Article

JHP

Journal of Health Psychology
18(8) 1100–1113

DOI: 10.1177/1359105312459096
hpq.sagepub.com
SAGE

Assessing Perceptions AbouT Hazardous Substances (PATHS): The PATHS questionnaire

G James Rubin[1], Richard Amlôt[2], Lisa Page[1], Julia Pearce[1] and Simon Wessely[1]

Abstract

How people perceive the nature of a hazardous substance may determine how they respond when potentially exposed to it. We tested a new Perceptions AbouT Hazardous Substances (PATHS) questionnaire. In Study 1 (*N* = 21), we assessed the face validity of items concerning perceptions about eight properties of a hazardous substance. In Study 2 (*N* = 2030), we tested the factor structure, reliability and validity of the PATHS questionnaire across four qualitatively different substances. In Study 3 (*N* = 760), we tested the impact of information provision on Perceptions AbouT Hazardous Substances scores. Our results showed that our eight measures demonstrated good reliability and validity when used for non-contagious hazards.

Keywords

beliefs, communication, information, public health psychology, risk

Introduction

Accidents or disasters involving the sudden exposure of large numbers of people to a hazardous substance are common. How members of the public react during such incidents plays a large role in determining their overall impact (Wray et al., 2008). For example, low uptake of emergency prophylaxis during an anthrax incident (e.g. SteelFisher et al., 2011), unnecessary mass evacuation away from a nuclear reactor (e.g. Ziegler et al., 1981), surges of unaffected people seeking treatment at hospital during an infectious disease outbreak (e.g. Chang et al., 2004) and the long-term avoidance and stigmatisation of community members following a radiological incident (e.g. Petterson, 1988) have all previously been observed and are likely to hamper a population's short- and long-term recovery from a disaster. However, these reactions can vary widely (Rogers et al., 2007). Existing theories of risk perception provide some explanation for this, with two factors often

[1]King's College London, UK
[2]Health Protection Agency, UK

Corresponding author:
G James Rubin, Department of Psychological Medicine (PO62), King's College London, Weston Education Centre, Cutcombe Road, London, SE5 9RJ, UK.
Email: Gideon.rubin@kcl.ac.uk

singled out as important: a person's perceptions about how likely they are to be affected and their perceptions about how severe any effects will be (Brewer et al., 2007; Leppin and Aro, 2009; Markon et al., 2011). While undoubtedly important, a narrow focus on perceptions of severity and likelihood is of limited usefulness to those who need to communicate with the public during a major incident. From their perspective, understanding why people believe that they are likely to encounter a hazard and why they believe that its effects are severe or are not severe is more important, as it may provide a better indication of what issues to address when talking to an affected community.

Other models of risk perception propose a broader range of determinants for how people respond to risks. For example, 15 characteristics were proposed by Slovic (1987) as differentiating risks that people are likely to accept from those that cause controversy. Many of these characteristics were properties of the hazard itself; is it observable, for example, or are its effects delayed? Although providing a more fine-grained approach to understanding risk perception, these characteristics were not specifically designed with a sudden major public health incident in mind.

Designing a questionnaire to assess the perceptions that people hold about a major incident would be useful in advancing our understanding of behavioural and emotional responses to these events. Although many categories of perceptions might be important, one set of perceptions that is particularly relevant is how an individual views the innate properties of a hazardous substance itself. In this article, we report three studies in which we tested a new questionnaire, which assesses Perceptions AbouT Hazardous Substances ('PATHS').

Study 1: piloting

In order to determine the types of perception that should be included in the PATHS, we reviewed previous qualitative studies that have explored how people perceive the risks associated with a hazardous substance (Cava et al., 2005; Etchegary et al., 2008; Glik et al., 2004, 2008; Janssen et al., 2006; Palinkas et al., 1993; Rubin et al., 2007, 2010; Stein et al., 2004; Wray et al., 2008). Nine categories occurred repeatedly in this literature as reflecting the main relevant beliefs: perceptions about the *severity of the health effects* that a substance can trigger, the difficulty that people can experience in *differentiating the symptoms* caused by a hazard from those of other common illnesses, the possibility of a *latency period* between exposure to a substance and the appearance of the first symptoms, the potential for exposure to cause *hidden harm* that may not become apparent for many years, the *ease or difficulty of detecting exposure*, the perceived *mechanisms* through which a substance can exert its effects, the perception that a hazardous substance exerts severe effects on specific *at-risk groups*, the perceived *environmental persistence* of a substance and an overarching sense of *uncertainty or mystery* that people feel about hazardous substances.

Methods

We generated 56 items to cover our nine domains, guided by our literature review and by adapting items from the Revised Illness Perceptions Questionnaire (IPQ-R; Moss-Morris et al., 2002), which measures some related concepts. Items were formulated as statements with responses ranging from strongly disagree (scored as 1) to strongly agree (5). Most items were intended to be combined into scales. However, perceptions relating to the mechanisms of action of a substance were measured using single items.

