Published in final edited form as:

Ann Behav Med. 2014 February ; 47(1): 120–129. doi:10.1007/s12160-013-9528-0.

Competitive testing of health behavior theories: how do benefits, barriers, subjective norm, and intention influence mammography behavior?

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Abstract

Background—Competitive hypothesis testing may explain differences in predictive power across multiple health behavior theories.

Purpose—We tested competing hypotheses of the Health Belief Model (HBM) and Theory of Reasoned Action (TRA) to quantify pathways linking subjective norm, benefits, barriers, intention, and mammography behavior.

Methods—We analyzed longitudinal surveys of women veterans randomized to the control group of a mammography intervention trial (n=704). We compared direct, partial mediation, and full mediation models with Satorra-Bentler χ^2 difference testing.

Results—Barriers had a direct and indirect negative effect on mammography behavior; intention only partially mediated barriers. Benefits had little to no effect on behavior and intention; however, it was negatively correlated with barriers. Subjective norm directly affected behavior and indirectly affected intention through barriers.

Conclusions—Our results provide empiric support for different assertions of HBM and TRA. Future interventions should test whether building subjective norm and reducing negative attitudes increases regular mammography.

Introduction

Application of health behavior theories to interventions is recommended to advance our understanding of the theoretical mechanisms that drive behavior change and to build consensus about common theoretical constructs and pathways (1). Several researchers have highlighted overlap in the conceptual definitions of constructs from different theories (e.g., beliefs about the target health behavior are labeled as perceived benefits and barriers in the Health Belief Model, attitude towards the behavior in Theory of Reasoned Action/Planned Behavior, and benefits and barriers in the Transtheoretical Model). Others argue that, while theories may share common constructs, the hypothesized pathways linking constructs to each other and behavior are distinct. Despite Noar and Zimmerman's (2) and Weinstein and Rothman's (3) call for building consensus across theories, few longitudinal studies have

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Conflict of Interest Statement: The authors have no conflict of interest to disclose.

examined direct and indirect causal pathways through which theoretical constructs influence behavior.

Brewer and Gilkey (4) describe two current schools of thought on how to best test health behavior theories: a summary approach and competitive hypothesis testing. In the summary approach, all constructs within one theory are measured and the ability of the constructs to predict variance in the behavior is evaluated using traditional structural equation modeling fit statistics. The competitive hypothesis testing approach pits two or more theories against each other by examining alternative pathways linking constructs. Each theory is treated as a group of separable arguments, whereby competing arguments are isolated to understand distinct mechanisms of a theory. Although the summary approach may promote a better understanding of an individual theory, competitive hypothesis testing identifies specific pathways that explain differences in predictive power across two or more theories.

Few investigators have tested pathways linking different constructs to each other and to mammography uptake behavior (5–8), although many have investigated whether various constructs are correlates or predictors of mammography. Moreover, most intervention developers have used constructs from multiple theories, and the majority have only examined whether each construct is directly associated with mammography behavior (9). Few studies have comprehensively applied all of the constructs within one particular theory (5, 10–12), and tested both direct and indirect pathways as hypothesized by a theory. None has used a competitive testing approach. Competitive hypothesis testing may refine the application of theory to mammography screening behavior and help identify specific pathways that increase the effectiveness of behavioral interventions to promote screening.

The purpose of this study is to test the pathways linking subjective norm, benefits, barriers, intention, and mammography behavior. We chose to focus on these theoretical constructs because the pathways linking them to each other and behavior are debated across the major theories of the Health Belief Model (HBM) and Theory of Reasoned Action/Planned Behavior (hereafter labeled TRA because we did not evaluate perceived behavioral control).

Beliefs about the target behavior appear in both HBM and TRA; however, their conceptual labels and pathway of influencing behavior differ (13–16). The HBM argues that positive and negative evaluations should be included as two distinct constructs (labeled perceived benefits and barriers), while the TRA argues that they can be combined into one global construct labeled attitudes towards the behavior. Our past psychometric work supported the formation of two latent constructs representing benefits and barriers (17). In addition, the TRA posits that these attitude-based constructs indirectly influence behavior through intention formation (14, 15), while HBM hypothesizes that the two constructs directly affect behavior (13). More recently, researchers seeking to extend the HBM have recommended adding intention as a mediating variable (18–20), but few have tested whether its addition enhances the theory's explanatory power (13, 21).

The role and importance of subjective norm differs between HBM and TRA. While subjective norm has been articulated as an important construct mediated by intention in TRA (14, 15), its role in HBM is not clearly specified (13, 16, 22). Some have argued that subjective norm is one external aspect of cues to action, citing empirical evidence that advice from others such as family, friends, and physicians is a direct determinant of mammography behavior (18). Others argue that subjective norm is a more distal factor that exerts its influence on behavior through the formation of perceived benefits (i.e., significant others endorsement of mammography encourages positive evaluations of the behavior)(23) or through perceived threat (24). In general, there is no consensus about how HBM constructs relate to each other (13).

