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RESEARCH PAPER

The Youth Attitudes about Vaccines (YAV-5) scale: adapting the parent attitudes about childhood vaccines short scale for use with youth in German, French, and Italian in Switzerland, exploratory factor analysis and mokken scaling analysis

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ABSTRACT

No validated measures of vaccine hesitancy (VH) for youth vaccination currently exist. We adapted the Parent Attitudes about Childhood Vaccines survey (PACV-15) for use in youth to create the version Youth Attitudes about Vaccines survey (YAV-14 and YAV-5), then translated it into three languages (German, French, and Italian). We administered the YAV-14 to 1,003 youth aged 15–26 years in Switzerland. We used exploratory factor analysis and Mokken scale analysis to explore the psychometric properties, Cronbach's alpha to investigate the reliability for the YAV-14 and the YAV-5, but we only report results of the YAV-5 analysis here. We determined construct validity by logistic regression of the association between youth VH as measured by the YAV-5 and non-receipt of the first human papillomavirus (HPV) vaccine dose. EFA produced a single scale in German and French while two factors were obtained in Italian. All language versions fit the Mokken scale models with medium-scale strength. There was a significant association between VH and HPV vaccine non-receipt for the full sample (odds ratio (OR); 1.93, 95% confidence interval (CI); 1.31–2.85). Language-stratified analyses found a significant association between VH and non-immunization in the German-language sample. Our results demonstrate that the German version of YAV-5 is a valid and reliable scale for identifying vaccine hesitant youth regardless of sex, and the French version is a valid and reliable scale for identifying vaccine hesitant female youth. Further validation is needed for Italian and French-speaking male youth.

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Introduction

Vaccine hesitancy (VH), defined as the delay in acceptance or refusal of some or all recommended adult and childhood vaccines despite the availability of vaccination services, was listed by the World Health Organization (WHO) as a threat to global health.[1–3] There is a need to develop reliable survey scales to measure VH. Much research has focused on parents, with recent systematic reviews identifying hundreds of studies on parental VH.[4,5] Several determinants of VH have been identified, including the 3Cs (confidence, complacency, and convenience),[6] knowledge, perceived risk, and performance expectancy[7,8] among others. While many of the previous studies on parental VH focus on childhood vaccines, another major area of interest is the vaccination against human papillomaviruses (HPV). Numerous studies examine parents' attitudes and intentions with regard to HPV vaccination of their adolescent children.[9] However, far fewer studies have reviewed youth attitudes and intentions. That said, there are studies that find large proportions of parents consult with adolescents during the HPV vaccine decision-making process[9] and that teens in many countries have the right to make vaccination decisions without parent consent.[10,11] The few studies that examined adolescent or youth attitudes toward HPV vaccination[12–14] did not use validated scales to measure VH.

Development of standardized scales is required to identify, classify, and measure VH.[5] One widely used scale is the Parent Attitudes about Childhood Vaccines (PACV), available in a long and a short version. The longer, 15-item scale, the PACV-15, is a self-administered scale readable at the sixth-grade level developed by Opel et al. to identify vaccine hesitant parents and has been validated in different languages and geographical settings.[15–17] Previous studies of parental vaccine hesitancy related to adolescent vaccines have used modified versions of the PACV-15.[18,19]

The 5-item short scale (PACV-5) has the possibility of reducing interviewee burden as well as being used as a VH screening tool in clinical settings because it is easier to administer.[20,21] We recently validated the PACV-5 for use of

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measuring VH in parents of young children in the three national languages of Switzerland (German, French, and Italian), establishing its use for comparative research.[22]

In 2008, the Swiss Federal Office of Public Health (FOPH) added HPV vaccination for girls to the national vaccination plan.[23–25]It recommended 3 primary doses of HPV vaccine within the course of 6 months for girls between the ages 11–14 years (reduced to 2 doses in 2012), and catch-up vaccination (3 doses) for unvaccinated youth aged 15–26 years. Each of the 26 cantons is responsible for organizing their HPV vaccination program, which is free to patients. There is considerable canton-specific variation in uptake,[25] with the estimated coverage levels for two doses of HPV vaccine among 16-year-old girls between 2014 and 2016 ranging from 19% to 79%.[26] In 2016, the FOPH recommended HPV vaccination for boys as well, and coverage levels among 16-year-old boys between 2017 and 2019 were 20% for the first dose, 17% for 2 doses, and 4% for 3 doses.[26,27]

