Engagement in Cancer Screening: A Model-based Meta-analysis

Abstract

Although early screening tests are beneficial for the detection and treatment of cancers, many people without symptomatic diseases have failed to do so. The present study aims to explore the theoretical underpinning of low participation in screening programs through a model-based meta-analysis. It was found that the health belief model is the most adopted theoretical framework. Moreover, the intended uptake of screening was positively predicted only by cues to action, health literacy, and perceived susceptibility; behavior was negatively predicted by intention. As a result, a revised health belief model was proposed, and the implications of the findings were also discussed.

Keywords: cancer screening; model-based meta-analysis; HBM

Cancer is one of the leading causes of morbidity and mortality worldwide (WHO, 2018). However, a substantial proportion of cancers could be prevented (Cokkinides, Albano, Samuels, Ward, & Thum, 2017) or even treated (National Cancer Institute, 2015; WHO, 2018) if the early detection of cancer such as medically warranted cancer screening (for a discussion with respect to overscreening, see Milhabet, Duprez, Krzeminski, and Christophe (2013)) could be undertaken [for a definition of screening, see Ogden (2012)]. Cancer screening in the present study is defined as detecting cancer at an asymptomatic stage of development using clinical services (cf. Ogden, 2012, p. 212; Rex, Johnson, Lieberman, Burt, & Sonnenberg, 2000). Consequently, some non-clinical means of prevention, such as, self-examination of breast, and using self-purchased medical kits, are irrelevant. A great number of screening trials have shown the efficacy of clinical cancer screening in reducing mortality for cancers of the breast, colon, mouth, skin, rectum, larynx, cervix, and lung (Cokkinides et al., 2017; Mandel et al., 1993; National Lung Screening Trial Research Team, 2011; Ogden, 2012; Tabar et al., 1985). Consequently, measures of early cancer detection, such as mammography associated with breast cancer, colonoscopy, sigmoidoscopy, and high-sensitivity fecal occult blood tests (FOBTs) associated with colorectal cancer, low-dose helical computed tomography associated with lung cancer, and Pap test and human papillomavirus (HPV) testing associated with cervical cancer, are strongly recommended (National Cancer Institute, 2015; Smith Robert, Brooks, Cokkinides, Saslow, & Brawley Otis, 2013; Sung et al., 2008; Wakefield, Loken, & Hornik, 2010).

Despite the fact that early screening tests are beneficial for the detection and treatment of cancers, many asymptomatic people have failed to do so (Hart, Barone, & Mayberry, 1997; Rex et al., 2000). Low participation in screening programs has been attributed to patient, health professional and organizational factors (Ogden, 2012), specifically including the lack of knowledge (Azubuike & Okwuokei, 2013; Elobaid, Aw, Grivna, & Nagelkerke, 2014) and physician recommendations (O'Malley et al., 2001), health insurance status (Rodríguez, Ward, & Pérez-Stable, 2005), socioeconomic inequalities (Maheswaran, Pearson, Jordan, & Black, 2006; O'Malley et al., 2001), and a variety of barriers (Klabunde et al., 2005; Lim & Ojo, 2017). These are all important factors, but a premium has to be placed on the elucidation of theoretical models of preventive health behavior (Prentice-Dunn & Rogers, 1986). As some (Kelly, Murphy, Sikkema, & Kalichman, 1993; Michie & Prestwich, 2010) pointed out, it is urgent to develop and adopt theory-based intervention programs to increase healthy behaviors. Valid theories can not only consistently explain why a phenomenon persists to develop effective interventions but also predict what will happen in the future to take preventive measures (cf. Kuhn, 1970). Theories or models used to address the issue of cancer screening behavioral intentions are abundant but are often applied without enough integration of relevant theories. According to our discursive search in major databases, at least 14 theories have been tried in this area (for a review, see Ogden, 2012). Among them, the health belief model (HBM) (Rosenstock, 1963, 1966), whose extensions account for 40% of the studies in our sample, is the most popular, followed by the theory of reasoned action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and its extension, namely, the theory of planned behavior (TPB) (Ajzen, 1985). Due to is popularity, the HBM will be primarily employed in the following analyses, whereas its connections with other closely related models are duly addressed.

Literature Review

The HBM and Its Extensions

The HBM (Hochbaum, Rosenstock, & Kegels, 1952) was originally formulated in response to the failure of a free tuberculosis (TB) health screening program, and was later developed to account for a variety of both long- and short-term preventive health behaviors.

