The health belief model and theory of planned behavior applied to mammography screening : a systematic review and meta-analysis

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Background

The Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) are used to explain screening behavior. Although reviews of each model have been conducted independently, none have compared the application of both to mammography screening.

Methods

A systematic review of literature published in 5 databases from 1974 to 2020 was performed. Meta-analysis was conducted of the explanatory value of the HBM and TPB, and effect sizes of their cognitive variables.

Results

Altogether, 673 papers reporting HBM studies and 577 reporting TPB studies were recovered, of which 43 HBM studies and 15 TPB studies met eligibility criteria. Twelve studies reported on the explanatory value of either model. The explained variance for HBM ranged from 25% to 89% (mean $R^2 = 0.55$), whilst the explained variance for TPB ranged from 16% to 81% (mean $R^2 = 0.24$ [screening behavior as outcome] and 0.46 [intention as outcome]). The component of 'cue to action' had the greatest effect size (mean OR 1.80 [95% CI: 1.58-2.04]).

Conclusions

Whilst the HBM and TPB both demonstrated positive explanatory value, most studies examined the individual constructs of each model and failed to report consistently on the effectiveness of the models.

Keywords: Health Behaviors, Mammography, Mass Screening, Meta-analysis, Systematic Review.

The Health Belief Model and Theory of Planned Behavior Applied to Mammography Screening: A Systematic Review and Meta-analysis

Background

Breast cancer is the most frequently occurring cancer in women, with over 2 million new cases diagnosed worldwide in 2018 (Bray et al., 2018). To address this burden, mammography screening has been developed to detect cancer at a more treatable stage. Whilst early detection of breast cancer via mammography screening ultimately reduces breast cancer mortality in the target population (Sarkeala et al., 2008) (Nelson, 2009), participation rates vary drastically from 6% to 80% (Basu et al., 2018). To improve participation in mammography screening it is important to identify the factors related to participation via validated models of human behavior (Griva et al., 2013). Two models often used to study participation in mammography screening are the Health Belief Model (HBM) and the Theory of Planned Behavior (TPB) (Savage & Clarke, 2001).

The Health Belief Model (HBM) is a cognitive framework viewing people as rational beings who use a multidimensional approach to decision-making regarding whether to perform a health behavior (Rosenstock, 1974). The HBM was initially formulated to explain low participation in disease prevention programmes by examining factors that may be motivating or inhibiting participation (Bk et al., 2005). Underpinning the development of the HBM are two central elements: the belief that an action will improve health or prevent ill-health; and the motivation to avoid ill-health. The HBM rests on both aspects plus an individual's perception regarding the barriers and benefits of the behavior that may improve health or prevent ill-health (Conner, 2001). The initial version of the HBM identified 4 components: perceived susceptibility (perception of individual risk); perceived severity (extent to which a person deems the condition as serious); perceived benefits (one's opinion on the usefulness of a behavior in decreasing risk); and perceived barriers (evaluation of the obstacles to adopting a behavior). Other constructs were later added including 'cues to action' (events, people or things that are associated with change in behavior) and 'self-efficacy' (one's confidence to act) (Bk et al., 2005). Figure 1 shows the components of the Health Belief Model (Glanz, K., Rimer, B. K., & Viswanath, 2008). Given the emphasis of the HBM on an individual's evaluation of the perceived benefits and barriers to adopting a behavior, the HBM has been frequently used to explain breast cancer screening participation. (Pasick & Burke, 2008). Analysis of the explanatory power of the HBM reported that the model explained between 15% to 27% of the variance in behavior (Yarbrough & Braden, 2001). However, meta-analyses of the utility of the HBM have concluded that the model varied in its effectiveness to predict behavior. This has given rise to a concern that the model may be more suited to describe rather than explain health behaviors (Champion et al., 1997) (Carpenter, 2010).