We piloted the items with a convenience sample of 21 participants recruited by sending an invitation e-mail to our institution's database of research volunteers (age range: 18 to 72 years; 14 female; 14 White British). Each was asked to consider one of four substances during a 30-minute telephone interview: polonium 210, anthrax, swine flu or carbon monoxide. These reflected qualitatively different substances that we expected participants to have some awareness of because they have been widely discussed in the British media following the Alexander Litvinenko affair, the US anthrax attacks, the 2009/2010 flu pandemic and public health campaigns about carbon monoxide. We asked participants to complete the PATHS for their selected hazard and to explain each answer or rephrase each question in their own words. Items that appeared difficult to understand were revised after every fourth interview. Ethical approval for this and all other studies was given by the King's College London Research Ethics Committee.

Results and discussion

We made several minor clarifications to item wording during the piloting. Piloting also revealed two more problematic issues. First, creating items to assess environmental persistence proved challenging, as persistence is a property of both the substance and the prevailing environmental conditions. We, therefore, made these questions conditional on a substance remaining within a stable environment. Second, it became apparent that questions about the ease with which someone could detect a substance needed to be qualitatively different when asked about a contagious disease, where concern focuses on detecting people who pose a risk. Our revised items are given in supplementary file 1.

Study 2: reliability and validity

In Study 2, four groups of participants completed the PATHS with respect to polonium 210, carbon monoxide, anthrax or swine flu. Responses were given at two time-points and were used to test the factor structure, internal consistency and test–retest reliability of the scales. For the questionnaire's validity, we hypothesised that scores would differ depending on what substance was being considered. We also hypothesised that scores would not simply reflect a stable personality trait and therefore tested their correlation with a measure of trait affect. To assess whether different hazardous substances trigger different levels of concern because of differences in the way people perceive them, we tested whether perception scores mediated any difference between the four substances in terms of how worried a participant felt someone should be if exposed to them. We predicted that any differences in worry between the four substances would be reduced once differences in the PATHS scores were controlled for.

Methods

Participants. Participants were members of an online panel maintained by the market research company Ipsos MORI. All were aged 16 years or more.

Questions. Participants first completed our items in relation to polonium 210, carbon monoxide, anthrax or swine flu. Items were presented in a random order. Participants were then asked how worried someone should be if they were exposed to the substance in question for the first time and felt ill 3 days later and if they were exposed to the substance for the first time and felt fine for the next 3 days. Responses could range from 0 (not at all worried) to 7 (extremely worried). Finally, participants completed the 10-item short form of the trait positive and negative affect schedule (PANAS (Thompson, 2007)).

Procedure. Potential participants were sent an email invitation for a survey about 'health risks'. Those who gave consent were allocated at random to one of the four versions of the survey, reminded of a previous incident involving their allocated substance and asked whether, before today, they had ever seen or heard anything about it. Those who had not previously heard of it were excluded. The remainder completed the first survey (time 1) immediately. After 1 week, participants were asked to complete a second identical survey (time 2). Recruitment for each version of the questionnaire was halted after 500 participants had completed it at time 1, a sample size which would allow us an adequate participant to item ratio for an exploratory factor analysis.

Analysis. We used exploratory factor analysis to assess the clustering of items that were intended for use as scales. This was performed separately for each version of the questionnaire, using time 1 data. We used principal axis factoring, examined scree plots to determine how many factors to extract and performed oblique rotation using direct oblimin. Pattern matrices for the four versions of the questionnaire were compared in order to identify items that consistently loaded onto the extracted factors across the different versions. We interpreted items that tended to load 0.45 or higher across versions as representing a factor. Factor scores were calculated by taking the mean of those items that loaded onto them, with items reverse scored where required. Internal reliability was tested by checking for adequate Cronbach's alphas (between 0.7 and 0.90), item-total correlations and inter-item correlations (between 0.2 and 0.9 for both) (Streiner and Norman, 2008). Test–retest reliability was calculated using intra-class coefficients for scales and linearly weighted kappa coefficients for individual items.

Validity was assessed by testing whether the results for the scales and individual items differed between the questionnaire versions (using analyses of variance and χ^2 tests) and whether the scales or individual items correlated with trait affect. We also tested whether the scales and individual items mediated any difference between the four questionnaire versions with respect to worry by using binary logistic regressions to assess the impact of including perceptions as potential mediators.

Results and discussion

Participants. Time 1 questionnaires were answered by 2030 people (between 506 and 511 people completing each version). Time 2 questionnaires were answered by 1327 people (between 311 and 350 people per version). The mean age of the sample was 41.27 years (standard deviation 14.48) at time 1. Men accounted for 51.4 per cent of the sample. Analyses of variance and χ^2 tests identified no differences between questionnaire versions in terms of age or sex at either time 1 or time 2 (all tests, $p > .73$).

Factor structure, reliability and validity. Preliminary factor analyses identified inconsistent loadings for those items that were intended to measure environmental persistence. These were removed from all the further analyses. Re-running the factor analyses suggested the presence of six (polonium 210, carbon monoxide, anthrax) or five (swine flu) factors, accounting for between 47.4 per cent and 50.5 per cent of the variance. The pattern matrix for each version is given in supplementary files 2 to 5.