The HBM (Rosenstock, 1963, 1966, 1974a, 1974b) hypothesizes that a person will take a health-related action if the individual perceives a severe negative health outcome (perceived severity), feels susceptible to it (perceived susceptibility), perceives high benefits of undertaking the preventive behavior (perceived benefits), or perceives low barriers to adopting those behaviors (perceived barriers such as cost, convenience, fear of pain, and embarrassment). In addition, the model also includes a cue to action whereby the individual is driven to engage in the preventive behavior. Cues to action could include external cues, such as a public service announcement or interpersonal interaction, or internal cues such as the perception of an unsound bodily state (Rosenstock, 1966, 1974a, 1974b).

Modifying variables, such as socio-demographic factors, were often included in empirical studies. Some researchers (Aiken, West, Woodward, & Reno, 1994; Katapodi et al., 2013; Ronis, 1992) modified the HBM while hypothesizing that screening intentions are directly influenced by the factor of perceived benefits, which are directly influenced by the susceptibility to the health threat and the perceived severity of the threat, and costs of the action. The HBM later included the component of self-efficacy (Bandura, 1977) as well as the incentive to behave (health motivation) (Rosenstock, Strecher, & Becker, 1988). Moreover, two models, i.e., the extended parallel process model (EPPM) (Witte, 1992, 1994) and the protection motivation theory (PMT) (Rogers, 1984, p. 104) (for a review on the differences with the HBM, see Prentice-Dunn & Rogers, 1986), are fairly similar to this version of the expanded HBM.

TRA and TPB

The HBM essentially explains the relationships between both internal and external health beliefs and health behaviors (or intentions), whereas such generalized connections are well documented in the TRA and its extension, namely, the TPB. The TRA has also been adopted to study various types of cancer screening behavioral intentions (Michels, Taplin, Carter, &

Kugler, 1995; Montaño, Thompson, Taylor, & Mahloch, 1997; Ogunsanya, Brown, Odedina, Barner, & Adedipe, 2016), and some expanded TRA has been employed for the same purpose. For instance, Montano and his associates (Montano & Taplin, 1991; Montaño et al., 1997) incorporated affect, habit, and facilitating conditions into their expanded TRA to predict mammography participation.

Many also have applied the TPB to examine participation in cancer screening (e.g. Devellis, Blalock, & Sandler, 1990; O'Neill et al., 2008; Rutter, 2000; Steadman & Rutter, 2004). Despite its popularity, Gaston and Gerjo (1996) reported that the TPB can explain 41% of the variance in intentions but only 34% of the variance in a variety of health behaviors. Therefore, some have made extensions to the TPB by including more factors to better account for actual behavior. For instance, Conner and Armitage (1998) extended the TPB by including past behavior and habit, belief salience, affect, self-identity, and moral norms, among others (also cf. Ajzen, 1991). The information-motivation-behavioral skill model (IMB) (Fisher, Fisher, Bryan, & Misovich, 2002) expanded the TPB by adding the component of functional cancer literacy, which includes three domains: breast cancer awareness, knowledge and screening, and prevention and control.

HBM Combined with TPB

Many have combined the HBM with either the TRA (Montano & Taplin, 1991; Poss, 2001) or the TPB (e.g. Dillard, Ferrer, Ubel, & Fagerlin, 2012; Gullate, 2006) in the same undertaking. Some combined the HBM and the TPB and renamed the models after further expansions, e.g., the attitude, social influence, and self-efficacy (ASE) model integrates the major concepts of the TPB and the HBM and further adds psychological and socio-economic factors (Lee & Kim, 2015).

In fact, the HBM, the TRA, and the TPB as well as SCT (Bandura, 1986) are all applications of expectancy-value theory (Bish, Sutton, & Golombok, 2000; Rosenstock et al., 1988). Therefore, not surprisingly, they have much in common (Bish et al., 2000). Many determinants in the respective theories are essentially the same (e.g., self-efficacy in the expanded HBM vs. perceived behavioral control in the TPB (cf. Ajzen, 1991)) or subordinate to another (e.g., perceived benefits in the HBM vs. outcome beliefs in the TPB and TRA). However, their shared origins and great commonalities have not rendered a clear picture but instead introduced disagreements and controversies (Norman & Conner, 1996; Ogden, 2012). For instance, Ajzen (2002) unequivocally held that the key factor in the HBM, namely, barriers, is actually the PBC [equivalent to (cf. Ajzen, 1991) or encompassing self-efficacy (cf. Ajzen, 2002)]; yet, Rosenstock et al. (1988) explicitly added self-efficacy to the original HBM. In view of their shared commonality, Fishbein (Fishbein, 2000; Fishbein & Ajzen, 2010; Fishbein & Cappella, 2006) incorporated environmental constraints (e.g., without insurance) and ability in addition to the original elements stipulated in the TPB by proposing an Integrative Model that combines the HBM with social cognitive theory (SCT) and other theoretical perspectives. IM is actually very similar to the TPB, notwithstanding some nomenclature differences (e.g., it changes PBC to self-efficacy and divides norms into injunctive and descriptive ones).