The Theory of Planned Behavior (TPB) is a socio-cognitive model that has been applied to many health-related behaviors (Griva et al., 2009). Figure 2 shows the components of the Theory of Planned Behavior (Ajzen, 1991). The model posits that health behavior is to a large extent a function of the intention to perform the behavior. Intention is in turn determined by attitudes, subjective norms, and perceived behavioral control (PBC). Attitudes are derived from beliefs about the likely outcomes of the behavior and the evaluation of the expected outcome. Subjective norms refer to the perceived social influence to engage in the behavior and are determined by the normative beliefs concerning expectations of significant others and the motivation to comply with these expectations. PBC reflects people's perceived ability to perform the behavior and is based on control beliefs about possible facilitators or inhibitors, and the strengths of those beliefs. Like attitudes and subjective norms, PBC is related to intentions but it can also influence behavior directly. The TPB derives from the earlier Theory of Reasoned Action by stressing the importance of a person's perceived behavioral control, which in the TPB performs a similar function to self-efficacy in HBM. The TPB has been applied to a broad range of behavioral domains, and meta-analytic reviews support its predictive validity for a range of health-related behaviors (Godin & Kok, 1996) (Armitage & Conner, 2001). Overall, the TPB has performed well in explaining intention, but less well in predicting behavior (Cooke & French, 2008).

While both models differ in their construction, each model measures individual beliefs and evaluations of a certain behavior and its outcome (Weinstein, 1993). However, the TPB differs from the HBM in the sense that the latter is specifically focused on health behavior, while the TPB is a general behavioral model. Additionally, the TPB addresses behavioral intention, which has led to the combination of intention with HBM variables to the study of breast cancer screening participation (Griva et al., 2009). Although several literature reviews and meta-analyses of the TPB and HBM have been conducted independently, to the best of the authors' knowledge, none have so far been published comparing the application of both models to mammography screening. Therefore, the aim of this study was to compare the use of the HBM and TPB in research on mammography screening participation, addressing the comparable aspects and points of divergence between both models. A systematic search of the literature was performed to identify articles pertinent to the research question and meta-analysis of the models and their cognitive components.

Method

A systematic review was performed of articles published between 1974 and 2020, using PubMed, Ovid, ProQuest, Web of Science, and the University of Antwerp discovery service to retrieve publications. The dates of publication for papers eligible to be included in the review was purposely set as wide as possible to be comprehensive. Therefore, the date of eligibility began from the initial publication of the HBM in 1974. Appendix 1 lists the detailed search strategy used for the review. The review followed the protocol for systematic reviews outlined in the Cochrane Reviewer's Handbook (Higgins JPT, 2019), comparing the use of the HBM and TPB in the research of cancer screening participation.

Selection of Articles

Studies had to address either of the behavioral models (HBM or TPB) and examine breast cancer screening in an asymptomatic population using mammography. Studies that considered other diseases (for example, cervical cancer) or other screening modalities (such as breast self-examination) were eligible for inclusion, provided data for mammography screening were presented independently. Studies remained eligible if they had used a modified version of the models, for example, by including additional variables. The dependent variables related to attendance at mammography screening or change in intention to participate in mammography screening. The independent variables were derived from either the HBM or TPB. Studies measuring intention as an outcome were eligible as intention is a close antecedent to participation in the TPB. All studies were published in English between 1974 to 2020. This date range was chosen to correspond with the initial date of publication of the HBM and thereby be comprehensive in capturing eligible studies.

Studies were excluded if they addressed women undergoing treatment for breast cancer, symptomatic women or if the study focused solely on breast self-examination. The method for applying the criteria for exclusion of articles from full analysis was agreed upon by consensus among the co-authors.

Data Extraction and Analysis

A comprehensive data extraction template based on the PRISMA statement was created in MS Excel to extract relevant data from the studies (Moher et al., 2009). The protocol was adapted from a method developed by a previous study (Nyambe et al., 2016). Studies underwent an initial checking of article titles against the exclusion criteria, before a review of the abstracts of the remaining studies was completed. Full text reviews were then performed to assess eligibility against the inclusion criteria. Only articles passing the full inclusion criteria were analyzed using the data extraction template.