To test alternative explanations posited by the TRA and HBM and quantify the role of subjective norm, benefits, barriers, and intention on mammography screening, we conducted a secondary analysis of data from a randomized, behavioral intervention trial to increase regular screening mammography (25, 26). Specifically, we evaluated the following competing hypotheses (Figure 1):

1. Do benefits and barriers directly influence mammography screening behavior (HBM) or indirectly influence behavior via intention (TRA)?
2. Does subjective norm directly influence mammography screening behavior (HBM cues to action) or indirectly influence behavior via intention (TRA)?
3. Does subjective norm directly influence intention to be screened (TRA) or indirectly influence intention via benefits and barriers (HBM)?

This secondary analysis was designed to accomplish two goals: a) advance our understanding of mammography and the mechanisms to increase adoption, and b) advance the integration of health behavior theories by comparing specific assumptions underpinning different theories.

Methods

Participants and Procedures

A sample of women aged 52 years or older as of June 1, 2000 was randomly drawn from the National Registry of Women Veterans. Women adherent and non-adherent with mammography guidelines (e.g., screened in the past two years) were eligible for the parent intervention trial (for more details about the study design and findings see (25, 26)). Breast cancer survivors, non-veterans, and women physically unable to complete a survey were excluded. Women were randomized to one of five groups (2 intervention groups and 3 survey-only control groups). Because temporal precedence is important to establish mediation, and we did not want to confound our results with the effect of the behavioral intervention, we analyzed data from the control group (Group 3) that received 3 surveys spaced one year apart over the study period. Women who were ineligible, refused, or did not respond to all surveys were excluded. Of the 2,818 women randomized to Group 3, 38.3% were ineligible for the following reasons: deceased, male, born after 6/1/1948, non-veteran, breast cancer survivor, serving on active duty, physically unable, or untraceable. Of the 1,738 eligible women, 33% refused and 26.4% did not respond to all surveys, leaving 704 women eligible for this analysis.

The protocol for all surveys was: mailed survey, reminder postcard after 3 weeks, second mailed survey after 7 weeks, and up to 6 telephone calls after 11 weeks. The follow-up surveys were administered approximately 1 year and 2 years after baseline. Among respondents the average time was 13.9 months (SD: 1.6; range 6.9 – 19.9) between the baseline and first follow-up survey and 12.0 months (SD: 1.4; range 6.2 – 19.5) between the first and second follow-up survey. The second follow-up survey was used to assess screening behavior status.

Measures

Psychometric analyses of the survey items measuring benefits, barriers, and subjective norm supported an adequately fitting measurement model (17). Items were assessed on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The individual items and a covariance matrix are available as electronic supplementary material (ESM; see ESM Tables 1 and 2).

Benefits—Five items from previous studies and two items developed for the trial measured the perceived positives of mammography (baseline Cronbach's alpha = 0.87) (10, 17, 27).

Barriers—Eight items drawn from scales developed by Rakowski and colleagues (10, 27) measured perceived negatives of mammography (baseline Cronbach's alpha = 0.82).

Subjective Norm—Four items adapted from a colorectal cancer screening trial measured perceived beliefs about and desire to comply with family and friends' attitudes toward mammography (baseline Cronbach's alpha = 0.83) (28). Subjective norm was only assessed on the baseline survey (i.e., not measured on follow-up year 1 and 2 surveys).

Intention—Women were asked on each survey when they planned to have their next mammogram: less than 6 months, 6 months to 1 year, 1 to 1½ years, 2 to 3 years, more than 3 years, not planning to have one, or don't know. Women responding 1 year or less were coded as having positive intention; others were classified as negative intention.

Mammography Behavior—Mammography behavior was measured by participant self-report (“If you have had one or more mammograms, when were your last two mammograms? Please provide month and year”) on the second follow-up survey. Women that reported a mammogram within 15 months of the survey date were considered screened.

Statistical Analysis

To test the three competing hypotheses described above, structural equation modeling analyses were performed in Mplus 7.0 (29). We used weighted least squares means-adjusted (WLSM) estimation that runs probit regressions to model the data because the dependent variables (mammography intention and behavior) were dichotomous and the independent variables were not normally-distributed (30). Regression coefficients should be interpreted as probabilities and not as values for the observed outcomes.

Participants in this analysis were required to answer all of the items measuring the dependent variables. Seventy-six percent ($n = 532$) had complete data for independent variables and 172 participants had some missing survey items. Missing data was handled using Full Information Maximum Likelihood (FIML).

