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Application of the Parent Attitudes about Childhood Vaccines (PACV) survey in three national languages in Switzerland: Exploratory factor analysis and Mokken scale analysis

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ABSTRACT

Vaccine hesitancy (VH) is a complex and context-specific phenomenon that is linked to under-immunization and poses challenges to immunization programs. The Parent Attitudes about Childhood Vaccines (PACV) is an instrument developed to measure VH. We translated the PACV into three languages (German, French and Italian) and administered it to 1388 Swiss parents. We used exploratory factor analysis (EFA) to confirm the scale sub-domains, Cronbach's alpha to assess internal consistency reliability, and Mokken scale analysis (MSA), to explore unidimensionality of each language version. We determined to construct validity by linking parental PACV score to children's immunization status for the first dose of measles vaccine. For the 15-item PACV, EFA extracted three sub-domains in German and French and four sub-domains in Italian. Cronbach's alpha was >0.8 across the three languages, and MSA produced a 13-item German, 14-item French, and 11-item Italian PACV. EFA and MSA of the short version PACV extracted a single factor and scale with Cronbach's alpha >0.7 in all three language versions. VH was significantly associated with non-timely receipt of the first dose of measles in all languages (odds ratio of 20.7, 21.3, and 8.3 for German, French, and Italian languages, respectively). The translated and revised PACV-15 versions are valid and reliable instruments for VH measurement. The structure and reliability of the short version of the PACV was as good as the long version. Our results suggest that the PACV can be used to measure parental VH outside the US in the validated languages.

Introduction

Vaccines are one of the most cost-effective interventions for improving health outcomes around the world, with the World Health Organization (WHO) estimating that vaccination saves about 2 to 3 million lives worldwide annually.[1–3] Despite the success of vaccination, vaccine hesitancy, defined as the delay in acceptance or refusal of some or all recommended adult and childhood vaccines despite the availability of vaccination services, can lead to outbreaks of diseases, preventable deaths and inability of countries to achieve their national immunization goals.[4,5] The WHO listed VH as one of the top 10 threats to global health in 2019. Addressing VH will be a key determinant to the success of future immunization programs.[6,7]

Vaccine hesitant parents (VHPs) are a diverse group of parents whose attitudes and behavior place between the extremes of those who accept all vaccine recommendations without hesitation and those who refuse all vaccines. VHPs may refuse some vaccines and accept others, accept vaccines with some delays, or accept all vaccines as recommended while harboring doubts about doing so.[8] It is important to better understand VH among VHPs because they seek relevant information before making vaccination decisions and are therefore open to behavioral change.[9]

The determinants of VH vary widely; the 3Cs model proposed by the WHO strategic advisory group of experts on immunization (SAGE) identified the determinants of VH as confidence, complacency and convenience related to affordability, accessibility, understandability due to literacy levels, and physical availability among others.[8] Similarly, perceived risk, performance expectancy, knowledge, and awareness were some of the factors that positively influenced parental intention to vaccinate their children in studies conducted in China.[10,11]

Recently, the need for active participation of patients in their own healthcare decision-making has been highlighted both nationally and internationally. However, factors such as lack of relevant materials, time, and knowledge may impair provider-parent communication about vaccination benefits, making it difficult to address parental concerns with a consequent loss of confidence in vaccines and providers.[12] It is important for providers to find ways to present evidence and optimally clarify parents' and patients' values without compromising the provider–parent relationship.[13–16]

Developing a standardized tool would help foster a better understanding of parental VH. While a number of quantitative scales measuring immunization beliefs and vaccine confidence exist, few have confirmed validity.[17,18] Some of these scales include the Vaccine Confidence Scale (VCS),[3,4] the Global Vaccine Confidence Index (GVCI), the Vaccine Acceptance Scale (VAS),[19] the Vaccine Confidence Index (VCI),[18] and the 5C scale.[5]