According to a 2014 survey, the most common reasons for women not being vaccinated against HPV included lack of information, being too old, logistic constraints and fear of side effects.[28,29] Among women aged 18- to 20-year old, 1 in 5 said they were not vaccinated against HPV either because of opposition to the HPV vaccine in particular or to vaccination in general. In addition, 7% and 8% of women not vaccinated against HPV reported it was because their physician or friends/family, respectively, were against receipt of the vaccine.[29] Research has shown that living in cantons with school-based vaccination services increases HPV vaccine uptake. However, spatial variation modeling suggests additional deterministic factors like religion, political and community opinion even in the presence of school-based vaccination services.[30,31]

In the present study, we adapt the PACV-15 for use in youth and aim to validate it as a scale for identifying VH among in Switzerland in three national languages. We call the new survey Youth Attitudes about Vaccines survey (YAV-14 and YAV-5). This represents an important step toward evidence-based approaches to addressing VH in youth.

Study objectives

The objectives of this study were to:[1] determine the dimensionality of the YAV-5 to measure VH using Exploratory Factor Analysis (EFA), a classical test theory (CTT) method;[2] investigate the dimensionality of the YAV-5 using the Mokken scale MHM and DHM non-parametric item theory (NIRT) models;[3] assess the internal consistency of the YAV-5 using Cronbach's alpha and;[4] determine the construct validity of YAV-5 by exploring the association between VH and immunization status with the first dose of the HPV vaccine among youths using logistic regression models.

Methods

This study, which aims at validating the YAV as a scale to measure VH among youth in Switzerland, is part of a National Research Program (NRP74) on the determinants of VH and under-immunization in Switzerland.[32]

We conducted a preliminary validation of the YAV-14 using EFA and MSA which showed that, as with our analysis of the PACV-15, we were unable to validate all questions across all languages.[22] Therefore, we focus only on YAV-5 validation in this paper. Results from the preliminary analysis of the YAV-14 can be found in the supplementary materials.

Study participants

Participants in this study were between 15 and 26 years old, covering the period at which youth are eligible for HPV vaccine as a catch-up vaccine and when they can make vaccination decisions independently.[32] We included only participants who spoke one of the main Swiss national languages (German, French, or Italian).

Sample size and recruitment

To investigate vaccine hesitancy and associations with under-immunization, we anticipated a high rate of vaccine hesitancy of 30%, given the novelty of the HPV vaccine and considering the fact that it was recommended in adolescent boys only for the past 4 years. With a power of 0.8 at a statistically significant level of 0.05, we estimated a sample size of 361 participants. To account for clustering for youth recruited in the same practice in contrast to a simple random sample, we assumed a design effect of 2, which gave a final sample size of 722 participants.[32] We recruited 1,003 youth in the German-, French-, and Italian-speaking regions of Switzerland, i.e., from the offices of medical providers and, in order to increase the number of male participants, from the military during enlistment for compulsory military service.

This study is part of a larger study of vaccine hesitancy in parents and youth in Switzerland, with recruitment for both subsamples conducted simultaneously at participating provider offices. 4824 individuals were contacted for the larger study, with 2894 (60%) consenting to participate and 2425 (50%) ultimately completing interviews. Response rates varied by provider type, with 58% of individuals contacted at doctor's offices giving consent and 47% ultimately completing interviews, versus 94% and 92%, respectively, during military recruitment. Information on individuals who did not consent to participate do not allow us to calculate response rates for the childhood vaccination and youth vaccination sub-samples separately. Details of the sample size calculation and recruitment process are available in the previously published study protocol.[32]

