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The internal consistency and validity of the Vaccination Attitudes Examination (VAX) Scale: A replication study

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Abstract:	Background: Vaccinations are important preventative health behaviors. The recently developed Vaccination Attitudes Examination Scale (VAX) aims to measure the reasons behind refusal/hesitancy regarding vaccinations. Purpose: The aim of this replication study is to conduct an independent test of the newly developed VAX scale in the U.K. We tested: (a) internal consistency (Cronbach's alpha); (b) convergent validity by assessing its relationships with beliefs about medication, medical mistrust and perceived sensitivity to medicines; and (c) construct validity by testing how well the VAX scale discriminated between vaccinators and non-vaccinators. Methods: A sample of 243 UK adults completed the VAX scale, the Beliefs about Medicines Questionnaire (BMQ), the Perceived Sensitivity to Medicines Scale (PSM) and the Medical Mistrust Index (MMI), in addition to demographics of age, gender, education levels and social deprivation. Participants were asked: (a) if they received an influenza vaccination in the past year; and (b) if they had a young child, had they vaccinated their young child against influenza in the past year. Results: The VAX: (a) demonstrated high internal consistency (α=0.92); (b) was positively correlated with medical mistrust, beliefs about medicines and less strongly correlated with perceived sensitivity to medicines; and (c) successfully differentiated parental influenza vaccinators from non-vaccinators. Conclusion: The VAX demonstrated good internal consistency, convergent and construct validity in an independent UK sample. It appears to be a useful measure to help us understand the health beliefs that promote or deter vaccination behavior.

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Running head: Assessment of the Vaccination Attitudes Examination scale

Title: The internal consistency and validity of the Vaccination Attitudes Examination (VAX) Scale: A replication study

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Background: Vaccinations are important preventative health behaviors. The recently developed Vaccination Attitudes Examination Scale (VAX) aims to measure the reasons behind refusal/hesitancy regarding vaccinations.

Purpose: The aim of this replication study is to conduct an independent test of the newly developed VAX scale in the U.K. We tested: (a) internal consistency (Cronbach's alpha); (b) convergent validity by assessing its relationships with beliefs about medication, medical mistrust and perceived sensitivity to medicines; and (c) construct validity by testing how well the VAX scale discriminated between vaccinators and non-vaccinators.

Methods: A sample of 243 UK adults completed the VAX scale, the Beliefs about Medicines Questionnaire (BMQ), the Perceived Sensitivity to Medicines Scale (PSM) and the Medical Mistrust Index (MMI), in addition to demographics of age, gender, education levels and social deprivation. Participants were asked: (a) if they received an influenza vaccination in the past year; and (b) if they had a young child, had they vaccinated their young child against influenza in the past year.

Results: The VAX: (a) demonstrated high internal consistency (α=0.92); (b) was positively correlated with medical mistrust, beliefs about medicines and less strongly correlated with perceived sensitivity to medicines; and (c) successfully differentiated parental influenza vaccinators from non-vaccinators.

Conclusion: The VAX demonstrated good internal consistency, convergent and construct validity in an independent UK sample. It appears to be a useful measure to help us understand the health beliefs that promote or deter vaccination behavior.

Introduction

Vaccinations are important for the maintenance of health. They help control the spread of infectious disease and evidence suggests they are safer and more effective than therapeutics (1). In 2008, The World Health Organization (WHO) proposed a population immunity target of >95% as key to the eradication of infectious diseases like influenza (1). Despite this, data from March 2017 indicated that parental uptake of booster vaccinations to protect against Haemophilus influenzae type band meningitis C for children at 2 years old was only 91.8% in the U.K. (2). This failure to vaccinate has caused the resurgence of other preventable diseases such as whooping cough and measles (1, 3), increasing the risk of serious health consequences for young children. Investigating the determinants of vaccination behavior is, therefore, an important area of behavioral medicine.