Loadings for the six factors in the polonium 210, carbon monoxide and anthrax versions were similar. They related to perceptions that the hazard would cause serious health effects (loaded on by six items), the potential for hidden harm (five items), the difficulty in differentiating health effects from those caused by other illnesses (three items), the ease of detecting exposure (three items), the mysterious nature of the hazard (four items) and the existence of at-risk groups (six items). Table 1 shows the Cronbach's alphas, item-total correlations and inter-item correlations for these scales, all of which were acceptable. Because Cronbach's alpha exceeded 0.90 for the 'existence of at-risk groups' scale in all three versions of the questionnaire, we reduced it to four items while retaining acceptable levels of internal consistency. Table 2 shows the results for the test–retest analyses. Test–retest reliability was fair to good for the scales and fair to moderate for individual items. Appendix 1 shows the items retained in the final version of the questionnaire.

The loadings for the five swine flu factors suggested that they reflected perceptions about the mysteriousness of swine flu (4 items), the general harm that could arise from the illness (12 items), the presence of at-risk groups (6 items),

Table 1. Inter-item correlations, item-total correlations and Cronbach's alphas for the new scales (Study 2).

Scale (number of items)	Polonium 210 version (n = 506)			Carbon monoxide version (n = 507)			Anthrax version (n = 506)		
	Cronbach's alpha	Mean corrected item-total correlation (minimum, maximum)	Mean inter-item correlation (minimum, maximum)	Cronbach's alpha	Mean corrected item-total correlation (minimum, maximum)	Mean inter-item correlation (minimum, maximum)	Cronbach's alpha	Mean corrected item-total correlation (minimum, maximum)	Mean inter-item correlation (minimum, maximum)
Mystery (4)	0.85	0.69 (0.57, 0.72)	0.58 (0.47, 0.70)	0.83	0.67 (0.57, 0.71)	0.55 (0.43, 0.68)	0.80	0.61 (0.48, 0.68)	0.50 (0.40, 0.61)
Serious health effects (6)	0.84	0.63 (0.59, 0.70)	0.48 (0.39, 0.59)	0.84	0.62 (0.58, 0.67)	0.47 (0.37, 0.58)	0.82	0.59 (0.56, 0.62)	0.43 (0.36, 0.51)
Hidden health effects (5)	0.70	0.47 (0.41, 0.55)	0.33 (0.19, 0.43)	0.85	0.66 (0.57, 0.69)	0.53 (0.45, 0.62)	0.80	0.58 (0.55, 0.66)	0.44 (0.34, 0.50)
Difficult to spot exposure (3)	0.72	0.54 (0.50, 0.59)	0.46 (0.39, 0.52)	0.65	0.47 (0.43, 0.52)	0.40 (0.34, 0.46)	0.67	0.49 (0.43, 0.56)	0.40 (0.31, 0.48)
Difficult to discriminate symptoms (3)	0.70	0.52 (0.43, 0.58)	0.45 (0.36, 0.57)	0.71	0.54 (0.47, 0.60)	0.47 (0.39, 0.57)	0.66	0.48 (0.32, 0.53)	0.40 (0.32, 0.53)
At-risk groups (4)	0.94	0.86 (0.82, 0.90)	0.80 (0.75, 0.88	0.92	0.81 (0.71, 0.88)	0.74 (0.65, 0.87)	0.94	0.86 (0.80, 0.90)	0.80 (0.73, 0.87)

Table 2. Test–retest reliability for scales and items for the polonium 210, carbon monoxide or anthrax versions of the questionnaire (Study 2).

Scale (number of items)	Intra-class correlation coefficient (for scales: ICC2 (A,1)) or weighted kappa (for single item) with 95% confidence interval in parentheses
Mystery (4)	0.77 (0.74–0.79)
Serious health effects (6)	0.71 (0.67–0.74)
Hidden health effects (5)	0.68 (0.64–0.71)
Easy to spot exposure (3)	0.64 (0.60–0.67)
Difficult to discriminate symptoms (3)	0.53 (0.48–0.58)
The existence of at-risk groups (4)	0.51 (0.46–0.55)
I think that X can affect your health if	
You breathe in air that contains X (1)	0.42 (0.37–0.47)
You eat food that has been contaminated by X and has not been cooked (1)	0.58 (0.54–0.62)
You eat food that has been contaminated by X and has been cooked (1)	0.52 (0.49–0.56)
You touch X but do not breathe it in or put it near your mouth (1)	0.49 (0.45–0.54)
You are coughed or sneezed on by a person who is currently ill because of X (1)	0.54 (0.51–0.58)
You come within 1 m (3 ft) of polonium 210, but do not breathe it in or touch it[a] (1)	0.43 (0.35–0.50)
How long does it usually take for the first signs of ill health to start to appear? (1)	0.47 (0.42–0.52)

[a]Item only asked in polonium 210 version of the questionnaire.

the mildness of the symptoms (2 items) and a fifth factor that was difficult to interpret. Cronbach's alphas, item-total correlations and inter-item correlations for these scales were satisfactory (data not shown). As for the other questionnaire versions, we were able to reduce the at-risk groups scale to four items without adversely affecting its internal reliability. Test–retest reliability was fair to good for the scales and fair to moderate for the individual items.