We compared three models (partial mediation vs. direct, partial vs. full mediation) within each hypothesis. The direct and full mediation models were nested in the partial mediation model (i.e., model with the most parameters) to examine whether direct and indirect paths were needed to maintain model fit. The indirect path is needed if fit is reduced when comparing the partial and direct models. If model fit is not reduced, the indirect path can be removed according to the principle of parsimony (31). As shown in Figure 1, for Hypothesis 1 (do benefits and barriers directly influence mammography screening behavior or indirectly influence behavior via intention?), the partial mediation model hypothesized two direct paths to screening behavior (HBM: p_1 and p_2) and two indirect paths via intention at year 1 (TRA: $a_1 \times b_1$ and $a_2 \times b_1$); the direct model tested only two direct paths (HBM: p_1 and p_2); and the full mediation model tested only the indirect pathways (TRA: $a_1 \times b_1$ and $a_2 \times b_1$).

Similarly, for Hypothesis 2 (does subjective norm directly influence mammography screening behavior or indirectly influence behavior via intention?), the partial mediation model hypothesized both a direct path (Figure 1, HBM: p_3) and an indirect path where intention at year 1 mediated subjective norm's effect (TRA: $a_3 \times b_1$); the direct model only hypothesized a direct effect of subjective norm on mammography behavior (HBM: p_3); and

the full mediation model tested whether all of the effect of subjective norm on behavior was mediated by intention (TRA: $a_3 \times b_1$).

Finally, as seen in Figure 1, for Hypothesis 3 (does subjective norm directly influence intention or indirectly influence intention via benefits and barriers?), the partial mediation model fit both a direct path between subjective norm and intention (TRA: p_3) and indirect paths via benefits and barriers (HBM: $p_1 \times b_1$ and $p_2 \times b_2$). The direct model hypothesized a single path from norm to intention (TRA: p_3). The full mediation model tested only the indirect paths (HBM: $p_1 \times b_1$ and $p_2 \times b_2$).

To determine which model fit the observed data better within each hypothesis, we computed the Satorra-Bentler χ^2 -difference test statistic (32–34). Satorra and Bentler showed that the difference between two mean-adjusted χ^2 follows a χ^2 distribution only when divided by a scaling correction factor; degrees of freedom (df) is the difference in df between the two models. A significant test statistic indicates that the hypothesized model with the lower χ^2 value fits the data better. A non-significant statistic indicates that the more parsimonious model with fewer paths is best (e.g., when comparing the partial mediation and direct models, the direct model would be selected) (31, 35). We also informally assessed relative model fit by computing the comparative fit index (CFI) and root mean-square error of approximation (RMSEA) and its respective 90% confidence interval. CFI values between 0.90–0.95 and RMSEA values between 0.08–0.10 were considered fair fit. Acceptable or good fit was indicated with CFI >0.95 and RMSEA <0.08 (36, 37).

Results

Participant characteristics are displayed in Table 1. Most women were Caucasian, had at least some college education, and reported an income greater than \$15,000. Just under half were married or living with a partner. Across the three surveys (baseline, Year 1, Year 2), the means and standard deviations for benefits and barriers were stable as was the percentage of respondents reporting positive intention (Table 1).

Hypothesis 1: Influence of Benefits and Barriers on Screening Behavior

In Hypothesis 1, when we compared the effect of benefits and barriers on intention and behavior, the partial mediation model fit the data better than the direct (Table 2: $\chi^2_{\text{diff}} = 676.36$, $p < 0.001$) and full mediation models ($\chi^2_{\text{diff}} = 255.12$, $p < 0.001$), suggesting both direct and indirect (via intention) paths to screening behavior. However, as shown in Figure 2, the paths from benefits at baseline to both intention at year 1 and screening at year 2 were not significant. Only barriers at baseline were negatively associated with intention and behavior. Benefits had a significant negative correlation with barriers. Intention was positively associated with screening behavior.

Hypothesis 2: Influence of Subjective Norm on Screening Behavior

The direct model fit the data best among all three models. Model fit was significantly reduced when comparing the full mediation model to the partial mediation model (Table 2: $\chi^2_{\text{diff}} = 97.54$, $p < 0.001$). This was also reflected in the probit regression coefficients (see ESM Table 4), which showed that path a_3 (subjective norm $\rightarrow$ intention) was non-significant in both the partial and full mediation models. There was no difference in fit when comparing the partial mediation and direct models ($\chi^2_{\text{diff}} = 3.44$, $p = .152$); thus, the most parsimonious model (direct) is better. Intention at year 1 was significantly predictive of screening at year 2 (Figure 3). The path at baseline from barriers, but not from benefits, to intention at year 1 was also statistically significant. Barriers negatively predicted intention.

