Published in final edited form as:

J Adv Nurs. 2013 September ; 69(9): 2107–2115. doi:10.1111/jan.12065.

The Household Risk Perception Instrument and the Self-Efficacy in Environmental Risk Reduction Instrument: psychometric testing using principal component analysis

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Abstract

Aim—This paper is a report of psychometric testing of the Household Risk Perception and Self-Efficacy in Environmental Risk Reduction Instruments using principle components analysis.

Background—There are limited instruments available to test household risk perception and self-efficacy related to environmental health behaviors. The Household Risk Perception Instrument was developed to measure personal perceptions of household environmental health risks. The Self-Efficacy in Environmental Risk Reduction Instrument was designed to measure caregivers' confidence in taking steps to reduce household risks.

Method—Baseline data from 235 caregivers enrolled in a randomized clinical trial testing a healthy housing intervention were collected between 2006 and 2009. Principal components analysis was used to determine principal components from measured responses to each instrument.

Results—Components were explored and compared to constructs used to design the original instruments. A five component structure showed the simplest solution and explained 65% of variance in the Household Risk Perception analysis. Cronbach's alpha values indicated satisfactory internal consistency for four of five identified components. Risk perception varied according to available sensory input of the specific risk. A four component structure explained 64% of the variance in the Self-Efficacy in Environmental Risk Reduction analysis. Cronbach's alpha values were satisfactory. Items mapped to steps in an action-oriented process versus agent-specific actions. Results from both analyses suggest that Environmental Tobacco Smoke is perceived differently than other household risks.

Conclusion—Previously, both instruments relied on item reliability and content validity testing. This study provides a basis for further instrument revision and theoretical testing.

Keywords

Household Risk Perception Instrument; Self-Efficacy in Environmental Risk Reduction Instrument; principal components analysis; nursing; psychometric testing; instrument development

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Conflict of interest: No conflict of interest has been declared by the authors.

Author Contributions:

All authors meet at least one of the following criteria (recommended by the ICMJE*) and have agreed on the final version:

1. substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;
2. drafting the article or revising it critically for important intellectual content.

* http://www.icmje.org/ethical_1author.html

INTRODUCTION

Throughout the world, children living in sub-standard housing face disproportionate exposures to environmental hazards associated with such conditions as asthma or neurodevelopmental disability, and often die from acute respiratory infections or diarrhea related to environmental conditions. (US HHS 2009, WHO 2011). Multiple organizations have called for improvements in home environments to further child health outcomes (WHO 2011). Perceptions of household environmental risks and self-efficacy beliefs must be understood when developing interventions to improve family home environments. There are few instruments measuring household environmental risk perception and self-efficacy among family child caregivers.

Background

The Environmental Risk Reduction through Nursing Intervention and Education (ERRNIE) study was a public health nurse-delivered intervention in two rural sites in the western United States which addressed multiple household risks that especially affect children: water contaminants, carbon monoxide, mold/mildew, radon, environmental tobacco smoke (ETS), and lead (Butterfield *et al.* 2011). The study was theoretically driven by nursing and environmental health (EH) science through two models. The Multiple Exposure-Multiple Effects (ME-ME) Model assumes that children exposed to a variety of environmental exposures have a myriad of health effects, and susceptibility is influenced by socioeconomic context (Briggs 2003). Dixon and Dixon's (2002) integrative model for environmental health nursing research, encompassing four domains (physiological, vulnerability, epistemological and health protection), defines the epistemological domain as personal thought and social knowledge of people regarding EH which provides a basis for actions. Health protection domain concerns actions that people take to reduce EH risks. Risk perception and self-efficacy were nested under epistemological and health protection domains.

Few instruments available to test environmental self-efficacy and risk perception have had little to no psychometric testing and often developed for individual environmental risk or for large global indices (Hoti *et al.* 2005). Instruments include psychometric paradigm models with limited variables to attempt to explain risk perception (Sjöberg 2003), substituting other health behaviors as a gauge against an environmental risk (Cabrera & Leckie 2009), or using in-classroom assessments (Weber *et al.* 2000).