Mean scores or frequencies for each hazard are given in Table 3. Analyses of variance (all F statistics ≥ 16.76, $p < .001$; see Table 3 for results of the post hoc Tukey's tests) and a χ^2 test ($\chi^2 = 543.62$, degree of freedom (df) = 18, $p < .001$) confirmed that significant differences existed between the various questionnaire versions for every scale and individual item, excluding those swine flu scales that could not be compared because of their different compositions. The differences were logical. The two more unusual hazards (polonium 210 and anthrax) were seen as being more mysterious and as more likely to cause serious or hidden health effects than carbon monoxide and swine flu. Polonium 210 was rated as more difficult to detect than carbon monoxide or anthrax. Carbon monoxide, which generally causes flu-like symptoms, was rated as having symptoms that are more difficult to distinguish from other common causes than polonium 210 or anthrax. Swine flu was rated as being most likely to have clearly identifiable 'at-risk' groups, in accordance with recent advertising campaigns in the United Kingdom, urging at-risk groups to be vaccinated. The different perceptions about mechanisms were also logical: carbon monoxide was rated as most likely to affect you by being breathed in; polonium 210, anthrax and swine flu, but not carbon monoxide, were seen as risks if present on food, though swine flu was seen as less risky if the food was cooked;

Table 3. Mean scores or frequencies (standard deviations or %) for Study 2.

Scale or item[a]	Polonium 210	Carbon monoxide	Anthrax	Swine flu[b]
Mysterious	3.50 (0.82)[c,d]	2.63 (0.74)[e,f]	3.40 (0.72)[c,d]	2.7 (0.72)[e,f]
Serious health effects	3.82 (0.59)[c,f]	2.44 (0.71)[e,f]	3.98 (0.57)[c,e]	Not used
Hidden health effects	3.39 (0.55)[c,f]	2.94 (0.67)[e,f]	3.25 (0.60)[c,e]	Not used
Easy to spot	1.93 (0.67)[c,f]	2.09 (0.77)[e]	2.19 (0.66)[e]	Not used
Difficult to discriminate symptoms	3.35 (0.65)[c,f]	3.59 (0.69)[e,f]	3.23 (0.59)[c,e]	Not used
'At-risk' groups exist	3.78 (0.82)[c,d]	4.01 (0.80)[d,e,f]	3.83 (0.79)[c,d]	4.17 (0.69)[c,e,f]
I think that X can affect your health if				
You breathe in air that contains X	3.76 (0.79)[c,d,f]	4.39 (0.77)[d,e,f]	4.09 (0.77)[c,e]	4.03 (0.73)[c,e]
You eat food that has been contaminated by X and has not been cooked	3.93 (0.81)[c,d]	2.42 (1.04)[d,e,f]	3.83 (0.83)[c,d]	3.42 (10.1)[c,e,f]
You eat food that has been contaminated by X and has been cooked	3.86 (0.84)[c,d,f]	2.29 (0.98)[d,e,f]	3.52 (0.86)[c,d,e]	2.64 (0.96)[c,e,f]
You touch X but do not breathe it in or put it near your mouth	3.33 (0.86)[c,d]	2.05 (0.93)[d,e,f]	3.37 (0.92)[c,d]	2.95 (1.01)[c,e,f]
You are coughed or sneezed on by a person who is currently ill because of X	2.73 (0.86)[c,d,f]	1.87 (0.81)[d,e,f]	3.25 (0.92)[c,d,e]	4.18 (0.70)[c,e,f]
You come within 1 m (3 ft) of polonium 210, but do not breathe it in or touch it[g]	3.06 (0.84)	Not asked	Not asked	Not asked
How long does it usually take for the first signs of ill health to start to appear?[h]				
Less than 24 hours	145 (28.7%)	335 (66.1%)	192 (37.9%)	27 (5.3%)
24 hours to 2 days	210 (41.5%)	91 (17.9%)	214 (42.3%)	290 (56.8%)
3 to 6 days	72 (14.2%)	29 (5.7%)	58 (11.5%)	158 (30.9%)
1 to 2 weeks	37 (7.3%)	18 (3.6%)	22 (4.3%)	32 (6.3%)
3 weeks to 1 month	12 (2.4%)	12 (2.4%)	11 (2.2%)	2 (0.4%)
1 to 2 months	10 (2.0%)	4 (0.8%)	2 (0.4%)	0 (0%)
More than 2 months	20 (4.0%)	18 (3.6%)	7 (1.4%)	2 (0.4%)

All significant differences were at the $p < .01$ level.
[a]All scores range from 1 to 5, except for 'how long does it usually take for the first signs of ill health to start to appear'. High scores indicate greater agreement with the scale or item.
[b]Only scores for scales that were directly comparable to the other questionnaire versions are given.
[c]Significantly different to carbon monoxide.
[d]Significantly different to swine flu.
[e]Significantly different to polonium 210.
[f]Significantly different to anthrax.
[g]Only asked for the polonium 210 version.
[h]Frequencies (%) given.

polonium 210 and anthrax were seen as risky if touched and swine flu was seen as particularly likely to be passed on by coughs or sneezes. Finally, the latency between exposure and the first symptoms appearing was logical, with carbon monoxide being seen by most participants as having an immediate effect (<24 hours: 66.1%), polonium 210 and anthrax as taking between 24 hours and 2 days to have an effect (endorsed by 41.5% and 42.3% of respondents, respectively) and swine flu as taking either from 24 hours to 2 days (56.8%) or between 3 and 6 days (30.9%) to take effect.