Hypothesis 3: Influence of Subjective Norm on Intention

When investigating the influence of subjective norm on intention, the partial mediation model fit the data better than the direct model (Table 2: $\chi^2_{\text{diff}} = 81.32$, $p < 0.001$); and the full mediation model fit the data better than the partial mediation model (Table 2: $\chi^2_{\text{diff}} = 1.96$, $p = .291$) suggesting that path p_3 should be removed from the model. Examination of the probit regression coefficients (Figure 4) showed that p_1 , the path from subjective norm at baseline to benefits at year 1, was also not significant. Collectively, this suggests that subjective norm was completely mediated by barriers at year 1. Further, benefits at year 1 positively predicted, and barriers at year 1 negatively predicted intention consistently across all three nested models (see ESM Table 5). At baseline, benefits and subjective norm were positively correlated, whereas barriers were negatively associated with benefits and norm (Figure 4).

Discussion

This study compared competing hypotheses of the TRA and HBM to quantify the roles of subjective norm, benefits, barriers, and intention in relation to mammography screening. Overall, we found empiric support for different assertions of the HBM and TRA. Our analyses clarify the pathways linking these constructs in promoting the regular uptake of screening mammography.

First, our findings provide support that benefits and barriers are separate latent factors that have different predictors and effects. We found that benefits are not predictive of intention or screening behavior; benefits' mechanism of influence was through its significant correlation with perceived barriers. In both Hypothesis 1 and 2, the path from benefits at baseline to intention at year 1 was not significant. Similarly, in Hypothesis 1, benefits were not predictive of screening behavior, and were only marginally significant in Hypothesis 3. Benefits were significantly correlated with barriers across all hypotheses; because the relationship between benefits and barriers is non-directional, an unmeasured third variable could explain this finding. Contrary to the TRA, intention only partially mediated the effect of barriers on behavior. We found that barriers were a significant predictor of both intention (Hypotheses 1, 2, and 3) and screening behavior (Hypothesis 1 and 3). Collectively, these findings argue against creating an overall measure that combines perceived benefits and perceived barriers (13, 18). As suggested by Weinstein (38), there appear to be important differences in the causal pathways through which benefits and barriers influence behavior. Future research should investigate theoretical constructs that affect the formation of benefits and barriers.

We found that subjective norm influences mammography behavior through multiple pathways, some of which were not hypothesized by the TRA. Subjective norm had a small, but significant direct effect on screening behavior (e.g., not mediated by intention) (Hypothesis 2). In addition, subjective norm did not have a direct influence on intention, as argued by the TRA, but was mediated by perceived barriers (Hypothesis 3). This finding contrasts with previous studies that reported a positive association between subjective norm and intention when controlling for attitudes (i.e., benefits and barriers) (7, 39–42). This may be due to different measures of subjective norm. Recommendation or advice from a physician, often labeled as subjective norm, is a consistent correlate of mammography (43–50) and may be strong enough to influence intention independent of barriers. Although our study assessed the normative effect of family and friends (versus physician), our findings suggest that subjective norm is a determinant of mammography screening that could be targeted by interventions. The most effective approach to influence women who score high on barriers may be to promote that other women do not endorse these same barriers. Future research should test intervention strategies that raise awareness about norms supporting

mammography to determine if these strategies help women reconsider their negative attitudes.

With respect to HBM, we argued that subjective norm is conceptually similar to the cues to action construct and tested whether it directly influenced mammography behavior. However, as we mentioned above, there are different formulations of HBM paths. For example, Becker and Maiman's (24) original drawing of the HBM showed a direct path from cues to perceived threat. We could not test this alternative formulation because the intervention trial did not measure perceived susceptibility and severity—the precursor constructs that comprise perceived threat. Given advances in structural equation modeling and the paucity of studies examining cues, future studies should test these alternative paths.

Finally, our analyses confirm intention as an important predictor of screening behavior (Hypothesis 1 and 2), but it is not the only psychosocial factor with a direct effect. Intention is a key construct of several health behavior theories (e.g., TRA, Protection Motivation Theory) (1, 21), and is often targeted in behavioral interventions. Researchers have advocated that HBM add intention and our empiric models support this extension (13, 18–21). However, unlike the TRA, intention is not the sole predictor of mammography behavior. In our models, intention did not completely mediate the effect of barriers and subjective norm (Hypothesis 1 and 2). This is congruent with the Theory of Planned Behavior which extended the TRA by adding perceived behavioral control (51). Future studies should examine whether perceived behavioral control is an additional factor with both a direct path to behavior and an indirect path through intention. As a whole, our findings suggest that both barriers and subjective norm are modifiable proximal determinants that should be targeted for interventions.

Our study has several methodologic and conceptual strengths. It drew from a national population of women veterans accessing health care through a variety of healthcare systems, was longitudinal, used structural equation modeling, and tested competing hypotheses of two health behavior theories. Based on Department of Veterans Affairs and U.S. Census estimates, the population of older women veterans is similar to the general U.S. female population with respect to race/ethnicity and educational attainment (52), which potentially broadens the generalizability of our results. We were able to establish temporal precedence by assessing subjective norm, benefits, and barriers prior to our measurement of the outcome variables (e.g., screening behavior and intention). Also, previous research showed empirical support for the validity of our measures minimizing the possibility that measurement error attenuated the magnitude of the probit regression coefficients (17).