Risk perception has been shown to be a critical variable when engaging in protective health behaviors such as radon testing (Sandman & Weinstein 1993, Weinstein *et al.* 1990, Duckworth *et al.* 2002), banning smoking in homes (Binns *et al.* 2009), and avoiding contaminated tap water (Doria Mde *et al.* 2009). Self-efficacy has been a consistent predictor of success in smoking cessation and making nutritious food choices (Baranowski *et al.* 2002) but has not been widely operationalized as a concept in environmental intervention studies (Postma *et al.* 2009). ERRNIE investigators developed the Household Risk Perception (HRP) instrument, designed to measure personal perceptions about multiple household environmental health risks, and the Self-Efficacy in Environmental Risk Reduction (SEERR) instrument which measures risk perception and self-efficacy specific to household EH risks. The SEERR instrument is based on Bandura's construct of self-efficacy that one's actions can produce desired results (Bandura 1977, 2001).

THE STUDY

Aim

The aim of this study was to complete psychometric testing of the Household Risk Perception and Self-Efficacy in Environmental Risk Reduction Instruments using principle components analysis.

Methodology

This study is an exploratory principal components analysis (PCA) of self-reported data previously collected from two instruments used in the ERRNIE randomized clinical trial (RCT). One instrument had undergone item reliability (SEERR) and both underwent content validity testing but neither had been examined by exploratory factor analysis.

Participants

A convenience sample of 235 households from two U.S. counties was enrolled in the ERRNIE study between June, 2006 and June, 2009. Baseline data from the 235 primary child caregivers in the household were used for the PCA. Table 1 summarizes sample characteristics. (For more details about the RCT design, sample, and findings, see Butterfield *et al.* 2011).

Instruments

Development—Original ERRNIE study aims focused heavily on self-efficacy as a cognitive construct relating to household risk reductions. Preliminary work included circulation among EH experts to assure content validity and strict adherence to Bandura's scale development guidelines (2001). Two pilot studies recruited 65 rural participants to refine the SEERR instrument and assure internal consistency. Cronbach's alpha for the final instrument was $>.80$ overall and for each subscale. Risk perception items were exploratory in the study and were developed iteratively in consultation with EH experts to evaluate content validity (Butterfield *et al.* 2011).

HRP Instrument—The 24 item "Household Risk Perception" contains six questions which ask respondents to identify how much they know about six agents, on a five-point Likert scale. The remaining 18 questions are organized by agent and ask respondents how strongly they agree or disagree, on a seven-point Likert scale, with three statements: My children are at risk for being exposed to (agent); My children are at risk for having health effects due to (agent); and health effects due to (agent) are likely to be serious. (Butterfield *et al.* 2004).

SEERR Instrument—The SEERR instrument contains 29 items divided into seven subscales: one subscale (11 items) measuring general environmental health self-efficacy, and six subscales of three items each (18 items) measuring risk-specific self-efficacy. Each risk-specific self-efficacy score addresses three aspects of risk reduction (identify risk, determine if home is safe, and act to reduce exposure). Scoring consists of a confidence scale to indicate a parent's ability to take action and ranged from 0 (no confidence) to 100 (absolutely confident). The pilot-tested instrument did not contain moisture/mold and this agent was added for the ERRNIE study (Hill 2006)

Ethical considerations

Study protocols were approved by institutional review boards at the respective universities. Previously collected anonymous data from the ERRNIE study were used in this secondary analysis.

Data analysis

PCA was used to find principal components from measured responses to each instrument (Hair *et al.* 2006, Watson & Thompson 2006). The goal was to produce the fewest number of components that accounted for the greatest amount of variability from the larger set of measures included in the HRP and SEERR instruments (Henson and Roberts, 2006, Ferguson & Cox 1993). Item-to-subject ratios reflected adequate sample size as suggested by Stevens (2002): 1:7 for SEERR (N=220) and 1:8 for HRP (N=201). The PASW Statistics 18 (Release Version 18.0.0, SPSS, Inc., 2009, Chicago, IL, USA) software was used. Bartlett's Test of Sphericity and the Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy were used to justify use of PCA based on a criterion of $p < .0001$ and 0.7 or higher, respectively (Kline 1994, Stevens 2002).

Initially, PCA was employed on each instrument without constraints. Promax rotation was used due to the inter-item correlation within each instrument, although results were confirmed using several methods (Costello & Osborne 2005). Components were extracted using three criteria: eigenvalues ≥ 1 , scree plot assessment, and Monte Carlo PCA for Parallel Analysis (Watkins 2000). Component loadings were set at ≥ 0.40 to increase saturation. The structure matrix was evaluated with the pattern matrix to determine the component names (Hayton *et al.*, 2004). Components were labeled by three members of the ERRNIE research team who were familiar with the theoretical underpinnings of the intervention.