Instrument and translation process

We adapted the questions of the original PACV-15 for the youth population. Item 11 *"If you had another infant today, would you want him/her to get all the recommended shots?"* of the PACV-15 was not relevant for the youth population and was subsequently removed. We call the new 14-item survey, the YAV-14. We then translated it into German, French, and Italian using the backward and forward techniques.[33,34] We included the YAV-14 in a broader survey exploring vaccine decision-making and adolescent vaccination among youth in Switzerland. The YAV-14 is not vaccine specific, with questions referring to adolescent vaccinations in general. However, the broader survey included

questions specific to HPV vaccine and its administration in Switzerland, and informed consent materials specifically mentioned that we were interested in childhood and HPV vaccination. We pretested the full survey among a convenience sample of 2–7 people in each language version and made adjustments based on the feedback. We piloted the adjusted questionnaire by conducting 56 interviews in the 3 target languages.[32] Finally, we administered the survey to participating youth through telephone or face-to-face interviews lasting 15–25 minutes. Interviewers entered survey responses into the Open Data Kit (ODK) using tablets. In addition, we asked youth for copies of their vaccination record, which we used to determine HPV vaccine uptake.

Instrument processing and scoring

We administered the full YAV-14 version modified for youth based on previous validation of both scales for parents of young children.[22] We examine only the YAV-5 here. The YAV-5 consists of five questions answered on a 5-point Likert scale. Items are scored 2 for the two most hesitant responses, 1 for middle responses, and 0 for the two least hesitant responses. The total score is the sum of the score for all items, ranging between 0 and 10. Based on previous studies, we transformed the total score obtained to a 0–10 scale by applying simple linear transformation and dichotomized the total YAV score, with a score <5 indicating non-hesitancy and ≥5 indicating VH.[20,35]

Statistical analysis

We analyzed the data collected using the statistical software STATA version 12.0 (Stata Corp, College Station, TX, USA).

Exploratory factor analysis (EFA)

We assessed the appropriateness of data and sampling adequacy using Barlett's test of sphericity and Kaiser–Meyer Olkin (KMO) measure, respectively. We performed EFA of the YAV-5 using the principal factoring (PCA) extraction technique and rotated the extracted factors with the oblique (oblimin) rotation technique. The factors retained were those occurring before the break in a scree plot of eigenvalues (eigenvalue ≥1) and only items with values >0.3 were retained on each factor. In the case of items with multiple factor loadings, we kept an item under the factor where it had the highest loadings.[35,36] EFA is one of the methods under the classical test theory (CTT) can be used to determine the underlying dimensions in questionnaires.[37] However, EFA has the limitation of not accounting for the categorical nature of items, it specifies a linear relation by analysis of correlation. This has important implications like making incorrect conclusions about the model fit and factor loadings.[38–41]

Internal consistency

We determined the reliability of each factor obtained from EFA with Cronbach's alpha for each language version of the YAV-5. We considered Cronbach's alpha estimates between 0.5 and 0.7 to be reliable.[15,42,43]

Mokken scaling analysis (MSA)

The non-parametric item response theory (NIRT), e.g., MSA is one of the methods under the Item Response Theory (IRT). It is an alternative to classical test theories (CTT) methods like Exploratory factor analysis and Confirmatory factor analysis.[44,45] It has the advantage of establishing a more precise relationship between an item score and the score on the latent trait than CTT techniques.[37]

We conducted MSA of each language version of the YAV-5 for the youth HPV sample using the Mokken package in STATA, an automated item selection algorithm consisting of various checks for the Mokken model assumptions.[46] As recommended in previous literature, we assessed the unidimensionality (all the items from the same scale or subscale are homogeneous or they measure the same latent trait) and local independence (responses to an item are independent of responses to other items within the scale) using the Loevinger's scalability H coefficient, $0 \le c \le 0.3$, where $0.3 \le H < 0.4$ is a weak scale, $0.4 \le H < 0.5$ is a medium scale and $0.5 \le H \le 1.0$ is a strong scale.[46–51] We assessed monotonicity (higher scores represent higher abilities and can be used to order individuals along the latent trait), with the *check. monotonicity* function of the Mokken package, which displays the indexes to check for violations. The default minvi (minimum size of a violation) is set at 0.03. The effect size of significant violations is presented by the Crit values and set according to guidelines set by Molenaar and Sijtsma.[52] Crit values <40 are considered minor violations due to sampling variation, 40≤ Crit<80 are non-serious violations that require further review and Crit≥80 seriously cast doubts on the fulfillment of the monotonicity assumption.[46,49,52,53] We assessed the Invariant Item ordering assumption (interpretation of the scale similarly irrespective of their ranking on the latent trait) by analysis of the P matrixes Hardoin et al. recommended, by means of the *nipmatrix* function of the Mokken package, which displays indexes to check non-intersection. The default minimum size of a violation of non-intersection is 0.03 and the significance level is set at 0.05. The Crit value threshold used to assess monotonicity is applied here as well.[44,46]