In addition to the aforementioned theories, there are still some less popular models that have been used to address cancer screening behaviors and intentions. Betancourt’s integrative model of culture, psychological processes, and behavior was adapted for health behavior (Betancourt & Flynn, 2009; Betancourt, Flynn, Riggs, & Garberoglio, 2010). Andersen's behavioral model (Andersen, 1968, 1995) posits that people's use of health services (e.g., cancer screening) is a function of their predisposition to use these services, enabling or impeding factors, and their need for care. Social ecological theory (Gregory et al., 2011) postulates that behavior shapes and is shaped by multiple levels of influences. The self-presentation theory of social anxiety (Schlenker & Leary, 1982) was also used. In addition, Lee, Wang, Yang, Huang, and Tsai (2016) proposed a model incorporating the concepts of knowledge, attitudes, and practices of the KAP model (Barretto, 1974), perceived barriers from the HBM, and fatalism from the Powe model (Powe, 1995) to examine the factors associated with the intention to receive a Pap test.

In summary, different theories with numerous predictors or similar theories with diverse combinations and configurations of predictors have been adopted to the same end, i.e., to account for the determinants of preventive health behavior. Some predictors were found to be important in some studies, but contrary conclusions were found in other studies. Consequently, meta-analysis, which is a means of quantitatively determining the real effect and effect size based on findings from previous research on a certain topic (Glass, Smith, & McGaw, 1981; Hunter, Schmidt, & Jackson, 1982; Rosenthal, 1991), is intended to clarify this confusion. Due to its popularity, several univariate meta-analyses have been used with the HBM (Carpenter, 2010; Harrison, Mullen, & Green, 1992; Janz & Becker, 1984; Zimmerman & Vernberg, 1994) or the HBM equivalent (Milne, Sheeran, & Orbell, 2000). The synthesis of Janz and Becker (1984) differentiated preventive-health behaviors (PHB) from sick-role behaviors (SRB) and found perceived barriers to be the most powerful of the HBM dimensions, yet perceived benefits and perceived severity were strong only for SRB. In addition, perceived susceptibility was a stronger contributor for explaining PHB than SRB. The meta-analysis of Carpenter (2010) also found that barriers and benefits were strong predictors but severity and susceptibility were not. In their meta-analysis, Harrison et al. (1992) concluded that the factor of costs (barriers) is a relatively more important predictor, whereas the effect of severity is negligible, and benefits and susceptibility play a trivial role in contributing to screening behavior. In the meta-analysis of the PMT, Milne et al. (2000) found that the association between threat appraisal (severity, vulnerability, and fear) and intention was small, whereas the associations between coping-appraisal variables (self-efficacy, and costs or barriers) and intentions were moderate. Moreover, all of these predictors had weaker associations with behaviors than with intentions. Therefore, the inconsistency in findings remains among these meta-analyses.

The correlations and complex relationships (e.g., moderation and mediation) in any theoretical models will affect the magnitude and the standard error of the statistic for testing the relationship between the predictor of interest and the dependent variable. Therefore, univariate meta-analysis as reviewed above inevitably shares the deficiency of primary studies, i.e., failing to shed light on the true relationships among the variables of a theory. In fact, few primary studies merely examined the bivariate correlation in actual studies but rather addressed more complex theoretical relationships through incorporating either covariates, moderators, or mediators (Wilson, Polanin, & Lipsey, 2016). Model-based as opposed to separate univariate correlation-based meta-analysis is a technique that can be used to analyze complex chains of events (Becker, 2009) and hence is adopted in the present study. Furthermore, due to the correspondence among the aforementioned value-expectancy-based theories, a meta-analysis focusing on any one of them would just prioritize idiosyncrasies but would be subject to the loss of generality. Accordingly, the present study elects to seek all of the pieces of the theoretical framework by studying the common outcome using the model-based meta-analysis, i.e., the behavior and intentions of participating in cancer screening, and subsequently form a variety of combinations of the pieces. That is, the purpose of the meta-analysis study is not to confirm the hypotheses stipulated in the relevant theories or models, so we will raise the following research questions rather than hypotheses:

1. What are the magnitudes of effects of perceived severity, perceived barriers, perceived benefits, health literacy, cues to action, perceived susceptibility and perceived behavioral control on cancer screening intentions and behaviors?

2. What kinds of significant relationships among predictors mentioned in RQ1 and outcomes (cancer screening intentions and behaviors) are present? What theories underpin these relationships?