Following the data extraction, a critical assessment was conducted to consider the quality of the studies included in the review. For this assessment, a checklist was used that was designed to assess the clarity and evidence-base for the conclusions of research, looking at the clarity of the research question, data collection methods, sampling strategy and size, and study limitations (Kampen & Tamás, 2014). Additional aspects were taken from an adapted version of the Newcastle Ottawa scale, which has been used to assess the quality of cross-sectional studies (Herzog et al., 2013). These additional questions were included to add a greater depth to the critical appraisal of the studies. To assess the reliability of the critical appraisal procedure, a random sample of 20% of the included studies were scored by three raters independently. Interrater reliability of the critical appraisal was established by comparing the blinded scores of the three raters for the randomly selected proportion of articles.

Data from the independent variables of both models were extracted only if reported as statistically significant per variable of the behavioral model. In addition, the overall explained variance (R^2) of the behavioral models was extracted from the studies. Meta-analysis of the effect sizes (odds ratios) for the independent variables of each model were analyzed using generic inverse variance method. The meta-analytic mean for the behavioral models' explained variance (R^2) for mammography screening behavior and intention was calculated using a varying coefficient meta-analytic tool (Krizan, 2010).

Results

The systematic search returned a total of 673 results for papers using the HBM after duplicates were removed. Following a review of abstracts, 578 articles were removed. Of the remaining 95 articles, the full text review resulted in removing an additional 52 articles. Consequently, 43 articles were eligible for inclusion. Figure 3 shows the PRISMA flow chart for papers exploring the HBM.

The search for papers based on the TPB returned a total of 577 publications after duplicates were removed. Based on the abstracts, 542 articles were removed for not meeting the inclusion criteria. Assessment of full texts of the remaining 35 articles resulted in removing another 20 articles, leaving a total of 15 articles for inclusion. Figure 4 shows the PRISMA flow chart for papers exploring the TPB.

Description of the Studies

Appendix 2 outlines all articles included in the review. Of the 58 papers reviewed in the analysis, only 2 papers had used both the HBM and the TPB as the conceptual basis to identify factors associated with participation in mammography screening. Both papers used one of the models as their primary conceptual framework, thus were included in the collective analysis for the respective models. Reported sample sizes ranged from 114 to 27 778 for the studies using the HBM, and 68 to 2657 in the studies based on the TPB. The study with largest sample size used secondary analysis of a large-scale mammography surveillance project in North America. Most studies used a cross-sectional design (HBM = 33/43; TPB = 11/15). Randomized-controlled trials (RCT) were used in 4 of the studies using the HBM with a sample size range of 120 to 773. In the papers based on the TPB, 2 studies used a RCT design with a sample size range of 100 to 184. For HBM articles, 2 longitudinal studies were reported with a sample range of 216 to 5100. Whereas for the TPB, 2 studies had a longitudinal design reporting a sample size range of 1215 to 2657. Three of the HBM articles used secondary analysis of existing datasets. The sample size range was 602 to 27 778.

The most frequent geographical location for the studies were North and Central America (HBM = 22/43; TPB = 8/15) and Europe (HBM = 9/43; TPB = 4/15). The most frequently assessed outcomes in HBM studies were to examine the association of factors from the HBM applied to mammography screening behavior (n = 18/43), assess adherence to mammography screening guidelines (n = 15/43), and investigate socio-cultural or environmental factors related to participation (n = 9/43). For TPB articles, the most frequently assessed outcomes were to examine the associations of TPB factors to mammography screening (n = 8/15), examine the associations of the TPB constructs to intention to screen (n = 4/15), and to assess adherence to mammography screening guidelines (n = 4/15). The most frequently assessed individual variables of the HBM-based studies were perceived barriers (n = 42/43,) perceived susceptibility (n = 40/43); and perceived benefits (n = 38/43). For TPB-based studies, the most frequent variables studied were subjective norm (n = 14/15), attitude toward participation in screening (n = 13/15), and perceived behavioral control (n = 13/15).

Quality Assessment

Studies concerned with both models scored relatively well in their application of appropriate statistical tests and data collection methods. The studies scored relatively less well in the assessment and comparability of outcomes, which was attributable to the lack of independent assessment and record linkage, as the high number of studies used cross-sectional methods.

Appendix 3 details the quality assessment criteria used in the review and complete scores per article included in the review.