Analysis of survey data and primary outcome

We present descriptive statistics of the socio-demographic characteristics of participants and of the responses to individual YAV items for each language version of the YAV. We used Analysis of Variance (ANOVA) to compare continuous sociodemographic variables while chi-square was used to compare categorical variables and participants' responses to the YAV-5 items across the three languages. We used logistic regression to assess the association between youth VH and non-receipt of the first HPV vaccine dose for the full sample and stratified by sex and language.

Results

Participant characteristics

We enrolled 1,003 participants in this study, and their socio-demographic characteristics are shown in Table 1. We recruited 67.3%, 16.9%, and 15.8% of the participants with

mean age 19.3 ± 2.8 years, 20.6 ± 3.5 years, and 17.9 ± 2.4 years in the German, French, and Italian language regions, respectively. Overall, majority were Swiss born (91.9%) and lived with their parents (82.4%). More than half the participants (63.2%) had non-hesitant YAV scores (<5); the mean YAV score and standard deviation were 3.38 ± 24.5, 3.73 ± 2.48, and 2.93 ± 1.84 in the German, French, and Italian language versions, respectively. The prevalence of VH (YAV score ≥5) was 29.6%, 36.5%, and 17.7% in German, French, and Italian languages, respectively. Participant sociodemographic characteristics like age, sex, and household type differed significantly across the three languages ($p < .01$). However, there was no significant difference in HPV vaccine uptake across the languages ($p = .07$).

In Table 2, we provide descriptive statistics for the YAV in the three languages. Comparison of participant's responses to the YAV-5 items across the three languages using Chi-square showed significant differences in responses to items 4, 7, 11, 12 while no significant difference was found for responses to item 6. In German, French and Italian, respectively, majority of the participants considered themselves not VH (74.7%, 64.1% and 85.4%), trusted the information they receive concerning vaccines (84.7%, 85.3% and 97.5%), and disagreed we get more vaccines than are good for us (78.9%, 71.2%, and 75.2%). More than half in each language disagreed with the statement, "It is better to develop immunity by getting sick than to get a vaccine," while less than a quarter believed that many of the illnesses that vaccines prevent are severe.

Table 1. Socio-demographic characteristics of study participants (N = 1,003).

Characteristics	German (n = 675)	French (n = 170)	Italian (n = 158)	Total (N = 1,003)	*P* Value
			N (%)		
Age in years					
≤18	261 (38.7)	51 (30.0)	102 (64.6)	414 (41.3)	
Mean age (SD), years	19.3 ± 2.8	20.6 ± 3.5	17.9 ± 2.4		<0.01, DF: 2
Sex					
Female	223 (33.0)	121 (71.2)	72 (45.6)	416 (41.5)	<0.01
Household Type					
Living with parents	568 (84.2)	112 (65.9)	146 (92.4)	827 (82.4)	<0.01
Nationality					
Swiss	641 (94.9)	139 (81.8)	142 (89.9)	922 (91.9)	<0.01
Provider office type where the youth were recruited					
Medical provider	335 (49.6)	170 (100.0)	123 (77.8)	628 (62.6)	<0.01
Military	340 (50.3)	0	35 (22.2)	375 (37.3)	
YAV-5 score*					
<5	475 (70.4)	108 (63.5)	130 (82.3)	713 (63.2)	
Mean YAV-5 score (SD)	3.38 ± 2.45	3.73 ± 2.48	2.93 ± 1.85		0.02 DF: 2
Vaccine uptake (Boys and Girls)	512 (75.8)	56 (32.9)	138 (87.3)	706 (70.4)	0.07

All data shown are number (%) of participating youths, unless stated otherwise. ANOVA *p* values and degrees of freedom given for comparison of continuous variables while Chi-square *p* values are given for comparison of categorical variables across the languages.
SD: Standard deviation.
*Percentages may not add up to 100% due to missing responses and/or rounding.
SD: Standard deviation.

