-
KN-AT[a]	13	0.186***	0.101	0.272	.000	.006	24.844*	-24.658	65.75	0.00	65.75	-	-	-
KN-BEH	32	0.142***	0.093	0.192	.011	.003	458.607***	-30.944	92.85	76.29	16.56	-	-	-
		0.376**	0.099	0.653	.007	.000	195.754***	-31.028	89.21	89.21	0.00	22.267**	8	16.083*

		0.208	-0.105	0.520	.005	.000	157.163***	-31.842	87.60	87.60	0.00	32.097**	10	20.898*
		0.190*	-0.114	0.494	.005	.000	153.205***	-34.162	77.38	77.38	0.00	38.379***	11	
KN-ST[a]	15	0.070**	0.023	0.118	.004	.000	39.889**	-18.833	68.39	68.39	0.00	-	-	-
	-	0.128	-3.088	3.344	.000	.000	22.584**	-14.832	0.00	0.00	0.00	17.304**	6	8.000
RP-AT[a]	13	0.239***	0.123	0.355	.044	.000	336.079***	2.739	96.17	96.17	0.00	-	-	-
RP-BEH[a]	8	0.127***	0.054	0.199	.008	.000	41.727***	-7.334	80.38	80.38	0.00	-	-	-
AT-BEH	41	0.189***	0.130	0.249	.030	.000	232.408***	-10.857	86.08	86.08	0.00	-	-	-
		0.183	-0.558	0.924	.028	.000	221.402***	-0.714	87.29	87.29	0.00	1.897	6	1.857
		0.130	-0.946	1.206	.028	.000	221.292***	1.268	87.61	87.61	0.00	1.916	7	1.875
		0.160	-0.966	1.285	.029	.000	221.176***	2.497	85.64	86.63	0.00	1.887	7	
AT-ST[a]	22	0.179	-0.089	0.447	.002	.036	87.060***	-25.599	81.88	3.33	78.54	-	-	-
TB-BEH[a]	15	0.060*	0.005	0.116	.010	.000	337.534***	-15.935	96.83	96.83	0.00	-	-	-
BEH-ST	124	0.084***	0.048	0.121	.004	.006	768.052***	-213.783	91.42	36.05	55.38	-	-	-
		0.285*	0.042	0.528	.004	.004	546.802***	-203.304	90.60	43.07	47.52	3.939	7	3.521
		0.245*	0.020	0.470	.004	.003	533.111***	-204.441	89.22	50.28	38.94	10.550	9	8.658
		0.282	0.070	0.494	.004	.002	519.343***	-204.484	86.40	56.94	29.45	-	-	-
BEH-WB[a]	8	0.189***	0.080	0.298	.005	.008	33.428***	-3.650	78.19	31.08	47.11	-	-	-
		0.040	-0.012	0.093	.000	.000	6.132	-8.118	0.00	0.00	0.00	27.295***	4	12.468*

Note. Values printed on top line are results of the standard multi-level meta-analytic model, values printed on second line are results of the meta-regression model in which the study effect size was regressed on the set of covariate (age, gender, sample type - clinical vs. non-clinical, study quality, study design), values printed on the third line are results of the meta-regression model in which the study effect size was regressed on the covariates and our moderators variables, and values printed on the fourth line are results of the meta-regression model in which the study effect size was regressed on the covariates and our moderators variables in addition to behavior measure type. [a]There were insufficient studies available in sub-groups to compute meta-regression analyses for covariate and moderator variables this correlation. [b]Coefficients reported on the second and third lines for each effect size is the intercept from the respective meta-regression model and is interpreted as the averaged effect size estimate when the moderators are at their reference value. [c]Degrees of freedom = 3 in each analysis.. *k* = Number of studies; *r* = Average sample-weighted correlation; σ^2 = Variance component from the multi-level model, an estimate of the 'true' variability in the effect size. L1 = Variance component attributable to variability between studies; L2 = Variance component attributable to variability between effect sizes within studies; *Q* = Cochrane's *Q* statistic; df = Degrees of freedom; AIC = Akaike's Information Criterion; var σ^2 = Percentage of overall variance attributable to within and between study variance components. HL = Health literacy; SE = Self-efficacy; KN = Knowledge; RP = Risk perceptions; AT = Attitudes; BEH = Behavior; ST = Health status. Associations for the following relations were omitted due to small samples: SE-WB, KN-WB, AT-WB, RP-WB, RP-ST, AT-TB, TB-WB, TB-ST.