Explanatory Value of the Models

Table 1 shows the meta-analytic mean of HBM and TPB applied to mammography screening behavior and intention. Seven studies reported on the effectiveness of the HBM as a model for explaining variation in the participation in mammography screening, covering a total number of 3776 participants. The mean R^2 reported for HBM was 0.55, with a reported R^2 range from 0.25 to 0.89. For studies exploring the TPB model, 5 of the 15 studies reported in their conclusions on the explained variance of the model for mammography screening behavior or intention. The results for the TPB constructs are presented independently regarding their explained variance for screening behavior and intention. This is due to model's assumption that intention is the immediate precursor to behavior and is, therefore, very often the outcome variable measured (Steele & Porche, 2005). Three studies measured intention as the outcome with an R^2 range of 0.24 to 0.81 and mean R^2 of 0.46. The remaining 2 studies focused on screening behavior, reporting a mean R^2 of 0.24. The characteristics and explanatory value of the HBM and TPB variables applied to mammography screening behavior and intention are reported in appendix 4. Values are not reported for several studies exploring the HBM (n = 19) and TPB (n = 4) as the papers did not report statistically significant values per the constructs of the models.

Tables 2 and 3 show the results of the meta-analysis of the effect-size of the components of both behavioral models. For the HBM, the component of cues to action had the greatest effect with a mean OR of 1.80 [95% CI: 1.58-2.04], with 7 studies reporting a significant result for cues to action, followed by perceived benefits with a mean OR of 1.42 [95% CI: 1.34-1.51], and 11 studies reporting a significant result. Perceived severity (0.94 [95% CI:

0.87-1.02]), perceived barriers (0.93 [95% CI: 0.92-0.95]) and health motivation (0.94 [95% CI: 0.89, 1.00]) were negatively associated with mammography screening behavior. For TPB, the component of intention had the greatest effect with a mean OR of 1.72 [95% CI: 1.39-2.13], with 3 studies reporting a significant result, followed by subjective norm (with intention to screen as the outcome) with a OR of 1.27 [95% CI: 1.10-1.47]; However, only 1 study reporting a significant result. Perceived behavioral control (0.99 [95% CI: 0.96-1.02]), and attitudes (0.98 [95% CI: 0.89-1.00]) were negatively associated with mammography screening behavior.

Discussion

The aim of this review was to compare the use of the HBM and TPB in the research of mammography screening participation by addressing the comparable aspects and points of divergence. The results of the systematic review indicated that both models showed significant associations of their variables with participation in mammography screening: the HBM explained between 25% to 89% of the variance in participation in mammography across the studies using the HBM, with a mean of 55%, while the percentage of variance explained by the TPB ranged from 16% to 32% with a mean of 24%. For studies measuring intention as the outcome, the mean explained variance was 46%. For both models the mean R^2 values were broadly in line with those reported in the literature (Carpenter, 2010) (Cooke & French, 2008). However, few studies reported the explained variance of the models in relation to screening behavior and intention.

For HBM studies, the components of cues to action and perceived benefits were the variables most strongly associated with participation in mammography screening. As reported in several studies, perceived barriers and severity appear to be the least strongly associated variables of the HBM (Yarbrough & Braden, 2001) (Lagerlund et al., 2000). This has been explained in the literature by the assertion that a clear majority of women would inevitably consider breast cancer to be a serious condition (Sallis et al., 2008).

For TPB studies, intention is clearly the most strongly associated variable for participation in mammography, and intention is associated with subjective norm. This corresponds to the theory's prediction that intention is the most immediate factor related to behavior and reflects the findings of previous assessments of TPB and mammography screening (Griva et al., 2009). They also confirm the results of the broader review by Godin and Kok (1996), which concluded that for clinical and screening studies, TPB performs well in explaining intention but less well in explaining behavior (Bowie et al., 2003).

The studies included in this review had several shared characteristics in the application of the HBM and TPB to mammography screening. Most studies contained a mixed sample of respondents who had either never been screened or screened at least once in their lifetimes. In many cases, insufficient detail was provided to determine which participants had never participated in mammography screening, except for those studies in which the specific goal was to investigate non-participation behavior. This represents a challenge to analyze the explanatory value as the behavioral and social variables were likely to be affected by whether the participation occurred for the first time, was established and routine or had lapsed entirely. Future analysis of the explanatory ability of the models applied to participation in mammography screening should be sub-categorized according to the nature of participation. This is especially relevant for the TPB, which is more explicitly related to the initiation of screening behavior than to the maintenance of screening behavior (Drossaert et al., 2003).