Methods

Classification of Constructs

Based on the ‘core health cognitions’ framework of McMillan and Conner (2007), we identified the major constructs associated with above-mentioned theories, and then consolidated these constructs into nine core categories: cues to action, health literacy, norms, perceived behavioral control, risk perceptions (including perceived severity and susceptibility), perceived barriers, intentions, and screening behavior. We inspected the underlying meanings of the variables in the included studies, and allocated the variables to the nine construct category on a ‘close fit’ basis (nominally close variables with different meanings such as response efficacy with self-efficacy, and injunctive norms with descriptive norms, are still kept separate) (for the descriptions of a theory coding scheme, see Michie and Prestwich (2010)).

Selection Criteria

Since cancer screening intentions and behaviors are the focus of our study, we tried combinations of the following keywords, namely, “screening tests for *cancer*”, “cancer* screening”, “screening for * cancer*”, “intent* cancer”, “participate* cancer” and “compliance cancer”, in eight different databases, including EMBASE, MEDLINE, Cochrane Database of Systematic Reviews, PsycINFO, PubMed, Web of Science, Scopus and Google Scholar, for published articles related to various factors associated with participation in cancer screening. The first round of the search started in November 2017, yielding 12,427 potentially eligible studies. We then made a screening of these articles. The selection criteria for the studies to be included in this systematic review were as follows: (a) quantitative studies with effect sizes; (b) articles with theoretical variables concerning the determinants and compliance or intentions of cancer screening (studies using only medical variables were hence excluded); and (c) reporting complete zero-order correlations among independent variables and dependent variables. After a series of filtered searches, we obtained 56 eligible articles.

For those articles not satisfying criterion c, we contacted the corresponding authors to request the missing information. This step retrieved an additional 10 eligible studies. We additionally searched through the reference lists of all located studies and obtained eight eligible articles. The final count of the total number of relevant eligible articles reached 73 with 3,108 valid effect sizes [cumulative N = 1,462,422. The cohort study of Roman et al. (2011) accounts for 97.23% of the cumulative sample size] (for the summary of the literature screening process, see Figure 1). With respect to the types of cancer screened in the 73 articles, breast cancer, colorectal cancer, cervical cancer, prostate cancer, both breast and cervical cancer, three combined types (breast, cervical, and colorectal cancer) and a general type without specifying the name accounted for 18 (25%), 14 (19%), 9 (12%), 5 (7%), 24 (33%), 1 (1%), and 1 (1%), respectively.

Unit of Analysis

The unit of analysis is the effect size, which is the correlation (Pearson's or other types of correlations that are appropriate for other measurement levels). In the following analyses, the original correlation will not be transformed into Fisher's z, a popular procedure termed the Rosenthal (1991) approach by Johnson, Mullen, and Salas (1995) in order to retain the correlation metric and the associated variances and covariances among the correlations for use in Stage 2 of MASEM (the method of Fisher's z transformation and back-transformation is not recommended in MASEM. For details, see Cheung & Hong, 2017; Wilson et al., 2016).

Coding Categories of Moderators

Differences in the methods and sample characteristics may introduce variability ("heterogeneity") among the true effects. Therefore, once heterogeneity is detected, the moderator analysis is imperative. The following information was coded from each article: (a) date of publication; (b) number of observations; (c) journal names; (d) data types (cross-sectional vs. time series); (e) sampling types (random or probability sampling vs. convenience sampling); (f) country of study (countries were classified into individualistic vs. collectivistic categories according to Hofstede (1984)); and (g) cancer types.

Three research assistants independently coded studies in accordance with the codebook. We selected 30% of the studies to check inter-coder reliability between pairs of coders, which was estimated via the "irr" package of R 3.4. The results of the inter-coder reliability estimation using Krippendorff's α ranged between .87 and .95 (moderator d through g). Partial discrepancies were resolved through discussion.

Procedures

Overall, there were five steps in the present study. Step 1 through Step 4 form stage 1 of the so-called two-stage meta-analytic structural equation modeling (MASEM) approach, leaving Step 5 in stage 2. However, unlike Cheung and Chan (2009) assumed that all studies have the same population correlation or covariance matrices, and thus, the heterogeneity is estimated using a homogeneity statistic Q (Brockwell & Gordon, 2001; Hedges, 1981; Higgins & Thompson, 2002; Schmid, Koch, & LaVange, 1991) in stage 1 (Jak, 2015). In the absence of homogeneity, the random effects model (as opposed to a fixed effects model, which assumes that the true effect is the same for all studies), which allows the true effect to vary across studies, is used (Brockwell & Gordon, 2001; National Research Council, 1992; Schmid et al., 1991). Furthermore, we account for variability in heterogeneous effect sizes by relating them to the coded attributes of the studies. That is, the pooled correlation matrix is adjusted by the moderator effect. Fitted models were estimated on the basis of the Akaike information criterion (AIC), followed by the QE (test statistic of residual the heterogeneity) and QM (omnibus test statistic of the significance of moderators) statistics.