Perception scales and items for the polonium 210, carbon monoxide and anthrax versions of the questionnaire showed only weak correlations with the PANAS scores (all Spearman's rho ≤ 0.20).

Association with worry. The two worry scores were strongly correlated (r = .70, p < .001). We combined them by taking the mean. Because the mean showed negative skew, we recoded it into scores of 0–4 (low worry) and 4.5–7 (high worry). There was a significant difference in the level of worry that participants felt someone should feel after exposure to the hazards (χ^2 = 490.23, df = 3, p < .001). More people felt that exposure to polonium 210 or anthrax should lead to a high level of worry (80.8% and 82.6%, respectively) than exposure to carbon monoxide or swine flu (36.1% and 30.5%). Post hoc tests showed no significant difference between polonium 210 and anthrax (χ^2 = 0.54, df = 1, p = .52) or between carbon monoxide and swine flu (χ^2 = 3.55, df = 1, p = .06).

To assess whether PATHS scores mediated the differences, we compared polonium 210 with carbon monoxide and anthrax with carbon monoxide. A binary logistic regression confirmed that polonium 210 was associated with more worry than carbon monoxide (odds ratio (OR) = 7.47, 95% confidence interval (CI) = 5.61–9.94). With all PATHS measures included in the regression, this association was reduced, but remained significant (adjusted OR (aOR) = 2.56, CI = 1.61–4.08). Only three PATHS measures showed a significant association with worry in the regression: the perception that the health effects of exposure were severe (aOR = 2.47, CI = 1.89–3.24), the perception that exposure might cause hidden health effects (aOR = 1.68, CI = 1.26–2.26) and the perception that the hazard could affect health if touched (aOR = 1.26, CI = 1.03–1.54). We observed a similar pattern of results when comparing anthrax and carbon monoxide. An initial regression confirmed the difference in terms of worry (OR = 8.41, CI = 6.28–11.27), which was reduced when PATHS measures were entered (aOR = 2.48, CI = 1.59–3.87). The only perception variables that showed a significant association with worry were the perceptions that the health effects of exposure were severe (aOR = 2.24, CI = 1.69–2.97), that exposure might cause hidden health effects (aOR = 1.53, CI = 1.15–2.03) and that someone's health could be affected by being coughed or sneezed on by a person who was ill (aOR = 1.44, CI = 1.15–1.78).

Study 3: effect of information provision

In Study 3, we tested whether PATHS scores were amendable to change by providing three groups of participants with three different types of information about carbon monoxide before asking them to complete the PATHS. We hypothesised that, in comparison to a control condition, information that emphasised the severity of the health effects caused by carbon monoxide would specifically elevate perceptions relating to severity, while information that emphasised the possibility of chronic health issues would raise perceptions that carbon monoxide causes hidden health effects and reduce perceptions that the first symptoms become apparent soon after exposure. As an additional test of the role of perceptions in determining levels of concern about a hazardous substance, we also assessed whether our information had any impact on levels of worry.

Methods

Participants. We recruited a new sample of participants from the Ipsos MORI panel. We aimed to halt recruitment after 750 people had completed the survey.

Questions. We asked participants to complete the carbon monoxide version of the PATHS, followed by the two worry items used in Study 2, rated on a 0–6 scale. Participants were also asked to evaluate the whole survey using five items, which asked for their opinion on overall satisfaction, survey topic, language/grammar, the time spent to complete the survey and question formulation and the instructions given. Response options used the colloquial phrases 'yuck', 'bad', 'meh', 'good' or 'brilliant'.

Procedure. Participants were recruited using the same procedure as Study 2 and were randomised to receive one of the three information passages regarding carbon monoxide (see supplementary file 6). The first acted as our control condition and described how carbon monoxide is produced. The second focused on the severity of the health effects caused by carbon monoxide (severe information condition). The third focused on the possibility that poisoning could give rise to health effects months or years after exposure (chronic information condition).

Analysis. We used exploratory factor analyses to check the clustering of items. We used one-way analyses of variance and χ^2 tests to test the effects of information provision on PATHS results and levels of worry.

Results and discussion

Each condition was completed by 253 or 254 participants. There were no differences between the groups in terms of the proportion of women (48.8%; $\chi^2 = 0.07$, $p = .97$), mean age (41.2 (standard deviation = 14.7); $F(2, 757) = 0.04$, $p = .99$) or highest educational qualification (10% postgraduate degree, 36.5% bachelor's degree, 23.7% A-level, 8.3% vocational qualification, 21.5% General Certificate of Secondary Education (GCSE; a UK examination taken by 16-year-old children); $\chi^2 = 9.8$, $p = .28$).