Another common characteristic was the reliance on self-report to establish participation or non-participation, which was linked to the use of a cross-sectional methodology. The retrospective design of most studies presented difficulties for establishing relationships between the independent variables and the behavioral outcomes. Prospective studies are, therefore, preferred as they can offer more accurate identification of the explanatory value of the models.

Both HBM and TPB share a characteristic in their weakness to account for demographic factors, such as socio-economic status and ethnicity, despite the fact that many studies focused on participation amongst minority ethnic groups. This absence may account for some of the unexplained variation of the models' explanatory power (Tanner-Smith & Brown, 2010). For this reason, several studies propose to amend and update the HBM to take better account of broader contextual factors (Pakenham et al., 2000) (Russell et al., 2006).

The studies analyzed in this review also share a problem in that they do not make sufficient efforts to distinguish between first time attendance, repeat attendance, and routine attendance behaviors pertaining to mammography screening. This element is crucial given that any prior experience with mammography will influence future behavior and affect certain constructs of the behavioral models. For example, perceived barriers have been found to be more influential for first-time attendance than repeat attendance, given that a woman may understand the possible barriers and be able to overcome them during repeat or routine attendance (Anagnostopoulos et al., 2012) (Sunil et al., 2014).

Finally, the operational definitions of the cognitive components of both models (e.g., perceived severity, subjective norm, etc.) vary in their application across the studies included in this review. In addition, various indicators have been adopted to measure the HBM and TPB variables, which leads to disparate operationalization of the cognitive constructs and the subsequent conclusions (Tanner-Smith & Brown, 2010). The effect of the variation in the operationalization of the cognitive constructs is mitigated using validated measurement tools. Champion's HBM scale, which is specifically designed for the application to mammography screening, is an example of such a tool that exists for the HBM. Such a validated measurement tool for the TPB has not yet been produced for use in breast cancer screening. This could therefore be a future research priority for the application of TPB to mammography screening.

Limitations

Firstly, publication and selection biases were possible, given the focus on English language articles only. Moreover, the date range for study inclusion (1974-2020) is very broad and spans a period in time in which considerable developments in society and improvements in mammography screening has taken place. Consequently, there may be some bias in the application of the components of the models, for example, following mass media discussion on the potential harms of mammography screening provoked by the Nordic Cochrane collaboration review first published in 2000 (Gøtzsche & Jørgensen, 2013). This may have had an impact on perceptions of risk and affect the social norms surrounding mammography screening, particularly in Europe. Many of the studies did not report whether the sample size of the study participation was large enough to detect modest but meaningful associations to support the conclusions of the studies, which inhibits generalization. The studies also failed to distinguish consistently between screening behaviors that were either first-time, occasional, or habitual. Values are not reported for any components of the models for 23 studies included in the review, which is a further limitation and indication of heterogeneity of reporting amongst the studies. The lack of consistent quantitative data presentation in the studies to analyze the overall explanatory value of the models regarding mammography screening behavior weakens the potential to review critically the extent to which both models were applied to mammography screening. Therefore, the analysis of the studies relies more on the application of the respective cognitive components.

Conclusions

This review compared the use of the HBM and TPB to mammography screening behavior. HBM and TPB demonstrated positive explanatory value for mammography screening participation, although only a minority of studies reported on the overall effect of either model. The results showed that the HBM is more widespread in the literature, benefits from the existence of a validated measurement tool for applying the model to breast cancer screening and has a positive explanatory value for mammography screening participation.

Few studies reported on the effectiveness of the models, as most focused on the models' cognitive components. The absence of such data presents limitations in analyzing the extent to which the models can explain variance in mammography screening behavior. Future research should include this element alongside validation measures of self-report, or prospective methodologic designs. Further research of the application of the models to clearly distinguish between first-time, infrequent, and repeat mammography screening behavior is required.

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Captions and Legends for Figures and Tables

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Abbreviations: CI, Confidence Interval; IV, Inverse Variance; SE, Standard Error.