Exploratory factor analysis

The Kaiser-Meyer-Olkin (KMO) value was 0.73, 0.71, and 0.66 in the German, French, and Italian language versions of the YAV-5. Barlett's test of sphericity was significant with a *p*-value <0.001 across the three languages indicating that the HPV data set was suitable for EFA. All items loaded on a single factor in the German and French versions, accounting for 44% and 40% of the overall variance within both scales, respectively. In the Italian version, three items loaded on factor 1 accounting for 30% of variance while YAV-5 items 1 and 3, "*We get more shots than are good for them"* and *"It is better to get fewer vaccines at the same time,"* had cross loadings under factor 1 and 2. We retained these items under factor 2 where they had the highest loading coefficients, and they accounted for 56% of variance within the scale (Table 3). The factor loadings in the three languages remained the same after applying the oblique (oblimin) rotation.

Reliability analysis

Cronbach's alpha for the YAV-5 was 0.66 and 0.61 for the German and French versions, respectively. For the Italian version, the Cronbach's alpha was 0.38 and 0.35 for factors 1 and 2, respectively (Table 3).

Mokken scale analysis

The YAV-5 Mokken H coefficients were 0.44, 0.40, and 0.39 in the German, French, and Italian scales, respectively (Table 3). The three language versions of the YAV-5 fulfill the monotonicity and IIO assumption of the Mokken DHM model as indicated by no significant violations. (Supplementary material; Tables S1 and S2).

Association of YAV score with uptake of HPV first dose (N = 706)

We use logistic regression to test the association between VH (YAV score ≥5) and non-immunization for HPV vaccine first dose for the full sample and stratified by sex and language. Table 4 reports sample N, odds ratios, and 95% confidence intervals for all analyses. VH was associated with 1.93 higher odds of non-immunization for HPV vaccine first dose in the full sample (95% CI; 1.31–2.85). When stratified by language, VH was associated with 2.05 higher odds (95% CI; 1.26–3.36) in German, but there was no significant association between VH and non-immunization for HPV vaccine for the French and German samples. When stratified by sex, VH was associated with 3.97 higher odds (95% CI; 2.32–6.78) of non-immunization for HPV vaccine for female youth, but there was no association for male youth, (OR; 1.79, 95% CI; 0.88–3.66). When stratified by sex and language, VH was associated with significantly higher odds of non-immunization with HPV vaccine for female youth in the German and French subsamples and for male youth in the German sub-sample (OR 3.76, 95% CI; 2.32–6.78; OR 4.37, 95% CI; 1.07–17.79; OR 3.6, 95% CI; 1.07–12.11, respectively).

Table 2. Participants responses and descriptive statistics of YAV items (N = 1,003).