One validated measure of VH is the PACV, developed by Opel and colleagues to measure VH in the United States.[20] The PACV includes 15 items under three domains (behavior, safety and efficacy, and general attitude). A pretest involving 25 parents confirmed the PACV's face and content validity. Its internal consistency was good, with Cronbach's alpha estimate ranging from 0.74 to 0.84, and research shows that parental PACV score is associated with the number of days children are under-immunized, confirming its construct validity.[20–22] Opel and colleagues have also developed a 5-item short-scale PACV (PACV-5) with items drawn from the PACV-15.[23,24]

Originally developed in American English, PACV translations exist in Malay,[25,26] Arabic,[27] Bahasa Indonesia,[28] Spanish,[29] Italian,[1] Turkish,[17] and Tamil.[30] Validated translations exist in Malay (validated using factor analysis and test-retest reliability), Arabic (validated using Cronbach's alpha), and Turkish (validated using confirmatory factor analysis, Cronbach's alpha, and McDonald Omega reliability coefficient).[1,11,19,21–24] However, further translations and validation of the PACV would enable more and better comparative research on VH. To this end, we developed and validated three new translations of the PACV in German, French, and Italian.

Methods

As part of an ongoing National Research Program (NRP74) on VH in Switzerland, we translated the PACV into the three national languages, German, French, and Italian. Our goal was to assess the reliability, dimensionality, and validity of the PACV in each of these languages using well-established methods. All study participants provided written informed consent. The local ethics committee (Ethikkommission Nordwest- und Zentralschweiz) approved the study.[31] To our knowledge, ours is the first study to administer the PACV in multiple languages in a European country. Validation of the PACV will help in the design of appropriate interventions that should improve communication on parent immunization concerns and increase immunization rates.[20]

Study objectives

The objectives of this study are (1) to confirm the sub-domains of the PACV-15 survey using exploratory factor analysis (EFA); (2) to determine the internal consistency reliability of the PACV-15 and PACV-5 using Cronbach's alpha for the French, German, and Italian versions; (3) to assess the unidimensionality (homogeneity) of the PACV-15 and PACV-5 using the Mokken scale analysis (MSA) as a scale for measuring VH; (4) to determine the construct validity of the PACV in the three target languages by exploring the association between parent total PACV score and child immunization status with the first dose of measles vaccine.

The Swiss context

Switzerland is a multilingual (German, French, Italian) country that offers an interesting setting to study vaccine hesitancy. The Federal Office of Public Health (FOPH) is responsible for making vaccine recommendations and setting the Swiss vaccination schedule.[32,33] However, there is no national vaccination registry or national mandate for vaccination in non-epidemic circumstances. The FOPH is committed to the elimination of measles, in line with the WHO global vaccine action plan (GAVIAP) guidelines.[34,35] The national uptake rates in the 2014–2016 Swiss national vaccination coverage survey for the first measles vaccine among the 2, 6, and 8 years old was between 94–96%, depending on the specific age group. Uptake of the second dose was lower, at 87–93% for the same period.[36] After officially being declared measles-free in 2018, small measles outbreaks occurred in 2019 and few Swiss cantons (states) have achieved 95% coverage for two doses of measles vaccine for children above two years.[34,37]

PACV

The PACV was designed as a self-administered scale readable at the sixth-grade level and takes less than five minutes to complete.[20,21] For this study, we administered the PACV-15 as part of telephone interviews included in a larger survey lasting 30–35 minutes. Table 1 shows the items in both the PACV-15 and the PACV-5.[21,24] We test the validity of both measures.

The PACV translation process

We used the backward and forward method[38,39] to translate the original PACV from English to German, French, and Italian. Two independent bilingual translators who are native speakers of the target language translated it from English into each of the target languages. We identified and corrected any discrepancies in the translations for each language. Then, two independent bilingual translators blinded to the initial survey items translated the French, German, and Italian versions back to English. We recruited a convenience sample of 2–7 people per language for the pretest of each language version of the questionnaire and then adjusted all versions based on feedback from the pretest. We piloted the adjusted questionnaire by conducting 56 interviews in the three target languages.[31]

Sample size and recruitment

As a key goal of the broader program is examining parent–provider relationship around vaccine decision-making, we recruited parents of children aged 0–11 years from the offices of participating providers from all language regions (German, French, and Italian-speaking) in almost all Swiss

Table 1. Socio-demographic characteristics of study participants.