RESULTS

HRP Instrument

Using data from 201 participants after listwise deletion of missing cases, Bartlett's Test ($p < .0001$) and the KMO measure (0.74) indicated PCA was appropriate. Initial eigenvalues indicated seven components. The scree plot displayed four to seven components and parallel analysis suggested six components. Communalities ranged from 0.55 to 0.91. Several runs using component loadings of four to seven were completed, with a five component structure showing the simplest solution and explaining 65% of variance (Table 2. Note: Item numbers, as shown on the tables, are from the questionnaire data set variables). Cronbach's alpha values for the five components indicate fair to good internal consistency, except for C5. The descriptions and labels for each component are as follows:

Component 1 (C1): *Susceptibility to unseen risks* points to participants' perceived susceptibility of their children to exposure and health effects associated with colorless and odorless agents (lead, radon, carbon monoxide).

Component 2 (C2): *Severity* indicates participants' perception of the seriousness of general health effects of household risks.

Component 3 (C3): *Susceptibility to sensed risks* suggests participants' perceived susceptibility of their children to exposure and health effects associated with agents sensed by smell or taste (mold/mildew and impure well water).

Component 4 (C4): *Knowledge* items address how much participants know about general household risks.

Component 5 (C5): *Susceptibility to environmental tobacco smoke* clusters two risk perception items specifically about ETS together. The item 'what do you know about radon' was negatively associated with this component. Removal of radon from the ETS component improved Cronbach's alpha (from 0.61 to 0.96).

SEERR Instrument

A total of 220 cases available after listwise deletion of missing cases with Bartlett's test ($p < .0001$) and the KMO Measure (0.90) indicated PCA was appropriate. Communalities ranged from 0.40 to 0.76. Initial eigenvalues showed 6 components, explaining 72% of the variance. The scree plot displayed two to six components. Parallel analysis showed four components. Several runs were made to find the most parsimonious structure, using three to seven components. Table 3 presents the final four component structure which explained 64% of the variance, had the fewest number of item cross-loadings, and produced interpretable solutions that reflected the theoretical design of the instrument. Cronbach's alpha values for the four components ranged from 0.75 to 0.93. The descriptions and labels for each component are:

Component 1 (C1): *Recognize risks* (eleven items) targets the participants' confidence in their ability to identify agent-specific risks and global household risks, with exception of ETS, suggesting that participants measure their ability to recognize household risks in general.

Component 2 (C2): *Investigate and act* (ten items) addresses participants' ability to find out if agent-specific household risks are present and take steps to reduce in a general action step, with the exception of ETS. Participants view their ability to investigate and act on assessing household risks.

Component 3 (C3): *Assure* (five items) relates to participants' confidence in their ability to convince themselves and others to make healthy changes towards reducing household risks.

Component 4 (C4): *Environmental Tobacco Smoke* clusters the three items related specifically to ETS together. Unlike the other agents examined, participants' confidence around identifying, taking action and making healthy changes to reduce ETS risk indicates a single approach.

Cross-loading of items to more than one component was minimal with only three items sharing a loading of >0.4 for each of two components (see Table 3). One item, Q55h, cross-loaded on C1: Recognize risks and C3: Assure. A second item, Q56b, cross-loaded on C2: Investigate and act and C1: Recognize risks. The third item, Q55i, did not load using the criteria of 0.4. By relaxing this criterion to 0.3, the item cross-loaded on C1: Recognize Risks and C3: Assure. For each of these three items, the component with the highest cross-loading was the most interpretable.

DISCUSSION

Our goal was to examine the psychometric properties of two instruments used in a RCT with a nurse-delivered intervention to explore the feasibility of reducing the number of items. A shorter instrument that more adequately reflects EH perceptions and beliefs may allow for quick assessments in home environments, where there is less time available for nurses to assess these concepts regarding risks.

Results from both analyses suggest ETS is perceived differently than other household risks. This finding is consistent with risk literature differentiating familiar versus unfamiliar risks, voluntary versus imposed risks, and beneficial risks versus those with no benefit (Fischhoff *et al.*, 1981). While ETS is clearly an air contaminant in the home environment, results suggest that strategies to address ETS should be different. This may be because people are more familiar with this risk due to anti-tobacco media campaigns, or that smoking is perceived as a voluntary risk. Further testing may show the need to remove ETS from the instruments.