Vaccination rates for communicable diseases are on the decline across the world and this has led to a proportionate increase of disease thought to be either eradicated or at least controlled. Anti-vaccination attitudes also appear to be increasing and may be somewhat responsible for vaccination failure (4-8). Positive attitudes towards vaccinations are also thought to be important predictors of vaccination behavior. The Vaccination Attitudes Examination (VAX) scale is a recently developed brief 12-item questionnaire created to better understand general vaccination attitudes (3). Higher total VAX scores suggest stronger anti-vaccination attitudes and four more specific subscales evaluate: 1) *mistrust of vaccine benefit (higher scores indicate more mistrust),* 2) *worries about unforeseen future effects (higher scores indicate more worry),* 3) *concerns about commercial profiteering (higher scores indicate more*

concern) and 4) *preference for natural immunity (higher scores indicate more of a preference)* (3). The questionnaire demonstrated high internal consistency across the four subscales in a U.S. population (3). The developers of the VAX scale found total scores to differentiate vaccinators from non-vaccinators and higher scores were positively correlated with increased perceived sensitivity to medicines and the tendency to obtain health information online (3).

The aim of this replication study is to assess the VAX in an independent UK sample and determine: (a) internal consistency; (b) convergent validity by testing the association between total VAX scores and beliefs about medication, measures of medical mistrust and perceived sensitivity to medicines, and (c) construct validity in differentiating vaccinators from non-vaccinators.

Hypotheses

VAX scores will; (a) demonstrate high internal consistency, (b) VAX scores will positively correlate with increased medical mistrust, negative beliefs about medicines and perceived sensitivity to medicines and (c) influenza non-vaccinators will display increased total VAX scores compared to influenza vaccinators.

Methods

Participants

243 U.K. residents (218 females and 25 males) aged 18 and over voluntarily completed an online questionnaire. Participants were recruited through the university by posting links on social media such as Facebook and twitter to take part in the survey. Table 1 shows demographic characteristics including mean Scottish Index of Multiple Deprivation (SIMD) (9) decile ranking scores, an indicator of socio-economic status, ranking from 1 (high deprivation) to 10 (low deprivation). The median age was between 35-44, and the median education level was an undergraduate university degree for the total sample and for the parents. Ethical approval was granted by the University of Stirling Psychology Department Ethics Committee prior to study commencement.

Measures

All data were captured electronically by Qualtrics online questionnaires including the 12-item VAX (3), the Beliefs about Medicines Questionnaire (BMQ) (10); the Perceived Sensitivity to Medicines Scale (PSM) (11); and the Medical Mistrust Index (MMI) (12): see supplementary material for further scale information. Participants were also asked their gender, postcode (for SIMD socio-economic status scores (9)), age, education level, if they (a) received an influenza vaccination in the past year, and (b) if they were parents to a young child, if they vaccinated their child against influenza or not in the past year (both free in the UK National Health Service). Self-reported influenza vaccine status has been found to be a sensitive and fairly specific indicator of actual vaccine status (13).

Procedure

The online questionnaire was constructed using Qualtrics software, then distributed to the University of Stirling Online Portal, Facebook and Twitter. Informed consent was obtained and anonymity was assured.

Data Analysis

Cronbach's α was used to test internal consistency of the VAX scale. For the full sample, logistic regression was used to predict vaccination status from VAX, BMQ, PSM and MMI mean scores. In a subsample, independent samples *t*-tests were conducted to compare parents who vaccinated their child to those who do not for VAX total and subscale scores, BMQ, PSM and MMI mean scores. Pairwise correlations between VAX, BMQ, PSM and MMI mean scores and between the 4 VAX subscales were also assessed. Multiple regression assessed the predictive effect of BMQ, MMI, PSM, gender, age, education and socio-economic status on mean VAX scores for the total sample. Statistical significance was set at .05. Statistical analyses were conducted using SPSS for Windows (v23). R 3.4.3 for Windows was employed for confirmatory factor analysis (CFA) using the Lavaan package: see supplementary material.

Results

Questionnaire Data

Internal consistency For the 12 item VAX, a Cronbach's α value of 0.92 was obtained, demonstrating excellent internal consistency in the sample (n = 243). Subscale internal consistency was: 1) *trust of vaccine benefits,* Cronbach's α = 0.89; 2) *worries over unforeseen future effects,* Cronbach's α = 0.79; 3) *concerns about commercial profiteering,* Cronbach's α = 0.91; and 4) *preference for natural immunity*, Cronbach's α = 0.86, all demonstrated good-excellent internal consistency. Internal consistency of the other scales were; BMQ, Cronbach's α = 0.84, PSM, Cronbach's α = 0.86, MMI, Cronbach's α = 0.89.