S/N	PACV Items	Parent responses	German N (%)	French N (%)	Italian N (%)	Total N (%)	P Value
1	Have you ever delayed getting a vaccine for reasons other than illness or allergy?	**No**	536 (84.1)	120 (80.0)	118 (79.2)	774 (82.6)	
		Yes	102 (15.9)	30 (20.0)	31 (20.8)	163 (17.4)	
2	Have you ever skipped a vaccine for reasons other than illness or allergy?	**No**	505 (78.5)	128 (76.6)	139 (89.6)	772 (80.0)	
		Yes	138 (21.5)	39 (23.4)	16 (10.3)	193 (20.0)	
3	How sure are you that it is a good idea to vaccinate you with the vaccines recommended by the Federal Office of Public Health.	**0-5**	637 (94.4)	163 (95.9)	157 (99.4)	957 (95.4)	
		6-7	25 (3.7)	4 (2.4)	1 (0.6)	30 (2.9)	
		8-10	8 (1.2)	0	0	8 (0.8)	
4	I believe that many of the illnesses that vaccines prevent are severe	**Disagree**	316 (47.0)	63 (37.5)	99 (62.7)	478 (47.9)	
		Agree	227 (33.8)	74 (44.1)	35 (22.1)	336 (33.7)	<0.01
		Not sure	129 (14.7)	31 (18.5)	24 (15.2)	184 (18.4)	
5	We get more vaccines than are good for us.	**Disagree**	528 (78.9)	121 (71.2)	118 (75.2)	767 (77.0)	
		Agree	73 (10.9)	28 (16.5)	18 (11.5)	110 (11.0)	
		Not sure	68 (10.2)	21 (12.4)	21 (13.4)	119 (11.9)	
6	It is better to develop immunity by getting sick than to get a vaccine. [a]	**Disagree**	414 (61.9)	101 (59.4)	111 (70.3)	626 (62.8)	
		Agree	136 (20.3)	35 (20.6)	20 (12.7)	191 (19.2)	0.17
		Not sure	119 (17.8)	34 (20.0)	27 (17.1)	180 (18.1)	
7	It is better to get fewer vaccines at the same time. [a]	**Disagree**	374 (56.8)	75 (44.4)	116 (73.9)	565 (57.4)	
		Agree	124 (18.8)	38 (22.5)	14 (8.9)	176 (17.9)	<0.01
		Not sure	160 (24.3)	56 (33.1)	27 (17.2)	243 (24.7)	
8	How concerned are you that you might have a serious side effect from a vaccine? [c]	**Not concerned**	544 (80.7)	94 (55.3)	118 (74.7)	756 (75.5)	
		Concerned	77 (11.4)	62 (36.5)	33 (20.9)	172 (17.2)	
		Not sure	53 (7.9)	14 (8.2)	7 (4.4)	74 (7.4)	
9	How concerned are you that one of the vaccines might not be safe? [c]	**Not concerned**	519 (77.2)	88 (52.7)	108 (68.4)	715 (71.7)	
		Concerned	78 (11.6)	60 (35.9)	41 (25.9)	179 (17.9)	
		Not sure	75 (11.2)	19 (11.4)	9 (5.7)	103 (10.3)	
10	How concerned are you that a vaccine might not prevent the disease? [c]	**Not concerned**	500 (74.9)	90 (53.3)	104 (65.8)	694 (69.8)	
		Concerned	90 (13.5)	62 (36.7)	39 (24.7)	191 (19.2)	
		Not sure	78 (11.7)	17 (10.1)	15 (9.5)	110 (11.1)	
11	Overall, how hesitant about vaccines would you consider yourself to be? [b]	**Not hesitant**	503 (74.7)	107 (64.1)	135 (85.4)	745 (74.6)	
		Hesitant	83 (12.3)	48 (28.7)	14 (8.9)	145 (14.5)	<0.01
		Not sure	87 (12.9)	12 (7.2)	9 (5.7)	108 (10.8)	
12	I trust the information I receive about vaccines. [a]	**Disagree**	28 (4.12)	8 (4.7)	1 (0.6)	37 (3.6)	
		Agree	570 (84.7)	145 (85.3)	154 (97.5)	869 (86.8)	<0.01
		Not sure	75 (11.1)	17 (10.0)	3 (1.9)	95 (9.5)	
13	I am able to openly discuss my concerns about vaccines with my doctor. [a]	**Disagree**	10 (1.5)	5 (3.0)	0	15 (1.5)	
		Agree	638 (96.4)	155 (93.9)	152 (96.8)	945 (96.0)	
		Not sure	14 (2.1)	5 (3.0)	5 (3.2)	24 (2.4)	
14	All things considered, how much do you trust your doctor?*	**0-5**	659 (98.3)	162 (98.8)	158 (99.9)	979 (97.6)	
		6-7	7 (1.1)	2 (1.2)	0	9 (0.9)	
		8-10	4 (0.6)	0	0	4 (0.4)	

Items highlighted blue indicate the items included in the short YAV version (YAV-5). All values shown indicate numbers (%) unless stated otherwise. Chi-square *p* value given for comparison of participant's responses to YAV-5 items across the languages.