Radon was problematic in both PCAs in that there were differences per study site that drove the overall PCA results. One site had a known radon risk while the other site did not. When each site was evaluated separately, radon associated with site-known risks. Because radon levels are geographically located (Environmental Protection Agency, N.D.), it may not be necessary to include radon in instruments in certain geographical areas.

Results from HRP findings suggest that risk perception varies depending on available sensory input of the specific risk. Mold and mildew can be seen and smelled, and people perceive (albeit incorrectly) that well water is contaminated if it appears discolored or smells or tastes “funny” (Doria Mde et al., 2009). Lead, radon, and carbon monoxide are not visible and do not smell (the exception to this is if mercaptans are added to gas to purposefully give it a “rotten egg” odor). Susceptibility to ETS stood apart as a component, and included a negative loading for radon knowledge. This may indicate that respondents recognize its relation to indoor air quality but perceive it differently than ETS. ETS is easily detectable and has received significant media attention. In contrast, radon as a risk is geographically bound and remains a silent killer (Environmental Protection Agency, N.D.).

Four components explained the items in the SEERR. The two items that cross-loaded on C1 and C3 began with the word ‘Find’. When these items were moved to C3 (Assure), internal consistency of C1 (Recognize risks) remained unchanged ($\alpha=0.925$) and increased for C3 ($\alpha=0.845$). Respondents may have interpreted ‘Find’ to mean ‘recognize’ rather than the intended action-oriented meaning. This conceptual overlap with the word ‘Find’ for the item ‘Find out if your home is safe or unsafe from radon’ may also explain the cross-loading of this item on C1 from C2. Rewriting these items to emphasize action, by changing the word ‘find’ to ‘locate’ or ‘attain’, piloting these instruments, and assessing cross-loadings is a potential next step.

Limitations

Respondents were primarily educated, rural, non-Hispanic white females. There were no previous component analyses of the instruments so no comparisons could be made. Future testing with diverse populations and sites is warranted to compare future results with these findings for resultant revisions of wording and numbers of questions to maximize external validity and decrease instrument burden.

CONCLUSION

This is the initial PCA study of two instruments developed to address in-home environmental risk reduction. Results show that respondents thought about self-efficacy in environmental risk reduction as steps in an action-oriented process, versus originally designed agent-specific. Risk perception included groupings of EH risks related to sensory input and recognition of general severity and knowledge of risks rather than as agent-specific. Findings reinforce Dixon and Dixon’s (2002) assertion that an agent-specific orientation to environmental health is insufficient and support the guiding principles of the “Healthy Housing” intervention approach, whereby numerous risks are addressed in the home versus one risk at a time (US HUD 2008).

Public health nurses in many countries visit families in home environments with EH risks. Currently, there are no instruments available to test for self-efficacy and risk perception regarding these in-home risks to children. Further development of the HRP and SEERR instruments may provide reliable easy-to-use tools for nurses to evaluate families at-risk for environmental hazards in homes with children, for appropriate environmental risk reduction.

Acknowledgments

Funding: We acknowledge the National Institute of Nursing Research (NIH R01 NR0009239:PI Butterfield) for its support.

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Summary Statement

What is already known about this topic

- Risk perception and self-efficacy are associated with engagement in protective health behaviors.
- It is critically important to have sound instruments for assessment of behavioral attributes associated with environmental health outcomes available to public health and behavioral health investigators.
- There are few instruments available to test environmental health risk perception and environmental health self-efficacy.

What this paper adds

- The Household Risk Perception Instrument and the Self-Efficacy in Environmental Risk Reduction Instruments are two new instruments designed to assess families' beliefs regarding household environmental health risks.
- Initial psychometric testing showed satisfactory internal consistency with component structures, except for Environmental Tobacco Smoke.
- Environmental household risks are perceived by available sensory input and by ability to take actions rather than by a risk posed by a specific agent.

Implications for practice/policy

- Validated easy-to use instruments may be used by health professionals to better gauge families' abilities to reduce environmental risks in their homes.
- Further evaluation of the component structures for each instrument with resulting modification is warranted followed by test-retest and comparative factor analyses. .