Our study does have some limitations. Our analyses are based on correlational data; thus, findings may overestimate the magnitude of the associations between the theoretical constructs and mammography behavior (53). Experimental studies that manipulate each of the theoretical constructs separately would provide more precise estimates. Also, the intervention trial did not measure the TRA construct, attitude towards the behavior, in the traditional way recommended by Fishbein and Ajzen(14); however, the benefits and barriers items were conceptually similar and psychometric analyses supported a two latent factor measurement model (17). Another potential limitation is that the timing of measurement was restricted to annual assessments over a three-year period. Subjective norm, benefits, barriers, and intention may have changed a number of times between the measurement intervals. It would be interesting to assess these measures over shorter intervals to examine whether the magnitude of the effect changes. In addition, response bias may limit our findings as 33% of survey respondents refused to participate and 26% did not complete all three surveys. There were no significant differences in sociodemographic characteristics or the accuracy of self-reported mammography behavior between women who responded to all 3 surveys versus 1

or 2 surveys, supporting the generalizability our findings to all women veterans enrolled in the trial (25). Finally, although we have found evidence that HBM and TRA work in the above described ways for mammography screening, these theories may work differently for other behaviors due to the nature of the target behavior (e.g., frequency of repetition such as daily versus intermittent).

Our findings provide empiric support for attempts to integrate theoretic models (1). The comparison of direct and indirect pathways for subjective norm, benefits, barriers, and intention enabled us to draw conclusions about which model better predicted intention and screening behavior, as well as identify potential intervention targets (9, 22, 54). Our results suggest that future interventions should test whether building social influence and reducing negative attitudes toward mammography are effective at increasing regular mammography.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

This work was supported in part by R01 NCI CA 76330 (Drs. Vernon and Tiro). This paper is based, in part, on the Ph.D. dissertation research project completed by Dr. Tiro at the University of Texas School of Public Health, Houston, TX.

References

1. Institute of Medicine. Speaking of Health: Assessing Health Communication Strategies for Diverse Populations. The National Academies Press; Washington, D.C.: 2002. Theory; p. 28-75.
2. Noar SM, Zimmerman RS. Health Behavior Theory and cumulative knowledge regarding health behaviors: are we moving in the right direction. *Health Educ Res.* 2005; 20:275–290. [PubMed: 15632099]
3. Weinstein ND, Rothman AJ. Commentary: Revitalizing research on health behavior theories. *Health Educ Res.* 2005; 20:294–297. [PubMed: 15632097]
4. Brewer NT, Gilkey MB. Comparing theories of health behavior using data from longitudinal studies: a comment on Gerend and Shepherd. *Ann Behav Med.* 2012; 44:147–148. [PubMed: 22828786]
5. Aiken LS, West SG, Woodward CK, Reno RR. Health beliefs and compliance with mammography-screening recommendations in asymptomatic women. *Health Psychol.* 1994; 13:122–129. [PubMed: 8020455]
6. Bowie JV, Curbow B, LaVeist TA, Fitzgerald S, Zabora J. The Theory of Planned Behavior and intention to repeat mammography among African-American women. *J Psychosocial Oncol.* 2004; 21:23–43.
7. Montañó DE, Taplin SH. A test of an expanded theory of reasoned action to predict mammography participation. *Soc Sci Med.* 1991; 32:733–741. [PubMed: 2035050]
8. Rauscher GH, Earp JAL, O'Malley M. Relation between intervention exposures, changes in attitudes, and mammography use in the North Carolina Breast Cancer Screening Program. *Cancer Epidemiol Biomarkers Prev.* 2005; 13:741–747. [PubMed: 15159304]
9. Curry SJ, Emmons KM. Theoretical models for predicting and improving compliance with breast cancer screening. *Ann Behav Med.* 1994; 16:302–316.
10. Rakowski WA, Dube CA, Marcus BH, Prochaska JO, Velicer WF, Abrams DB. Assessing elements of women's decisions about mammography. *Health Psychol.* 1992; 11:111–118. [PubMed: 1582379]
11. Rakowski WA, Fulton JP, Feldman JP. Women's decision making about mammography: a replication of the relationship between stages of adoption and decisional balance. *Health Psychol.* 1993; 12:209–214. [PubMed: 8500450]