Convergent Validity

Correlations between Scale Scores

Table 2 shows correlations measuring the associations between the BMQ, VAX, PSM and MMI means for the total sample (n = 243). Mean VAX scores correlated positively with medical mistrust and beliefs about medicines and less strongly with perceived sensitivity to medicines.

Construct Validity

A multiple regression analysis with forced entry methodology was used to predict mean total VAX scores from BMQ, MMI, PSM, gender, age, socio-economic status, and education for the total sample (n = 243). The final model was statistically significant $F(3, 242) = 63.5$, $p < 0.001$, *Adjusted* $R^2 = 0.44$ and retained BMQ ($p < 0.001$), MMI ($p < 0.001$), and education levels ($p = .007$). All added significantly to the predication (see Table 3).

Vaccinators and Non-Vaccinators

Logistic regression was performed to ascertain whether total VAX, BMQ, PSM, and MMI questionnaire scores were associated with the likelihood that participants did not receive the flu vaccination. In the first univariate model, a 1 point increase in the total VAX scale score was associated with a 1.69 increased likelihood of non-vaccination status. In the second multivariate model, total BMQ, PSM, & MMI scores were added and although the overall model was significant, none of the individual scales emerged as significant univariate predictors of non-vaccination status (see Table 4a).

Child Vaccinators and Non-Vaccinators

Table 4b shows *t*-test comparisons for parents who did or did not vaccinate their children for influenza in the last 12 months (total $n = 85$). Parents of non-vaccinators had significantly higher total VAX scale scores and significantly higher mean scores for VAX subscale 2): worries over unforeseen future effects ($p<0.05$).

Confirmatory factor analysis

Replicating previous findings (3), CFA was run on all 12 VAX items grouped into the 4 predetermined subscales (3 items for each subscale). The Tucker-Lewis Index was greater than 1 and the Normed Fit Index (0.998) suggested a good model fit (see supplementary material).

Discussion

This replication study investigated the internal consistency and validity of the newly developed VAX scale in an independent U.K. sample. The VAX: (a) proved to have high internal consistency; (b) demonstrated convergent validity with the hypothesized positive relationships with medical mistrust, beliefs about medicines and perceived sensitivity to medicines; and (c) successfully differentiated parental vaccinators/non-vaccinators.

The four VAX subscales may be important for furthering our understanding of vaccination attitudes. We provided confirmatory independent evidence that the four subscales of the VAX correlated significantly with one another (3). Furthermore, confirmatory factor analysis verified the use of four subscales from the 12-item VAX in this U.K. participant sample. This supports the conclusions by the VAX developers, who suggest that the four subscales are distinct but correlated. When comparing participants who vaccinated themselves in the past year to non-vaccinators, in univariate analysis, the VAX clearly differentiated vaccinators from non-vaccinators. Critically, only the VAX differentiated parents who vaccinated their child in the past year to non-vaccinators. This suggests the VAX may be a particularly useful measure of potential psychological determinants of vaccination behavior for parents of young children.

Limitations of the study include the low number of male participants, particularly amongst the parents of young children. We also had twice as many influenza non-vaccinators as vaccinators. The use of influenza vaccination questioning to establish participants as either vaccinators or non-vaccinators should be interpreted with caution

as not all participants were medically indicated to receive this vaccination annually. Looking at the sample age characteristics, most participants were aged less than 65 years and would not have been eligible for free vaccination in the UK. However, many younger people in the UK do opt to pay a small fee (£10 ≈ $14) for annual flu vaccination. Further studies should now evaluate the use of the VAX in a more homogenous sample of participants who are medically indicated to receive this vaccination (including: parents of young children, expectant mothers and older individuals). In addition, more comprehensive psychometric evaluations of the VAX would be welcome.