$^{*}p < .05$ $^{**}p < .01$ $^{***}p < .001$

Table 2

Standardized Parameter Estimates of Direct and Indirect Effects in Multi-Level Meta-Analytic Structural Equation Model for the Full Sample Analyses Unadjusted and Adjusted for Covariates

Effect	Model unadjusted for covariates			Model adjusted for covariates		
	β	95% CI		β	95% CI	
		LL	UL		LL	UL
Direct effects						
Health literacy→Self-efficacy	.228***	.196	.260	.219***	.187	.251
Health literacy→Knowledge	.299***	.265	.333	.290***	.256	.325
Health literacy→Risk perceptions	.175***	.091	.259	.166***	.082	.250
Health literacy→Attitude	.167***	.122	.211	.158***	.113	.202
Health literacy→Behavior	.064***	.038	.090	.062***	.037	.087
Health literacy→Health status	.074***	.030	.118	.071**	.028	.113
Self-efficacy→Behavior	.218***	.168	.261	.214***	.169	.258
Self-efficacy→Health status	.030	-.035	.095	.028	-.035	.091
Knowledge→Behavior	.048	-.008	.104	.045	-.010	.101
Knowledge→Health status	.014	-.069	.096	.010	-.071	.092
Risk perceptions→Behavior	.023	-.070	.116	.020	-.072	.112
Risk perceptions→Health status	.200	-.049	.450	.193	-.055	.441
Attitude→Behavior	.124***	.069	.180	.121***	.067	.176
Attitude→Health status	.025	-.061	.110	.022	-.062	.106
Indirect effects						
Health literacy→Self-efficacy→Behavior	.050***	.036	.063	.047***	.034	.059
Health literacy→Self-efficacy→Health status	.007	-.008	.022	.006	-.008	.020
Health literacy→Knowledge→Behavior	.014	-.003	.031	.013	-.003	.029
Health literacy→Knowledge→Health status	.004	-.021	.029	.003	-.021	.027
Health literacy→Risk perceptions→Behavior	.004	-.012	.020	.003	-.012	.019
Health literacy→Risk perceptions→Health status	.035	-.012	.083	.032	-.013	.077
Health literacy→Attitude→Behavior	.021***	.010	.032	.019***	.009	.030
Health literacy→Attitude→Health status	.004	-.010	.018	.003	-.010	.017
Sums of indirect effects						
Health literacy→Behavior[a]	.089***	.064	.113	.082***	.059	.106
Health literacy→Health status[b]	.050*	.010	.091	.045*	.006	.084
Total effects						
Health literacy→Behavior[c]	.153***	.134	.172	.144***	.125	.163
Health literacy→Health status[d]	.124***	.103	.146	.115***	.094	.137
Correlations						
Self-efficacy↔Knowledge	.154***	.070	.237	.150**	.066	.233
Self-efficacy↔Risk perceptions	.190***	.095	.285	.185***	.090	.280
Self-efficacy↔Attitude	.348***	.307	.389	.342***	.302	.383
Knowledge↔Risk perceptions	.073	-.023	.168	.068	-.028	.164
Knowledge↔Attitude	.155***	.082	.227	.150***	.077	.222
Risk perceptions↔Attitude	.202***	.134	.271	.196***	.127	.265
Behavior↔Health status	.059***	.026	.092	.056***	.024	.089

Note. Model parameters are adjusted for the following covariates: publication year, age, gender, sample type (clinical vs. non-clinical), study quality, and study design. [a]Sum of indirect effects of health literacy on behavior through all variables; [b]Sum of indirect effects of health literacy on status through all variables; [c]Total effect of health literacy on behavior; [d]Total effect of health literacy on status. β = Standardized path coefficient; 95% CI = 95% confidence interval of parameter estimate; LL = Lower limit of 95% CI.

$^{***}p < .001$ $^{**}p < .01$ $^{*}p < .05$

Figure 1. Proposed model illustrating relations among health literacy, social cognition constructs, behavior, and health status. Panel (a) illustrates hypothesized relations among variables in the proposed model and panel (b) presents a summary of results of the meta-analytic structural equation model estimating relations among the model variables - coefficients shown are standardized parameter estimates with 95% confidence intervals.