12. Taplin SH, Montano DE. Attitudes, age, and participation in mammographic screening: a prospective analysis. *Journal of the American Board of Family Practice*. 1993; 6:13–23. [PubMed: 8421925]
13. Abraham, C.; Sheeran, P. The health belief model. In: Conner, M.; Norman, P., editors. *Predicting health behavior*. 2nd ed. Open University Press; Philadelphia, PA: 2005. p. 28-80.
14. Ajzen, I.; Fishbein, M. *Understanding attitudes and predicting social behavior*. Prentice-Hall, Inc.; Englewood Cliffs, NJ: 1980.
15. Fishbein, M.; Ajzen, I. *Belief, attitude, intention and behavior: An introduction to theory and research*. Addison-Wesley; Reading, MA: 1975.
16. Champion, VL.; Skinner, CS. The Health Belief Model. In: Glanz, K.; Rimer, BK.; Viswanath, K., editors. *Health Behavior and Health Education: Theory, Research and Practice*. 4th ed. Jossey-Bass; San Francisco: 2008. p. 45-65.
17. Tiro JA, Diamond P, Perz CA, et al. Validation of scales measuring attitudes and norms related to mammography screening. *Health Psychol*. 2005; 24:555–566. [PubMed: 16287401]
18. Becker MH, Haefner DP, Kasl SV, Kirscht JP, Maiman LA, Rosenstock IM. Selected psychosocial models and correlates of individual health-related behaviors. *Med Care*. 1977; 15:27–46. [PubMed: 853780]
19. King JB. The impact of patients perceptions of high blood pressure on attendance at screening. An extension of the Health Belief Model. *Soc Sci Med*. 1982; 16:1079–1091. [PubMed: 7112160]
20. Calnan M. The health belief model and participation in programmes for the early detection of breast cancer: a comparative analysis. *Soc Sci Med*. 1984; 19:823–830. [PubMed: 6505748]
21. Norman, P.; Conner, M. Predicting and Changing Health Behavior: Future Directions. In: Conner, M.; Norman, P., editors. *Predicting Health Behavior*. 2nd ed. Open University Press; Philadelphia, PA: 2005. p. 324-372.
22. Trafimow, D. Attitudinal and normative processes in health behaviour. In: Norman, P.; Abraham, C.; Conner, M., editors. *Understanding and changing health behaviour: from health beliefs to self-regulation*. Harwood Academic Publishers; Amsterdam, The Netherlands: 2000. p. 101-113.
23. Mattson M. Towards a reconceptualization of communication cues to action in the health belief model: HIV test counselling. *Communication Monographs*. 1999; 66:240–265. [PubMed: 12349681]
24. Becker MH, Maiman LA. Sociobehavioral determinants of compliance with health and medical care recommendations. *Med Care*. 1975; 13:10–24. [PubMed: 1089182]
25. del Junco DJ, Vernon SW, Coan SP, et al. Promoting regular mammography screening I. A systematic assessment of validity in a randomized trial. *J Natl Cancer Inst*. 2008; 100:333–346. [PubMed: 18314473]
26. Vernon SW, del Junco DJ, Tiro JA, et al. Promoting regular mammography screening II. Results from a randomized controlled trial in US women veterans. *J Natl Cancer Inst*. 2008; 100:347–358. [PubMed: 18314474]
27. Rakowski WA, Andersen MR, Stoddard AM, et al. Confirmatory analysis of opinions regarding the pros and cons of mammography. *Health Psychol*. 1997; 16:433–441. [PubMed: 9302540]
28. Vernon SW, Myers RE, Tilley BC. Development and validation of an instrument to measure factors related to colorectal cancer screening adherence. *Cancer Epidemiol Biomarkers Prev*. 1997; 6:825–832. [PubMed: 9332766]
29. Muthén, LK.; Muthén, BO. *Mplus Version 7.0*. Muthén & Muthén; Los Angeles, CA: 2012.
30. Yu, C-Y. Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes (dissertation). University of California; Los Angeles: 2002.
31. Raykov T, Marcoulides GA. On desirability of parsimony in structural equation model selection. *Structural Equation Modeling*. 1999; 6:292–300.
32. Satorra A, Bentler PM. A scaled difference chi-square test statistic for moment structure analysis. *Psychometrika*. 2001; 66:507–514.
33. Bryant FB, Satorra A. Principles and practice of scaled difference chi-square testing. *Structural Equation Modeling*. 2012; 19:372–398.