Characteristics	German (n = 877)	French (n = 262)	Italian (n = 249)	Total N (%)
Relationship to Child				
Mother	764 (87.8)	227 (86.9)	231 (92.7)	1222 (88.6)
Parent Age (in years)				
18–29	82 (9.4)	25 (9.5)	22 (8.8)	129 (9.3)
≥30	795 (90.7)	237 (90.5)	227 (91.2)	1259 (90.7)
Household Type*				
Couple with 1 or more children	793 (91.2)	230 (88.1)	217 (87.2)	1240 (89.9)
Single parent with 1 or more children	46 (5.3)	18 (6.9)	20 (8)	84 (6.1)
Some of the people are related	17 (1.9)	10 (3.8)	8 (3.2)	35 (2.5)
No one is related	13 (1.5)	3 (1.2)	4 (1.6)	20 (1.5)
Highest type of Parental education				
Completed 9 years of compulsory school	6 (0.7)	8 (3.2)	9 (3.8)	23 (1.7)
Technical/business school	5 (0.6)	2 (0.8)	4 (1.7)	11 (0.8)
Completed apprenticeship	164 (19.2)	33 (13.1)	43 (18.1)	240 (17.8)
College	25 (2.9)	64 (25.5)	68 (28.6)	334 (4.2)
Primary school teaching seminar	11 (1.3)	2 (0.8)	0	13 (0.9)
Higher professional school	166 (19.4)	46 (18.3)	53 (22.3)	265 (19.7)
Bachelor/Master/Doctorate	466 (54.5)	143 (56.7)	113 (47.5)	722 (53.7)
Others	12 (1.4)	2 (0.8)	1 (0.4)	15 (1.1)
Household Income (Swiss francs)*				
<20,000–<40,000	40 (4.6)	18 (6.9)	5 (2.0)	63 (4.6)
<60,000–<80,000	190 (21.8)	50 (19.9)	21 (8.4)	261 (19.0)
<100,000	146 (16.8)	41 (15.7)	12 (4.8)	199 (14.4)
<120,000	132 (15.2)	46 (17.6)	7 (2.8)	185 (13.4)
<150,000	91 (10.5)	32 (12.3)	2 (0.8)	125 (9.1)
≥ 150,000	107 (12.3)	27 (10.3)	7 (2.8)	141 (10.2)
Don't know/decline to answer	144(16.5)	43 (16.4)	189 (76.6)	376 (27.2)
Nationality				
Swiss	699 (80.3)	212 (81.4)	181 (72.7)	1092 (79.1)
Provider office type where parent was recruited				
Biomedical provider	477 (55.5)	170 (72.9)	199 (84.7)	846 (63.8)
Children median age in months (interquartile range) 12 (3)				
Timeliness of vaccination among children aged 12 months and older (N = 972)				
Yes	394 (66.8)	130 (67.7)	162 (85.3)	686 (70.5)
Parent PACV-15 score				
<50	626 (72.0)	156 (59.8)	222 (88.8)	1004 (72.8)
Parent PACV-5 score				
<50	538 (61.9)	139 (53.3)	199 (79.6)	876 (63.5)

All data shown are number (%) of participating parents, unless stated otherwise. *Percentages may not add up due to missing responses.

cantons. Participating providers, working either individually or in a group practice, included biomedical pediatricians and general practitioners, complementary and alternative medicine (CAM) pediatricians and general practitioners, and CAM providers without conventional medical training. Power analysis estimated that we needed a sample size of 1,350 at a statistically significant level of 0.05, power of 0.8, and design effect of 2 to answer our main research questions. Details of the sample size calculation and recruitment process are available in the previously published study protocol.[31]

Data collection and analysis

Interviewers entered the information obtained from the telephone-administered survey into Open Data Kit (ODK) using tablets. When possible, they also obtained children's vaccination booklets from parents. We entered and analyzed the data using the statistical software STATA version 12.0 (Stata Corp, College Station, TX, USA).