*Percentages may not be complete due to missing values.

[a]Agree shows combined responses of strongly agree and agree; disagree shows combined responses of strongly disagree and disagree.

[b]Hesitant shows combined responses of very and somewhat hesitant; not hesitant shows combined responses of not at all and not too hesitant.

[c]Concerned shows combined responses of very and somewhat concerned; not concerned shows combined responses of not concerned at all and not too concerned.

[d]Response category on a 0–10 scale, with 0 being 'do not trust at all' and 10 being 'completely trust.'

Table 3. YAV-5 Exploratory factor analysis loadings, reliability estimates, and Loevinger's H coefficients of Mokken scale for HPV (N = 1,003).

		EFA				MSA		
		German	French	Italian		German	French	Italian
YAV-5 items				Factor 1	Factor 2			
1	I believe that many of the illnesses that vaccines prevent are severe	0.7	0.6	0.4	0.5	0.4	0.3	0.4
2	It is better to develop immunity by getting sick than to get a vaccine.	0.7	0.7	0.5	-	0.5	0.3	0.3
3	It is better to get fewer vaccines at the same time	0.5	0.7	0.4	0.8	0.4	0.4	0.6
4	Overall, how hesitant about vaccines would you consider yourself to be?	0.8	0.7	0.6	-	0.5	0.3	0.4
5	I trust the information I receive about vaccines.	0.6	0.5	0.8	-	0.4	0.4	0.6
		-	-	-	-	0.44	0.40	0.39
Reliability estimates		0.66	0.61	0.38	0.35			

Only EFA factor loadings and Loevinger's H coefficients of Mokken scale >0.3 were considered.

Table 4. Unadjusted odds of non-uptake of HPV vaccine for hesitant vs. non-hesitant youth by language and gender, bivariate logistic regression models.

	N	OR	95% CI	
Full sample	706	1.93	(1.31-	2.85)
German-language sample	512	2.05	(1.26-	3.36)
French-language sample	56	1.45	(0.48-	4.43)
Italian-language sample	138	1.61	(0.66-	3.93)
Female youth only				
Full sample	277	3.97	(2.32-	6.78)
German-language sample	180	3.76	(1.96-	7.21)
French-language sample	38	4.37	(1.07-	17.79)
Italian-language sample	59	3.17	(0.80-	12.54)
Male youth only				
Full sample	429	1.79	(0.88-	3.66)
German-language sample	332	3.6	(1.07-	12.11)
French-language sample	18	0.12	(0.01-	1.26)
Italian-language sample	79	1.2	(0.33-	4.34)

Hesitant defined as YAV-5 score ≥ 5.

Discussion

In this study, we investigated the dimensionality of the YAV-5 using the EFA and the two Mokken scale models (MHM and DHM) as well as the internal consistency using Cronbach's alpha in German, French, and Italian languages. We also determined its construct validity by showing that VH (YAV score ≥5) is associated with increased odds of non-immunization with a first dose of HPV vaccine in Swiss youth. To our knowledge, this is the first time a scale measuring VH has been validated for use in youth.

In EFA of the YAV-5, all the items were retained under a single factor, similar to previous findings,[22] confirming that the scale measures a single dimension. In the Italian version, we observed a two-factor structure where items 1 and 3 were retained under factor 2. An explanation for the difference in the number of factors identified in the Italian scale could be the similarly skewed distribution observed for the two items, highlighting the importance of applying the EFA on normally distributed data set for accurate results as well as the relevance of IRT techniques like MSA.[38,40] However, this does not affect the dimensionality of the YAV-5.