In addition, the compilation of effect sizes showed a clear hierarchical structure, as there were multiple effect sizes for many studies. Consequently, to sidestep the dependence problem among the effect sizes, we analyzed these data with multilevel mixed-effects modeling using the metafor package of the R language (Viechtbauer, 2010), which is generally superior to other approaches, e.g., robust variance estimation and averaging effect sizes (Berkey, Hoaglin, Antczak-Bouckoms, Mosteller, & Colditz, 1998; Moeyaert et al., 2017; Wilson et al., 2016). It should be noted that this practice in Stage 1 is also different from the procedure proposed by Cheung (Cheung & Chan, 2009; Cheung, 2015b).

The two-stage MASEM approach that the present study performs consists of the following five steps:

Step 1: The first step involves the estimation of a pooled correlation matrix of the relations. A matrix is constructed to represent the zero-order relations among the variables for each of the 73 studies. The unadjusted pooled correlation matrix as well as the heterogeneity is estimated using the random-effects meta-analysis with the multilevel modeling approach. The cell number indicating the position of a particular correlation in the original correlation matrix is tested as a moderator in the model without the intercept. The resulting coefficients are the pooled correlation matrix.

Step 2: The next step is again to run the random-effects meta-analysis in the multilevel model with the intercept taking into account the aforementioned study moderators.

Step 3: The resulting meta-regression coefficients and associated residual values in the above meta-regression model are used to calculate the moderator-adjusted correlations.

Step 4: Estimate the adjusted pooled correlation matrix in the same way as in Step 1, but replace the original correlation coefficients with the adjusted ones derived in Step 3.

Step 5: The path models involving the predictors of the intention and behavior based on the HBM and relevant theories based on the adjusted pooled correlation matrix are estimated using the weighted least squares (WLS) estimation (with 5,000 parametric bootstrap replicates) of metaSEM (Cheung, 2015a).

Results

The multilevel modeling in Step 1 was performed to derive the pooled correlation matrix (It was shown in Table 1). The test for residual heterogeneity [QE (df = 1031) = 22862.2995, $p < .0001$] and the test of moderators [QM (df = 36) = 736.331, $p < .0001$] were both significant. The intraclass correlation (ICC) value is .102, which indicates that 10.20% of the variance is attributable to the between-study variability. The pooled correlation matrix presents the anticipated results (see Table 1), which are generally predicted by the expanded HBM. The variable of perceived barriers was negatively correlated with all other variables, and there generally existed weak correlations among all other variables. However, the correlations between perceived severity and perceived barriers, perceived benefits, self-efficacy, cues to action, health literacy, intentions and screening behavior were not significant (also cf. Bish et al., 2000; Harrison et al., 1992; Janz & Becker, 1984). The correlation between perceived susceptibility and self-efficacy and that between health literacy and cues to action were not significant either.

None of these study moderators were found to be significant in Step 2 through Step 3. Consequently, Step 4 was skipped, and the unadjusted pooled correlation matrix generated in Step 1 was used in Step 5. Three models were tested and compared on the performance (R^2). All variables directly predicted cancer screening behavior in model 1, while all variables predicted intentions and behavior at the same time in model 2. Model 2 was further simplified into model 3, in which intentions fully mediated the effects of the independent variables on behavior. Through comparing changes in R^2, model 3 was found to be superior to both model 2 and model 1. In model 3, the R^2 values of behavior and intentions were 3% (4% in both model 1 and mode 2) and 17% (12% in model 2), respectively, which indicated a trivial amount of the explained variance of behavior but an acceptable amount of the explained variance of intentions. Furthermore, all of the fit indices of model 3 met the cut-off criteria (cf. Hu & Bentler, 1999) (see Table 2), indicating that the model fits the data well. It was found that the variable of intentions was only positively predicted by cues to action, health literacy, and perceived susceptibility and that behavior was negatively predicted by intentions (see Table 2). All other predictions were not significant. The total indirect effect was -.094, which means that all of the predictors had trivial negative effects on behavior through intentions.

Discussion

Gap between Health Intentions and Health Behaviors

This study found that the gap between intention and behavior is real, and this result is also consistent with part of the prior findings (e.g., Webb & Sheeran, 2006). For instance, some researchers (Bish et al., 2000; Zimmerman & Vernberg, 1994) found that the HBM was weakly predictive of behavior in comparison with social cognitive theories, such as the TPB and the TRA (cf. Carpenter, 2010). The present study has further discovered that the determinants of both intentions and behavior embodied in the TRA and the TPB also only partially predict intentions (cf. Bish et al., 2000) and that the performance of behavior is not as simple as a natural outcome of intentions (Fishbein, 2000; Fishbein & Cappella, 2006). The HBM (as well as other value-expectancy-based theories) is better represented as an effect of health beliefs on health intentions rather than behavior and hence is hardly a behavior prediction theory.