Conclusion and Implications

In an independent U.K. sample, the VAX scale exhibited high internal consistency and successfully differentiated parents who vaccinated their children from those who did not. Higher VAX scores were associated with higher medical mistrust and general concerns about medication. Finally, increased education predicted lower VAX scores. The VAX appears to be a useful new measure to help us understand the health beliefs that promote and deter vaccination behavior.

Tables

Table 1: Demographic characteristics and descriptive information for the total sample (n=243).

Demographics	**Overall sample *(N, %)***		
Age			
18-24	60 (25%)		
25-34	56 (23%)		
35-44	65 (27%)		
45-54	43 (18%)		
55+	19 (8%)		
Sex			
Male	25 (10%)		
Female	218 (90%)		
Education			
High School	37 (15%)		
College	67 (28%)		
University	105 (43%)		
Postgraduate	34 (14%)		
Mean (SD) SIMD Decile Ranking	5.7 (2.7)		
	Yes	No	Maybe
Take medication regularly	129 (53%)	114 (47%)	.
Got flu vaccination this year	80 (33%)	163 (67%)	.
Child got flu vaccination this year [a]	48 (20%)	37 (15%)	.
Will get flu vaccination next year	78 (32%)	165 (68%)	.
Child will get flu vaccination next year	54 (22%)	19 (8%)	19 (8%)

Note: SD = Standard Deviation; SIMD = Scottish Index of multiple deprivation: an indicator of socio-economic status 2012, ranking from 1 (high deprivation) to 10 (low deprivation). [a] sub-sample of 85 participants who were parents of a young child.

Table 2: Correlation matrix showing associations between mean VAX scale scores and relevant questionnaires (n = 243).

Measure	VAX Mean	BMQ Mean	PSM Mean	MMI Mean
VAX	-	-	-	-
BMQ	.602***	-	-	-
PSM	.157*	.209**	-	-
MMI	.509***	.479***	.122	-

Note: VAX: Vaccination Attitudes Examination Scale; BMQ: Beliefs about Medicines Questionnaire; PSM: Perceived Sensitivity to Medicines Scale; MMI: Medical Mistrust Index. * p < .05. ** p = < .01. *** p = < .001.

Table 3: Summary of the regression analysis for the total sample (n = 243) predicting overall Vaccination Attitudes Examination Scale score.

Variable	B	SE^B	β	95%CI for B	
				Lower	Upper
Intercept	0.89	0.19	-	0.53	1.26
BMQ	0.47	0.06	0.47***	0.36	0.59
MMI	0.23	0.05	0.26***	0.14	0.33
Education	-0.10	0.04	-0.13**	-0.18	-0.03

Note: *Adjusted* R^2 = *.44*. BMQ: Beliefs about Medicines Questionnaire; MMI: Medical Mistrust Index; VAX: Vaccination Attitudes Examination Scale. ** p = < .01. *** p = < .001.

Table 4 (a): Summary of logistic regression analysis for the total sample (n = 243) to predict non-vaccination status.

Measure	Model 1				Model 2			
			95%CI for Exp(B)				95%CI for Exp(B)	
	B	**Exp(B)**	**Lower**	**Upper**	***B***	**Exp(B)**	**Lower**	**Upper**
Intercept	-0.56	0.57	-	-	-1.36	0.26	-	-
VAX	**0.52***	**1.69**	**1.12**	**2.54**	0.24	1.27	0.75	2.15
BMQ	-				0.15	1.16	0.68	1.99
PSM	-				0.11	1.11	0.77	1.60
MMI	-				0.33	1.38	0.90	2.12
Nagelkerke r^2	3.7%				5.8%			
χ^2	6.61, *d*f = 1, *p*=0.010				10.32, *d*f = 4, *p*=0.035			

Table 4 (b): *t*-test results showing means (SD), *t*-values, *p*-values and effect size scores for parents who did/did not vaccinate their children for influenza in the last 12 months (total n = 85).