The data for each condition showed an identical six-factor structure, replicating that in Study 2 (data not shown).

There were significant differences between the three groups in terms of their perceptions about the severity of carbon monoxide poisoning ($F(2, 757) = 25.67$, $p < .001$), the likelihood of it causing hidden health effects ($F(2, 757) = 143.65$, $p < .001$), the difficulty of discriminating the symptoms of carbon monoxide poisoning from other conditions ($F(2, 757) = 19.83$, $p < .001$) and the latency of the first symptoms following exposure ($\chi^2 = 25.05$, df = 12, $p = .02$). Post hoc Tukey's tests (Table 4) revealed that the severe information condition resulted in increased perceptions of the severity of carbon monoxide poisoning compared to both the chronic and control conditions, and that the chronic information condition (which also mentioned some health effects of exposure) increased perceptions of severity in comparison to the control information. The chronic information condition resulted in higher perceptions that carbon monoxide might cause hidden health effects than either of the other conditions and reduced the number of people who felt that the first effects of carbon monoxide poisoning would appear within 24 hours. Finally, while emphasising the severe nature of the effects of carbon monoxide made people feel that its effects are easy to distinguish from those resulting from other causes, our chronic information condition had the opposite effect.

Our two worry items showed a smaller correlation than in Study 2 ($r = .56$, $p < .001$) and were not combined. As for Study 2, we dichotomised them into scores of 0–4 or 5 and 6. There was no difference between the groups in terms of the level of worry they felt someone should feel 3 days after exposure to carbon monoxide if feeling ill ($\chi^2 = 1.80$, df = 2, $p = .41$) or feeling fine ($\chi^2 = 1.24$, df = 2, $p = .54$).

Between 612 and 615 people (81%) completed each survey evaluation question. For every question, most participants (91.5%–95.4%) rated the survey as good or brilliant.

Discussion

The PATHS questionnaire provides reliable, valid measures of the perceptions people hold

Table 4. Mean scores or frequencies (standard deviation or %) for the carbon monoxide questionnaire following provision of information emphasising the severity of its effects, the chronic nature of its effects or a control condition (Study 3).

Scale or item[a]	'Severe' information	'Chronic' information	'Control' information
Mysterious	2.54 (0.74)	2.64 (0.73)	2.54 (0.74)
Serious health effects	3.64 (0.73)[b,c]	3.21 (0.62)[b,d]	3.43 (0.71)[c,d]
Hidden health effects	3.06 (0.73)[c]	3.94 (0.50)[b,d]	3.06 (0.75)[c]
Easy to spot	2.02 (0.71)	2.02 (0.71)	2.04 (0.78)
Difficult to discriminate symptoms	3.41 (0.77)[b,c]	3.80 (0.54)[b,d]	3.57 (0.75)[c,d]
'At-risk' groups exist	4.05 (0.91)	4.10 (0.73)	4.16 (0.71)
I think that carbon monoxide can affect your health if			
You breathe in air that contains it	4.44 (0.75)	4.42 (0.77)	4.38 (0.75)
You eat food that has been contaminated by it and has not been cooked	2.51 (1.16)	2.51 (1.06)	2.36 (1.13)
You eat food that has been contaminated by it and has been cooked	2.27 (1.05)	2.37 (0.95)	2.24 (1.03)
You touch it but do not breathe it in or put it near your mouth	2.06 (1.02)	2.04 (0.85)	1.90 (0.89)
You are coughed or sneezed on by a person who is currently ill because of it	1.80 (0.96)	1.79 (0.81)	1.67 (0.80)
How long does it usually take for the first signs of ill health to start to appear?[e]			
Less than 24 hours	202 (79.5%)	160 (63.2%)	187 (73.9%)
24 hours to 2 days	37 (14.6%)	58 (22.9%)	46 (18.2%)
3 to 6 days	5 (2.0%)	10 (4.0%)	9 (3.6%)
1 to 2 weeks	4 (1.6%)	5 (2.0%)	4 (1.6%)
3 weeks to 1 month	2 (0.8%)	6 (2.4%)	3 (1.2%)
1 to 2 months	1 (0.4%)	2 (0.8%)	2 (0.8%)
More than 2 months	3 (1.2%)	12 (4.7%)	2 (0.8%)

All significant differences were at the $p < .05$ level.
[a]All scores range from 1 to 5, except for 'how long does it usually take for the first signs of ill health to start to appear'. High scores indicate greater agreement with the scale or items.
[b]Significantly different to control condition.
[c]Significantly different to chronic condition.
[d]Significantly different to severe condition.
[e]Frequencies (%) given.

about the properties of non-contagious hazardous substances. Study 1 demonstrated that the questions are readily understood and can be applied to any hazardous substance with only minor rewording. Study 2 demonstrated that our attempt to produce a measure of the environmental persistence of a hazardous substance was unsuccessful. This was probably because of the range of factors (including prevailing environmental conditions) that determine persistence. However, our other items clustered as expected for the three non-contagious hazards, producing scales that were internally consistent and had good test–retest reliability. Test–retest reliability for our single-item measures was lower, though still comparable to that for similar items designed by others (Barr et al., 2008). Face validity for the measures relating to non-contagious hazards was established in Study 1, while their lack of association with measures of trait affect (Study 2), their ability to discriminate between different types of hazard (Study 2) and their amenability to change when people were presented with different types of information (Study 3) all add weight to their validity.