The reliability estimates we obtained were considered satisfactory in German and French (0.66 and 0.61), although they were lower than 0.70 and 0.85 found when validating the PACV-5 in parents of young children. The reliability estimates for the Italian version were below the acceptable levels (0.39 and 0.35) for factors 1 and 2, respectively. Cronbach's estimate has been shown to be influenced by the number of items in the scale. This is clearly seen from the higher estimates obtained from the 5-item factor in German and French compared to the 3-item and 2-item factors obtained in Italian.[15,35,54,55]

The German, French, and Italian versions of the YAV-5 all fulfill the assumptions for MHM and DHM models of the Mokken scale, as indicated by the unidimensionality and local independence of all the items with medium overall scalability coefficients. This corresponds to the findings of a previous study that assessed the unidimensionality of the PACV-5 in German, French, and Italian among parents of young children in Switzerland.[22] Very few significant violations and crit values below the critical level <80 also confirm the three language versions meet the monotonicity and IIO assumptions. This further validates the EFA results and shows that a total score of an individual's responses to the YAV-5 can be used to measure vaccine hesitancy.[46] Based on the consistency of items across the language versions, we conducted construct validation using YAV-5, testing the association between YAV-5 score and HPV non-immunization for the full sample and by language and sex. The need for sex-stratified analyses arose due to the recent nature of HPV vaccine recommendations for boys and the low uptake of HPV vaccine overall for this group, which suggests that factors affecting HPV vaccine uptake may be different for male and female youth.

Overall, our results confirm the construct validity of the YAV-5 as a scale for measuring VH by showing that VH (YAV score ≥5) was associated with significantly increased odds for non-immunization with the first dose of HPV for the full sample. This is consistent with a recent study from Italy that found that higher PACV scores among parents of adolescents were associated with adolescents' under-immunization with HPV vaccine,[19] although that study focused on parents rather than youth.

Sex and language-stratified analyses provided more mixed findings. The association between VH and HPV non-immunization held for the German language full sample, for the female youth full sample, and for sex- and language-stratified analyses for female youth in French and German and for male-youth in German. Small sample size could account for the lack of association in some cases. Notably, the largest samples, in the German-language, found an association for both male and female youth. Variations in the overall levels of vaccine-hesitancy may also have contributed to lack of findings. For example, this might explain why we find an association in the French female youth sub-sample but not the Italian female youth sub-sample. The Italian sample had the lowest overall levels of vaccine-hesitancy, whereas the French sample had the highest. Further research with larger samples is needed to fully confirm the validity of YAV-5 in Italian for both male and female youth and in French for male youth.

The relatively recent FOPH recommendation for boys could have also influenced the results considering that 59% of the study participants are male youth and the chi-square results showed no significant differences in HPV vaccine uptake across the languages. Further studies are recommended to clarify the impact of the relative newness of the HPV vaccine recommendation on uptake among male youth in Switzerland.

This study has some limitations. First, we obtained low reliability estimates for the Italian YAV-5 version because few items retained under the two factors extracted from EFA. Second, the overall Loevinger's H coefficients obtained from each language version were adequate, at medium strength, but not as strong as validations in parent populations. This highlights the need to validate the YAV-5 among youth in other geographical contexts and languages. Third, the participants were recruited from the offices of medical providers and from the military during enlistment. As youth are generally healthy, they are less likely to seek medical care, meaning that those who do not see any of these providers regularly may not be included. As such, youth in our study may differ in important ways from youth in Switzerland overall. Also, our recruitment strategy is not representative of the overall youth population in Switzerland. As such, we are unable to draw any conclusions about the prevalence of vaccine hesitancy in Switzerland or about differences between cantons and language regions. In addition, participants were interviewed via telephone or face-to-face, which may have introduced social desirability bias. Finally, the small number of female youth from each language region who provided vaccine uptake data limited our ability to fully validate the scale in Italian.

Conclusion

Overall, YAV-5 showed robust psychometric properties confirming the integrity of the scale. We recommend the YAV-5 because of the consistency of its items across the languages. The main new elements in this study include highlighting the importance of confirming scale validation using NIRT models that account for the categorical nature of item responses and have less stringent assumptions rather than making conclusions on the factor structure of a scale based on EFA results alone rather. In addition, VH was significantly associated with HPV first dose non-immunization among all youth in the German version of the questionnaire and among female youth in the French version of the questionnaire. Our findings show that the YAV-5 can be useful in identifying, classifying, and measuring youth VH. This will help explore the determinants of vaccine hesitancy in youth and help design evidence-based, targeted interventions that could improve HPV and other youth vaccine uptake among youth in Switzerland and elsewhere.

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