34. Satorra A, Bentler PM. Ensuring positiveness of the scaled difference chi-square test statistic. *Psychometrika*. 2010; 75:243–248. [PubMed: 20640194]
35. Cook, T.; Flay, BR. The temporal persistence of experimentally induced attitude change: an evaluative review. In: Berkowitz, L., editor. *Advances in experimental social psychology*. Academic Press; New York: 1978. p. 1-57.
36. Hu, LH.; Bentler, PM. Evaluating model fit. In: Hoyle, RH., editor. *Structural equation modeling*. Sage Publications; Thousand Oaks, CA: 1995.
37. Hu LH, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*. 1999; 6:1–55.
38. Weinstein ND. The precaution adoption process. *Health Psychol*. 1988; 7:355–386. [PubMed: 3049068]
39. Baumann LJ, Fontana SA, Brown RL, Cameron L. Testing a model of mammography intention. *J Applied Soc Psychology*. 1993; 23:1733–1756.
40. Lauver D, Nabholz S, Scott K, Tak Y. Testing theoretical explanations of mammography use. *Nurs Res*. 1997; 46:32–39. [PubMed: 9024422]
41. Montaña DE, Thompson B, Taylor VM, Mahloch J. Understanding mammography intention and utilization among women in an inner city public hospital clinic. *Prev Med*. 1997; 26:817–824. [PubMed: 9388793]
42. Zapka JG, Stoddard AM, Costanza ME, Greene HL. Breast cancer screening by mammography: Utilization and associated factors. *Am J Public Health*. 1989; 79:1499–1502. [PubMed: 2817160]
43. Burns RB, Freund KM, Ash A, Shwartz M, Antab L, Hall R. Who gets repeat screening mammography: the role of the physician. *J Gen Intern Med*. 1995; 10:520–522. [PubMed: 8523157]
44. Halabi S, Skinner CS, Samsa GP, Strigo TS, Crawford YS, Rimer BK. Factors associated with repeat mammography screening. *J Fam Pract*. 2000; 49:1104–1112. [PubMed: 11132060]
45. Howe HL. Repeat mammography among women over 50 years of age. *Am J Prev Med*. 1992; 8:182–185. [PubMed: 1633007]
46. Jepson R, Clegg A, Forbes C, Lewis R, Sowden A, Kleijnen J. The determinants of screening uptake and interventions for increasing uptake: a systematic review. *Health Technol Assess*. 2000; 4:1–133.
47. Lerman CL, Rimer BK, Trock BJ, Balshem AM, Engstrom PF. Factors associated with repeat adherence to breast cancer screening. *Prev Med*. 1990; 19:279–290. [PubMed: 2377590]
48. Lipkus IM, Rimer BK, Halabi S, Strigo TS. Can tailored interventions increase mammography use among HMO women? *Am J Prev Med*. 2000; 18:1–10. [PubMed: 10808977]
49. Mayne L, Earp JA. Initial and repeat mammography screening: different behaviors/different predictors. *Journal of Rural Health*. 2003; 19:63–71. [PubMed: 12585776]
50. Rimer BK, Lerman CL, Trock BJ, King ES, Engstrom PF. Why do some women get regular mammograms? *Am J Prev Med*. 1991; 7:69–74. [PubMed: 1910890]
51. Ajzen I. The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes*. 1991; 50:179–211.
52. Department of Veteran Affairs. [Accessibility verified Feb. 13, 2007] National Survey of Veterans (NSV): Final Report. 2001. Available at <http://www1.va.gov/vetdata/page.cfm?pg=5>.
53. Weinstein ND. Misleading tests of health behavior theories. *Ann Behav Med*. 2007; 33:1–10. [PubMed: 17291165]
54. Nigg CR, Allegrante JP, Ory M. Theory-comparison and multiple-behavior research: common themes advancing health behavior research. *Health Educ Res*. 2002; 17:670–679. [PubMed: 12408211]

Figure 1. Three hypotheses comparing the Health Belief Model (HBM) and the Theory of Reasoned Action (TRA). How do benefits, barriers, subjective norm, and intention influence screening mammography?

NOTE: Dashed lines represent non-significant paths. Significant paths are represented with solid lines and probit regression coefficients are adjacent

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

^aThe partial mediation model demonstrated the best fit (Table 2) and is displayed in the figure. Probit regression coefficients for the direct and full mediation models are available [online \(see ESM Table 3\)](#).

Timepoints: B = measured at baseline; Y1 = measured at Year 1; Y2 = measured at Year 2

Figure 2.

Final model^a for Hypothesis 1: Do benefits and barriers directly influence screening mammography (HBM) or indirectly influence screening mammography via intention (TRA)?

NOTE: Dashed lines represent non-significant paths. Significant paths are represented with solid lines and probit regression coefficients are adjacent

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

^aThe direct model demonstrated best fit (Table 2) and is displayed in the figure. Therefore, the path from subjective norm at baseline to intention at year 1 is not shown. This path was not significant in the partial or full mediation models. Probit regression coefficients for the partial and full mediation models are available [online \(see ESM Table 4\)](#).

Timepoints: B = measured at baseline; Y1 = measured at Year 1; Y2 = measured at Year 2

Figure 3. Final model^a for Hypothesis 2: Does subjective norm directly influence screening mammography (HBM) or indirectly influence screening mammography via intention (TRA)?