Although the PATHS questionnaire performed well for non-contagious hazards, this was not true when we used it to assess perceptions of swine flu. This may reflect a deeper distinction in the way people perceive contagious and non-contagious hazards. While non-contagious agents are often seen as separable from a person and as present in the environment, people may find it difficult to appreciate the difference between a virus or bacteria and the contagious disease that it causes. Although we tried to make this explicit by asking participants to consider 'the germs that cause swine flu', it is possible that people were still thinking about the illness when responding. Additional research to explore and measure the perceptions that people hold about contagious illnesses would be justified, for example, how contagious the illness is and how it can be contracted.

Despite this, our questionnaire fills a gap that exists in our ability to understand perceptions during a major public health incident involving a non-contagious hazardous substance. At present, research in this field focuses on assessing the perceived severity of being exposed to a given substance and the perceived likelihood of being exposed to it. Assessing perceptions about the nature of the substance causing the risk has been neglected by researchers. This is surprising. Although a person's 'mental model' of an external threat can determine whether or not they take protective actions in relation to it (Morgan et al., 2001), a questionnaire to assess the more common themes within these perceptions has, until now, been unavailable. The availability of the PATHS questionnaire should help communicators to understand whether members of the public hold perceptions about a given substance that are substantially out of step with scientific knowledge, and whether those perceptions are, in turn, associated with levels of worry or changes in behaviour. By targeting perceptions that are associated with the outcomes of interest, using messages that are designed following best practices in risk communication (e.g. Wray et al., 2008), it may be possible to promote more adaptive responses to an incident involving hazardous materials.

Evidence that PATHS do indeed partly determine responses to them can be found in our own Study 2, with the association between a hazard and ratings about how worried someone should feel once exposed to it being substantially reduced once perceptions about the hazard were controlled for. On the other hand, experimentally manipulating perceptions in Study 3 did not affect levels of worry. It is possible, then, that there is no causal association between the perceptions we assessed and worry, or that a person's emotional response determines their initial perceptions about a hazard until detailed information about it has been received. Alternatively, it is possible that the failure of our information to affect levels of worry was due to the artificial nature of our survey, which may have encouraged participants to process information at a relatively shallow level. Had our information related to a risk that was of greater relevance to the participant, it might have resulted in more systematic processing, resulting in changes in worry (Trumbo, 1999).

Conclusion

The ability to measure perceptions that members of the public hold about the properties of a hazardous substance should help communicators judge how best to target their messages during a public health incident. We hope that the PATHS questionnaire will facilitate this.

Funding

This work was produced by under the terms of a research training fellowship issued by the UK National Institute for Health Research. The views expressed in this publication are those of the authors and not necessarily those of the NHS, The National Institute for Health Research or the Department of Health.

References

Barr M, Raphael B, Taylor M, et al. (2008) Pandemic influenza in Australia: Using telephone surveys to measure perceptions of threat and willingness to comply. *BMC Infectious Diseases* 8: 117.

Brewer NT, Chapman GB, Gibbons FX, et al. (2007) Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology* 26: 136–145.

Cava MA, Fay KE, Beanlands HJ, et al. (2005) Risk perception and compliance with quarantine during the SARS outbreak. *Journal of Nursing Scholarship* 37: 343–347.

Chang HJ, Huang N, Lee C-H, et al. (2004) The impact of the SARS epidemic on the utilization of medical services: SARS and the fear of SARS. *American Journal of Public Health* 94: 562–564.

Etchegary H, Lee JEC, Lemyre L, et al. (2008) Canadians' representation of chemical, biological, radiological, nuclear, and explosive (CBRNE) terrorism: A content analysis. *Human and Ecological Risk Assessment* 14: 479–494.

Glik D, Harrison K, Davoudi M, et al. (2004) Public perceptions and risk communications for botulism. *Biosecurity and Bioterrorism* 2: 216–223.

Glik DC, Drury A, Cavanaugh C, et al. (2008) What not to say: Risk communication for botulism. *Biosecurity and Bioterrorism* 6: 93–107.

Janssen AP, Tardif RR, Landry SR, et al. (2006) 'Why tell me now?' The public and healthcare providers weigh in on pandemic influenza messages. *Journal of Public Health Management and Practice* 12: 388–394.

Leppin A and Aro AR (2009) Risk perceptions related to SARS and avian influenza: Theoretical foundations of current empirical research. *International Journal of Behavioral Medicine* 16: 7–29.

Markon M-P, Lemyre L and Krewski D (2011) Uncertainty beyond probabilities of BSE: Appraisals predicting worry and coping strategies in the Canadian public. *Journal of Toxicology and Environmental Health: Part A* 74: 226–240.

Morgan MG, Fischoff B, Bostrom A, et al. (2001) *Risk Communication: A Mental Models Approach*. New York: Cambridge University Press.