There are two possible paths to improve the prediction of behavior. The first is to strictly stick to the original or reconsider both the conceptualization and operationalization of factors encompassed in these theories. For instance, attitudes, subjective norms and perceived behavioral control were often incorrectly directly measured and tested in many applied studies (see the review with respect to these factors above). In addition, as Fishbein and Cappella (2006) pointed out, specific instead of general beliefs associated with screening characteristics ultimately underlie and determine intentions and behaviors. Some important determinants of health behavior have been notably unheeded in the literature, and hence, they may be included to translate intentions into behavior. For instance, Gollwitzer (Gollwitzer, 1993; Gollwitzer & Sheeran, 2006) proposed the implementation of intentions to improve the prediction of actual behavior while arguing that individuals pass control to the environment, which acts as a cue to action. When cues are present, the performance of the intended behavior ensues (Gollwitzer, 1993). Fishbein (Fishbein, 2000; Fishbein & Cappella, 2006) incorporated actual ability and environmental factors in addition to intentions. Wakefield et al. (2010) underscored policy support. Furthermore, screening intentions may be temporal and situational (Bish et al., 2000). Consequently, some authors (Bowdy, 1998; Champion et al., 2003) combined the HBM and the transtheoretical model (TTM) (or stages of change) in their screening research, whereas others (Manne et al., 2002) further incorporated the dual process model in the combination of the HBM and TTM. Moreover, suggesting a distinction between pre-intentional motivation processes that lead to a behavioral intention and post-intentional volition processes that lead to actual behavior, Schwarzer and his associates (Schwarzer, 2008; Sniehotta, Scholz, & Schwarzer, 2005) proposed the health action process approach (HAPA) by incorporating three post-intentional factors (planning, maintenance self-efficacy, and action control) to the expanded HBM. These efforts are commendable, but the effect should also be amenable to a model-based meta-analysis.

Significant Predictors of Cancer Screening Intentions

We found that the individual importance of predictors of the HBM is unequal. Cues to action, health literacy, and perceived susceptibility are the more effective determinants of the cancer screening intention. The long-believed core components of the HBM, i.e., perceived barriers, perceived benefits and perceived severity, played a marginal role in predicting intentions. Therefore, a much more parsimonious revised HBM model is proposed (see Figure 2). Internal cues to action and perceived susceptibility are directly related to personal immediate vulnerability or the probability of getting cancer. Moreover, internal cues and perceived vulnerability may be triggered or primed by external cues to action, and there is no salient or discernible imminent threat or risk without sufficient awareness and knowledge (cf. Rosenstock, 1974b). By the same token, general outcome expectancies or beliefs about screening benefits and barriers are too distant to concern and urge people, who do not act until they realize they are in real danger. Although perceived behavioral control was not significant in the overall model, it was still incorporated into our revised HBM due to its theoretical importance and the significant contribution to changes in the R^2. Our revised HBM was tested with a perfect model fit (the RMSEA and RSMR were 0 and the CFI was 1), and all predictors had significant positive effects on intentions ($\beta s \cong$ [.11, .18], ps <.001, R^2 = 13%). Although the proposed parsimonious model is open to further tests, it has a very similar explanatory power to the complex HBM, albeit with significant predictions on intentions using the collective data source. Consequently, the present study has significantly advanced the development of theory on cancer screening intentions.

Practical and Methodological Implications

The findings also have profound practical implications. Health communication campaigns should focus on enlightening and engaging the public through all necessary means to raise awareness and transfer knowledge in relation to screening procedures as well as cancers per se. Nevertheless, the downside of the finding is that the knowledge gap (Donohue, Tichenor, & Olien, 1975) or inequality in health literacy is pervasive among ethnicities and various social strata (cf. Scarinci, Beech, Kovach, & Bailey, 2003; Weller & Campbell, 2009) and is hence a thorny worldwide problem to tackle. Therefore, to improve universal health literacy, health communication has a long way to go.

To our knowledge, the present paper is one of the very few model-based meta-analytical studies in health communication, although Eisend (2017) briefly summarized the gist of MASEM, and James (2010) applied MASEM in an interdisciplinary journal. In addition, this study has discovered the limitations of the HBM and other similar value-expectancy-based theories in predicting cancer screening intentions and behavior. As a result of this finding, a parsimonious model is proposed, and other remedies to the existing models are also discussed. Moreover, effective health communication strategies and interventions are suggested. Therefore, the present study has made substantial theoretical, methodological, and practical contributions to health communication.