Table 1

Characteristics of Study Participants

Participant Characteristics:	Study Group (n=235)
Gender primary adult, n (% female)	218 (93%)
Mean age primary adult $\pm$ SD, years	33.0 $\pm$ 6.8
White, n (%)	213 (91%)
Hispanic ethnicity, n (%)	12 (5%)
Mean years of education $\pm$ SD	15.1 $\pm$ 2.3
Annual household income, n (%)	
<\$25,000	64 (27%)
\$25,000 – <\$50,000	126 (54%)
\$50,000 or >	44 (19%)
Marital status, n (% married)	185 (79%)
Living condition of home, n (%)	
Poor	20 (9%)
Moderate	47 (20%)
Good	168 (71%)
Own Home, n (%)	130 (55%)

Table 2
The Household Risk Perception Inventory modified component structure – 5 component solution

New component name/item (loadings above 0.4 are shown)	New component loadings ^a					h ²	Alpha ^b
	1	2	3	4	5		
1. Susceptibility to unseen risks							0.88
Q16b: My children are at risk for having health effects due to lead	0.83	-0.09	-0.01	0.02	0.12	0.83	
Q16a: My children are at risk for being exposed to lead	0.80	-0.10	-0.05	0.05	0.03	0.76	
Q21b: My children are at risk for having health effects due to radon	0.74	0.03	0.08	-0.004	0.05	0.89	
Q21a: My children are at risk for being exposed to radon	0.72	0.007	0.07	-0.02	0.02	0.87	
Q26b: My children are at risk for having health effects due to carbon monoxide	0.70	0.11	0.08	-0.04	-0.03	0.68	
Q26a: My children are at risk for being exposed to carbon monoxide	0.69	0.06	0.12	-0.03	-0.05	0.70	
2. Severity							0.88
Q26c: Health effects due to carbon monoxide are likely to be serious	0.17	0.82	-0.21	0.03	-0.07	0.74	
Q21c: Health effects due to radon are likely to be serious	0.05	0.82	-0.02	-0.22	-0.09	0.72	
Q16c: Health effects due to lead are likely to be serious	0.04	0.81	-0.07	0.08	-0.04	0.73	
Q44c: Health effects due to second hand smoke are likely to be serious	-0.12	0.78	-0.12	0.08	0.32	0.64	
Q31c: Health effects due to impure well water are likely to be serious	0.01	0.77	0.19	0.01	-0.07	0.72	
Q36c: Health effects due to household mold and mildew are likely to be serious	-0.21	0.72	0.28	0.02	0.02	0.72	
3. Susceptibility to sensed risks							0.86
Q36a: My children are at risk for being exposed to household mold and mildew	0.09	-0.05	0.81	-0.007	0.08	0.81	
Q36b: My children are at risk for having health effects due to household mold and mildew	0.10	-0.04	0.81	0.002	-0.03	0.81	
Q31a: My children are at risk for being exposed to impure well water	-0.009	0.008	0.77	0.01	0.13	0.71	
Q31b: My children are at risk for having health effects due to impure well water	0.06	0.07	0.74	0.003	0.14	0.76	
4. Knowledge							0.79
Q9d: How much do you know about lead poisoning	-0.02	0.005	0.11	0.81	-0.12	0.71	
Q9f: How much do you know about household mold and mildew	-0.19	-0.02	-0.01	0.74	0.11	0.70	
Q9c: How much do you know about contaminated well water	-0.08	-0.006	0.25	0.74	-0.14	0.65	

New component name/item (loadings above 0.4 are shown)	New component loadings ^a					h ²	Alpha ^b
	1	2	3	4	5		
Q9e: How much do you know about second hand smoke	0.02	0.002	-0.16	0.65	0.21	0.65	
Q9b: How much do you know about carbon monoxide	0.24	0.01	0.04	0.65	-0.09	0.63	
5. Susceptibility to environmental tobacco smoke							0.61
Q44a: My children are at risk for being exposed to second hand smoke	0.12	0.001	0.04	0.04	0.89	0.91	
Q44b: My children are at risk for having health effects due to second hand smoke	0.10	0.03	0.06	-0.002	0.88	0.90	
Q9a: How much do you know about radon	0.20	0.08	-0.04	0.30	-0.45	0.55	

^aExtraction Method: Principal Component Analysis. Rotation Method: Promax with Kaiser Normalization.