Moss-Morris R, Weinman J, Petrie KJ, et al. (2002) The revised illness perception questionnaire (IPQ-R). *Psychology & Health* 17: 1–16.

Palinkas LA, Downs MA, Petterson JS, et al. (1993) Social, cultural and psychological impacts of the Exxon Valdez oil spill. *Human Organization* 52: 1–13.

Petterson JS (1988) Perception vs reality of radiological impact: The Goiania model. *Nuclear News*, November, 84.

Rogers MB, Amlôt R, Rubin GJ, et al. (2007) Mediating the social and psychological impacts of terrorist attacks: The role of risk perception and risk communication. *International Review of Psychiatry* 19: 279–288.

Rubin GJ, Amlôt R, Carter H, et al. (2010) Reassuring and managing patients with concerns about swine flu: Qualitative interviews with callers to NHS Direct. *BMC Public Health* 10: 45.

Rubin GJ, Page LA, Morgan O, et al. (2007) Public information needs after the poisoning of Alexander Litvinenko with polonium-210 in London: Cross sectional telephone survey and qualitative analysis. *BMJ* 335: 1143–1146.

Slovic P (1987) Perception of risk. *Science* 236: 280–285.

Stein BD, Tanielian TL, Ryan GW, et al. (2004) A bitter pill to swallow: Nonadherence with prophylactic antibiotics during the anthrax attacks and the role of private physicians. *Biosecurity and Bioterrorism* 2: 175–185.

Streiner D and Norman GR (2008) *Health Measurement Scales: A Practical Guide to the Development and Use*. Oxford: Oxford University Press.

Thompson ER (2007) Development and validation of an internationally reliable short-form of the positive and negative affect schedule (PANAS). *Journal of Cross-Cultural Psychology* 38: 227–242.

Trumbo CW (1999) Heuristic-systematic information processing and risk judgement. *Risk Analysis* 19: 391–400.

Wray R, Becker SM, Henderson N, et al. (2008) Communicating with the public about emerging health threats: Lessons from the pre-event message development project. *American Journal of Public Health* 98: 2214–2222.

Ziegler DJ, Brunn SD and Johnson JH (1981) Evacuation from a technological disaster. *Geographical Review* 71: 1–16.

Appendix 1

The Perceptions AbouT Hazardous Substances (PATHS) questionnaire

Below are some statements that other people have made about X. For each one, please say whether you strongly disagree, disagree, neither agree nor disagree and agree or strongly agree. Do not worry if you are not entirely sure for some of the statements. We are interested in whether you personally agree or disagree with them, based on what you currently know. So even if you are not sure, please give your best answer, based on what you think.

Mystery scale

1. X is a mystery to me.
2. I do not understand X.
3. I have a clear picture or understanding of X.
4. I have a good idea of how X works.

Severity scale

1. I think that if someone does not receive treatment, the health effects of being exposed to X are usually permanent.
2. I think that if someone does not receive treatment, the health effects of being exposed to X are usually serious.
3. I think that if someone does not receive treatment, the health effects of being exposed to X are usually mild.
4. I think that if someone does not receive treatment, being exposed to X is usually fatal.
5. I think that people who are exposed to X usually make a full recovery, even if they do not receive any treatment.
6. I think that if someone does not receive treatment, being exposed to X will usually damage a person's organs.

Hidden health effects scale

1. I think that some of the health effects from X can take years to develop.
2. I think that people who survive exposure to X often develop new health problems many years down the line.
3. I think that X can cause hidden damage to your body that only becomes apparent years later.
4. I think that X can trigger health problems that only affect you years later.
5. I think that even people who do not experience any health effects in the weeks after exposure to X might still become ill years later.

Easy to spot exposure scale

1. I think that it is easy for normal people to spot X
2. I think that you can detect X by either taste, smell or sight.
3. I think that there are easy ways for a normal person to tell if X is present in a room.

Difficult to discriminate symptoms scale

1. I think that it is easy to mistake the symptoms caused by X with the symptoms of a different illness.
2. I think that the symptoms of exposure to X are similar to those caused by other common illnesses.
3. I think that the symptoms of exposure to X are easy for a normal person to confuse with something else.

The existence of at-risk groups scale

I think that the health effects of X are usually more severe for the following:

1. Children aged below 5 years.
2. Pregnant women.
3. People who are 65 years old or more.
4. People who already have a serious medical condition.

Mechanisms. Different substances can affect your health in different ways. Below are several statements about ways that X might affect someone. For each one, we are interested in whether you think that X is able to affect a person in that way or not.

I think that X can affect your health if:

1. You breathe in air that contains X.
2. You eat food that has been contaminated with X and has not been cooked.
3. You eat food that has been contaminated with X and has been cooked.
4. You touch X but do not breathe it or put it near your mouth.
5. You are coughed or sneezed on by a person who is currently ill because of X.

Symptom latency. If someone is exposed to X, how long do you think it usually takes before the first signs of ill health start to appear?

Response options of:

Less than 24 hours.
24 hours to 2 days.
3 to 6 days.
1 to 2 weeks.
3 weeks to 1 month.
1 to 2 months.
More than 2 months.