Limitations and Future Research Directions

This study has limitations. Both the conceptualization and measurement of the same factors in the primary studies are far removed from one another. This would call into question the validity of the variables used in the model. In addition, since the model-based meta-analysis requires complete correlations, some meaningful predictors such as trust in health providers, social capital, and demographics were removed in the present study. This constraint has prevented us from exploring more possibilities of theory testing as well as advancement. An additional limitation results from the developmental nature of model-based meta-analysis methodology, whose algorithms and software packages are works in progress. As a result, some forms of theory explorations may not be available.

Moreover, we only considered the studies that examined the positive cancer screening intentions and behaviors, but neglected those that studied the behaviors of overscreening. Nevertheless, overscrening has psychological and social implications (Milhabet et al., 2013), future meta-analysis should include studies in the two separate lines of research, and ideally examine the differences in predictors and effect sizes.

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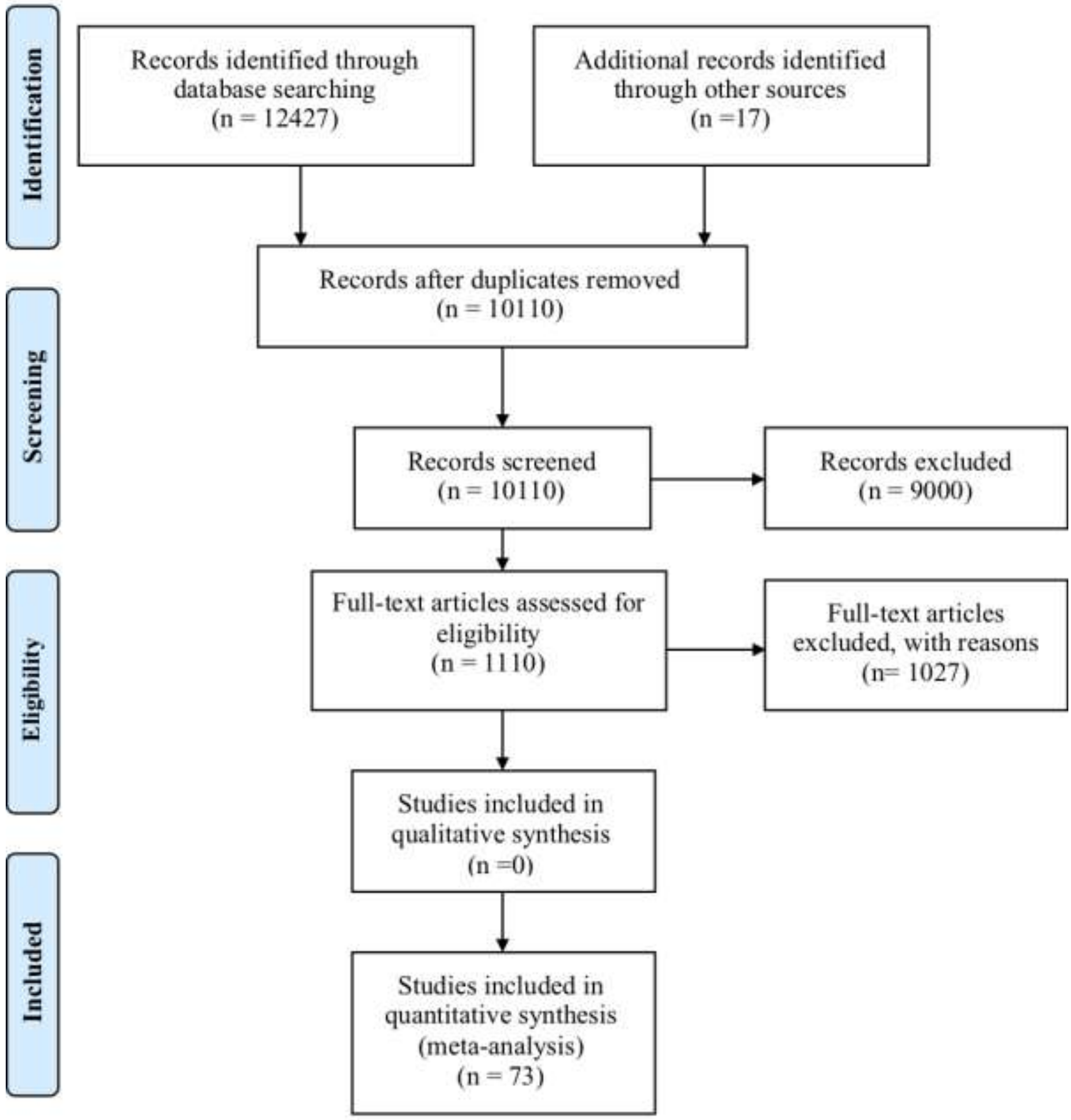