^bCronbach's alpha for new component

Table 3

The Self-Efficacy in Environmental Risk Reduction Inventory modified component structure – 4 component solution

New component name/item. (Loadings above 0.4 are shown with exception to one non-loading item)	New component loadings ^a				h^2	α^b
	1	2	3	4		
1. Recognize risks						0.93
Q58a: Identify potential health effects for children caused by exposures to unsafe well-water	0.84	0.08	-0.10	0.05	0.76	
Q59a: Identify potential health effects for children caused by exposures to lead	0.84	0.04	-0.07	0.03	0.71	
Q56a: Identify potential health effects for children caused by exposures to radon	0.82	0.07	-0.14	-0.04	0.65	
Q61a: Identify potential health effects for children caused by exposures to moisture/mold	0.80	-0.13	0.11	0.09	0.67	
Q55e: Recognize some health effects caused by environmental exposure to contaminants.	0.69	-0.23	0.29	0.13	0.62	
Q60a: Identify potential health effects for children caused by exposures to carbon monoxide	0.68	0.14	-0.002	0.11	0.66	
Q55b: Identify dangerous chemicals in your home that may affect your families health	0.65	-0.03	0.18	0.01	0.53	
Q55g: Identify local resources to assist you in solving environmental problems in your home.	0.62	-0.04	0.36	-0.39	0.64	
Q55k: Identify potential hazards in your home that may affect the health of your child or children	0.57	-0.009	0.35	0.06	0.66	
Q55h: Find an easy solution to most environmental problems in your home	0.46	0.18	0.41	-0.31	0.71	
Q55i : Find information about an environmental problem within your home ^c	0.36	0.12	0.32	0.09	0.49	
2. Investigate and act						0.93
Q60c: Take steps to reduce your child or children's exposure to carbon monoxide if you ever needed	-0.16	0.80	0.24	0.001	0.72	
Q59c: Take steps to reduce lead levels in your home if you ever needed to	-0.28	0.80	0.35	0.03	0.76	
Q60b: Find out if your home is safe or unsafe from carbon monoxide	0.15	0.74	-0.04	-0.007	0.67	
Q58b: Find out if your home is safe or unsafe from well-water contamination	0.35	0.70	-0.26	-0.02	0.71	
Q59b: Find out if your home is safe or unsafe from lead	0.05	0.69	-0.02	0.15	0.72	
Q58c: Take steps to reduce your child or children's exposure to unsafe water if you ever needed	0.27	0.69	-0.05	-0.03	0.56	
Q56c: Take steps to reduce your child or children's exposure to radon if you ever needed	-0.16	0.69	0.26	-0.04	0.58	
Q61c: Take steps to reduce your child or children's exposure to moisture/mold if you ever needed	-0.21	0.66	0.38	0.02	0.63	
Q61b Find out if your home is safe or unsafe from moisture/mold	0.36	0.62	-0.06	-0.07	0.69	
Q56b Find out if your home is safe or unsafe from radon	0.42	0.57	-0.35	0.11	0.66	
3. Assure						0.81

New component name/item. (Loadings above 0.4 are shown with exception to one non-loading item)	New component loadings ^a				h^2	Alpha ^b
	1	2	3	4		
Q55f: Convince other household members to do things to help prevent environmental exposures to children in your home.	0.000	-0.02	0.77	0.06	0.59	
Q55c: Convince others in your household to make healthy changes to your home environment.	-0.07	0.04	0.74	0.07	0.55	
Q55d: Reduce the chance of your child or children will get sick from something in their environment	0.14	0.01	0.65	0.07	0.57	
Q55a: Make healthy changes to your home environment	0.35	0.08	0.55	0.07	0.40	
Q55j: Ensure that your child or children are safe from harm resulting from an environmental exposure	0.29	0.14	0.44	0.07	0.56	
4. Environmental Tobacco Smoke						
0.75						
Q57b: Find out if your child is safe or unsafe from tobacco smoke	-0.002	0.11	-0.01	0.79	0.69	
Q57c: Take steps to reduce your child or children's exposure to environmental tobacco smoke if you ever needed	-0.006	0.000	0.29	0.72	0.66	
Q57a: Identify potential health effects for children caused by exposures to environmental tobacco smoke	0.38	-0.08	0.06	0.62	0.65	

^aExtraction Method: Principal Component Analysis; Rotation Method: Promax with Kaiser Normalization;

^bCronbach's alpha for new component

^cItem did not meet the criteria requiring a loading of 0.4 or greater