Measure		Child Vaccinator n=48	Child Non-Vaccinator n=37	*t*-Value	*p*-Value	Cohen's *d*
VAX		**2.51(0.46)**	**2.78(0.72)**	**-2.025**	**.040***	**0.48**
	VAX SUB 1	2.08(0.61)	2.36(0.94)	-1.643	.104	0.36
	VAX SUB 2	**3.05(0.61)**	**3.38(0.82)**	**-2.129**	**.036***	**0.47**
	VAX SUB 3	2.35(0.62)	2.59(0.90)	-1.462	.147	0.32
	VAX SUB 4	2.56(0.75)	2.78(0.80)	-1.373	.173	0.28
BMQ		2.48(0.59)	2.69(0.60)	-1.642	.104	0.35
PSM		2.33(0.73)	2.48(1.02)	-0.821	.414	0.17
MMI		2.87(0.71)	2.80(0.73)	0.442	.659	0.10

Note: BMQ: Beliefs about Medicines Questionnaire; MMI: Medical Mistrust Index; PSM: the Perceived Sensitivity to Medicines Scale; VAX: Vaccination

Attitudes Examination Scale; VAX SUB 1: trust of vaccine benefits; VAX SUB 2: worries over unforeseen future effects; VAX SUB 3: concerns about commercial profiteering; and, VAX SUB 4: preference for natural immunity. * $p < .05$.

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Supplementary material

Further scale information

For the convergent validity, we included the following scales: Beliefs about Medicines Questionnaire (BMQ) by Horne et al., (1999) (10) the Perceived Sensitivity to Medicines Scale (PSM) by Horne et al., (2013) (11) and the Medical Mistrust Index (MMI) by LaVeist et al., (2009) (12).

The 8-item general version of the BMQ was included and asks participants about their personal views, beliefs and worries about taking medicines (e.g., “Doctors use too many medicines”). Responses are indicated on a 5-point Likert answer option, which varies from 1 ‘strongly disagree’ to 5 ‘strongly agree’. Higher scores indicate stronger and more negative beliefs about the use of medicines (10). This scale was selected to probe perceptions about medicines in general and evaluate similarities to vaccination attitudes.

The short 5-item PSM scale was included to understand in what way participants generally respond when they take prescribed medication (e.g., “My body is very sensitive to medicines”). Responses are captured on a 5-item Likert-type scale and range from 1 ‘strongly disagree’ to 5 ‘strongly agree’. Higher scores indicate more perceived sensitivity to medicines and someone with a high score may less willing to take as much medication to either avoid a potential adverse effect or because they believe they require less medication compared to others with lower PSM scores (11).

Here, we wanted to see if these perceptions about medicines were similar to attitudes about vaccination.

The 7-item MMI asks participants about their feelings and trust with regards to the National Health Service (the publicly funded national healthcare system in the U.K.) in their local area including a hospital, clinic or the general health care system (e.g., “mistakes are common in the NHS”). Responses are captured on a 5-item Likert-type scale and range from 1 ‘strongly disagree’ to 5 ‘strongly agree’. Higher scores indicate more perceived mistrust in the health service (12) and these negative believes may be similar in those with anti-vaccination attitudes.

Confirmatory factor analysis

Confirmatory factor analysis of the four previously determined VAX subscale factors was achieved using the Lavaan package for R version 3.4.3. A diagonally weighted least squares algorithm specifying ordinal data was employed using all 12 VAX items in the following model and fit*:

```
model: <- ‘
subscale1 =~ vax1r + vax2r + vax3r
subscale2 =~ vax4 + vax5 + vax6
subscale3 =~ vax7 + vax8 + vax9
subscale4 =~ vax10 + vax11 + vax12
‘
```

```
fit <- cfa(model, data = vaxdata,
           ordered=c("vax1r","vax2r","vax3r",
                     "vax4", "vax5", "vax6",
                     "vax7", "vax8", "vax9",
                    "vax10", "vax11", "vax12"))
```

* Note: subscale1 = trust of benefits, subscale2 = worries over future effects, subscale3 = concerns about commercial profiteering and subscale4 = preference for natural immunity, reverse item scoring is indicated by (r).

Results of confirmatory factor analysis suggest a good model fit with X^2 (48, N = 243) = 33.898, p = 0.938, Comparative Fit Index = 1.00, Normed Fit Index = 0.998, Tucker-Lewis Index = 1.001, Root Mean Square Error of Approximation 0.000, and 90% confidence interval = 0.000 – 0.010.