Figure 1: PRISMA 2009 Flow Diagram

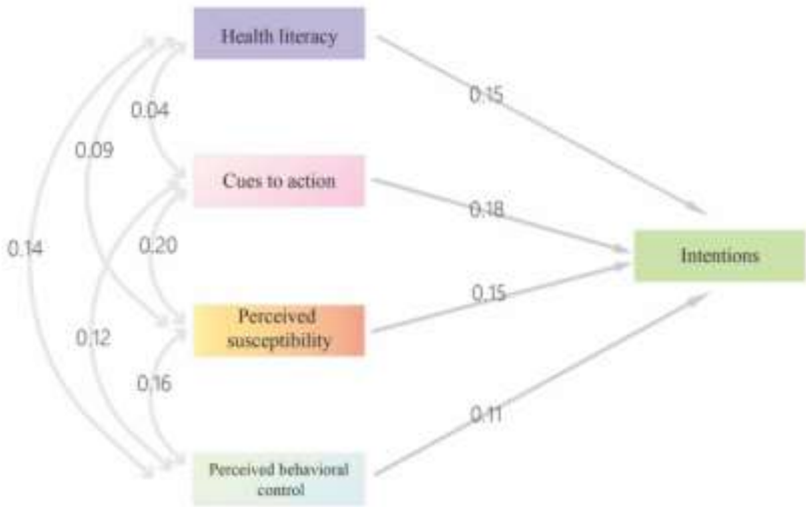

Figure 2 The revised HBM

Table 1

Pooled zero-order correlation matrix

	PBAR	PBEN	PBC	INT	PSEV	PSUS	CTA	CS	LIT
PBAR	1	49 (52527)	70 (62731)	84 (62130)	31 (19138)	42 (39261)	43 (32655)	124 (64034)	65 (38460)
PBEN	$-.135^{***}$	1	18 (31486)	20 (34780)	12 (8412)	20 (25018)	12 (15568)	19 (18021)	19 (9630)
PBC	$-.103^{***}$	$.283^{***}$	1	31 (39591)	8 (6359)	13 (18942)	13 (16703)	39 (28169)	19 (15645)
INT	$-.134^{***}$	$.271^{***}$	$.21^{***}$	1	10 (5389)	25 (20021)	33 (20319)	25 (26028)	34 (16113)
PSEV	-.021	.077	.004	.023	1	10 (7505)	9 (3922)	16 (6106)	10 (7344)
PSUS	$-.068^{*}$	$.183^{***}$	.03	$.176^{***}$	$.193^{***}$	1	9 (9281)	19 (15255)	18 (16883)
CTA	$-.094^{***}$	$.101^{*}$	$.088^{\#}$	$.161^{***}$	.006	$.142^{*}$	1	35(2763873)	14 (9064)
CS	$-.153^{***}$	$.203^{***}$	$.177^{***}$	$.261^{***}$	.028	$.125^{**}$	$.169^{***}$	1	49 (27300)
LIT	$-.054^{*}$	$.17^{***}$	$.181^{***}$	$.15^{***}$	.003	.049	.051	$.142^{***}$	1

Note: *** *p* <.001, ** *p* <.01, * *p* <.05, # *p* <.10. CS=screening behavior, INT=intention, CTA=cues to action, LIT= health literacy, PBAR=perceived barriers, PBC=perceived behavioral control or self-efficacy, PBEN=perceived benefits, PSEV=perceived severity, and PSUS=perceived susceptibility. The numbers shown in the upper triangular matrix represent the k (number of studies) and total sample size (within brackets).

Table 2

Results of the WLS estimation using metaSEM

	Estimate	Std. Error	z value	Pr (>|z|)
CS on INT	-.158	.036	-4.416	0
INT on CTA	.237	.025	9.591	0
INT on LIT	.135	.033	4.06	0
INT on PBAR	-.013	.056	-.227	.82
INT on PBC	-.03	.066	-.457	.648
INT on PBEN	.041	.048	.849	.396
INT on PSEV	.105	.065	1.627	.104
INT on PSUS	.119	.06	2.007	.045

Note: *N*=1,410,240, $\chi^2(7)$ = 55.989, $p < .001$, RMSEA= .002, $\text{RMSEA}_{\text{lower 95\% CI}}$=.002, $\text{RMSEA}_{\text{upper 95\% CI}}$=.003, SRMR= .042, TLI= .648, CFI =.932, AIC =41.989, and BIC= -43.126. CS=screening behavior, INT=intention, CTA=cues to action, LIT= health literacy, PBAR=perceived barriers, PBC=perceived behavioral control or self-efficacy, PBEN=perceived benefits, PSEV=perceived severity, and PSUS=perceived susceptibility