NOTE: Dashed lines represent non-significant paths. Significant paths are represented with solid lines and probit regression coefficients are adjacent

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

^aThe full mediation model demonstrated best fit (Table 2) and is displayed in the figure. Probit regression coefficients for the direct and partial mediation models are available [online \(see ESM Table 5\)](#).

Timepoints: B = measured at baseline; Y1 = measured at Year 1; Y2 = measured at Year 2

Figure 4. Final model^a for Hypothesis 3: Does subjective norm directly influence intention (TRA) or indirectly influence intention via benefits and barriers (HBM)?

Table 1

Demographic and psychosocial characteristics of eligible respondents randomized to Group 3 who responded to all three surveys for Project HOME, a mammography intervention trial, November 2000 – October 2004, n=704

Demographic characteristics	Respondents (n=704)	
	n	%
Age		
Mean	62.4	
SD	9.6	
Ethnicity		
White	626	88.9
Black	42	6.0
Other	36	5.1
Married	329	46.7
Education		
High school graduate	85	12.1
Some college	408	58.0
College graduate	194	27.6
Refused/missing	17	2.4
Household income		
< \$15,000	100	14.2
\$15,000–35,000	167	23.7
\$35,001–50,000	146	20.7
\$50,000	252	35.8
Refused/Missing	39	5.5
Screening Status		
Currently screened	528	75.0
Overdue	142	20.2
Never screened	27	3.8
Unknown/missing	7	1.0

Psychosocial scales ^a	Baseline	Year 1	Year 2
Subjective Norm ^b –mean (SD)	3.33 (0.90)		
Benefits ^c –mean (SD)	4.16 (0.72)	4.13 (0.79)	4.09 (0.82)
Barriers ^d –mean (SD)	1.81 (0.69)	1.84 (0.69)	1.88 (0.75)
Intention–no. (%)			
Positive	478 (67.9)	480 (68.2)	445 (63.2)
Negative	226 (32.1)	224 (31.8)	259 (36.8)

^a Mean scores for the multi-item psychosocial scales were derived from the raw data (not imputed data) and some respondents were missing data; thus, sample sizes varied for each scale in particular years.

^b Subjective norm was only measured at baseline; sample size was 630.

^cFor benefits, the sample sizes for baseline, Year 1, and Year 2 surveys were 699, 696, and 654, respectively.

^dFor barriers, the sample sizes for baseline, Year 1, and Year2 surveys were 700, 694, and 655, respectively.

Table 2

Fit indices for theory testing hypotheses for Group 3 respondents participating in Project HOME, a mammography intervention trial, n=704

Model	χ^2	SCF	DF	CFI	RMSEA (90% CI)
Hypothesis 1					
Partial Mediation	947.493	0.2672	113	0.926	0.102 (0.096–0.108)
Direct	1637.635	0.3611	115	0.860	0.137 (0.131–0.143)
Full Mediation	1293.687	0.2943	115	0.895	0.121 (0.115–0.127)
Hypothesis 2					
Partial Mediation	1305.523	0.3012	180	0.922	0.094 (0.089–0.099)
Direct	1284.543	0.3088	181	0.924	0.093 (0.088–0.098)
Ful Mediation	1547.664	0.3171	181	0.906	0.104 (0.099–0.108)
Hypothesis 3					
Partial Mediation	3779.743	0.2811	545	0.926	0.092 (0.089–0.095)
Direct	3823.731	0.2885	547	0.926	0.092 (0.089–0.095)
Full Mediation	3750.686	0.2838	546	0.927	0.091 (0.089–0.094)

Model Testing ^a	Mean-Adjusted χ^2 diff ^b	DF diff	SCF diff	p-value ^c
Hypothesis 1				
Partial vs. Direct	676.360	2	11.333	<0.001
Partial vs. Full	255.124	2	3.651	<0.001
Hypothesis 2				
Partial vs. Direct	3.443	1	1.677	0.152
Partial vs. Full	97.541	1	3.179	<0.001
Hypothesis 3				
Partial vs. Direct	81.321	2	4.610	<0.001
Partial vs. Full	1.959	1	1.755	0.291

NOTE: SCF = scaling correction factor; DF = degrees of freedom; CFI = comparative fit index; RMSEA = root mean-square error of approximation; CI = confidence interval; diff = difference

^aDirect and fully mediated models were nested in the partially mediated model (i.e., the model with the most parameters) to examine whether direct and indirect paths were needed to maintain model fit. If model fit is reduced, this indicates the direct or indirect path is needed; if model fit is not reduced, the path is not needed

^bThe difference between two mean-adjusted χ^2 for nested models does not follow a χ^2 distribution. Satorra and Bentler derived a formula (32–34) for testing the difference in nested χ^2 values to permit scaled difference testing

^cA significant test statistic indicates that the hypothesized model with the lower χ^2 value fits the data better. A nonsignificant statistic indicates that the more parsimonious model (i.e., the one with fewer paths) is best (32).