PACV processing and scoring

Following standard procedures,[1,21,26,40] we collapsed the different PACV response formats (dichotomous, 5-point Likert scale and 10-point Likert scale) into three response categories: (1) hesitant, (2) not sure, and (3) not hesitant. "Hesitant" responses receive a score of 2, "not sure or don't know" a score of 1, and "not hesitant" 0. We then added scores on individual items, giving a total score of 0–30 for the PACV-15 and 0–10 for the PACV-5. In line with previous reports, we transformed the total score obtained to a 0–100 scale by applying simple linear transformation, and we dichotomized the total PACV score generated, with a score <50 indicating non-hesitancy and ≥50 indicating hesitancy.[1,18,21,40]

Exploratory factor analysis (EFA)

First, we used Barlett's test of sphericity to assess the appropriateness of the data and the Kaiser-Meyer Olkin (KMO) measure to determine sampling adequacy.[41,42]

A Barlett's test of sphericity with a significant *p*-value of <0.05 and KMO of at least 0.5 is necessary to proceed with EFA. Then, we confirmed the sub-domains of the 15-item and 5-item PACV in the target languages by EFA using the principal component factoring (PCA) extraction technique.[21,25] The factors retained were those occurring before the break in a scree plot of eigenvalues (eigenvalue ≥ 1), and an item was considered to belong to a factor if it had a loading greater than 0.3. Finally, we applied the oblique (oblimin) rotation technique on the extracted factors for better interpretability and retained items that loaded on more than one factor under the factor where it had the highest value. We used the Cronbach's alpha to determine the internal consistency reliability of the sub-domains and overall scale of the PACV-15 and PACV-5. Generally, Cronbach's alpha of between 0.5 and 0.7 are considered reliable.[43,44]

Mokken scale analysis (MSA)

We used MSA to review the unidimensionality (homogeneity) of the two versions of the PACV across the three languages. The Mokken scale is a non-parametric item response theory (NIRT) consisting of two models, the monotone homogenous model (MHM) and the double monotone homogenous model (DMM) defined by the unidimensionality, monotonicity, local independence, and invariant item ordering assumptions.[45] A scale is considered unidimensional if all items from the same scale or sub-scale measure the same latent trait.[46] The Loevinger's scalability coefficients are measures of unidimensionality that allows the selection of only items that measure the latent trait in the Mokken scale from an item pool. Some consider it the purest assessment for unidimensionality.[47,48] The scalability of variables are graded as follows: $0.3 \leq H < 0.4$ is a weak scale, $0.4 \leq H < 0.5$ is a medium scale, and $0.5 \leq H \leq 1.0$ is a strong scale.[45,47,49–52] Based on the result of the MSA, we revised the number of items in the PACV-15 and PACV-5 across the three languages for construct validity assessment.

Analysis of survey data and primary outcome

We present descriptive statistics showing the socio-demographic characteristics of participants and the responses to individual PACV items for the three languages. The primary outcome of the validation study was timeliness of children's vaccination with the first dose of measles vaccine. We defined timely vaccination as being vaccinated by the recommended age +3 months.[37,53] Because the recommended age for receiving the first dose of measles vaccine changed from 12 months to 9 months in Switzerland in 2019, we defined timely vaccination as between 12 and 15 months for children born prior to March 2018, and between 9 and 12 months for children born in March 2018 or later.[54] We used logistic regression to assess the association between parent vaccine hesitancy and timeliness of vaccination for the first dose of measles vaccine using the revised PACV-15 and PACV-5.

Results

Participant characteristics

We enrolled 1,388 parent participants and obtained 1,058 (76.4%) vaccination booklets. Participant characteristics are shown in Table 1. We recruited 63.2%, 18.9%, and 17.9% of participants in Geman, French, and Italian languages. Most of the participants were mothers, were Swiss, aged ≥30 years, lived as a couple with one or more children, and had obtained college education. We recruited 55.5%, 72.9%, and 84.7% of participants in biomedical provider offices in German, French, and Italian languages, respectively; the other participants were recruited in CAM provider offices.

There was timely uptake of the first measles dose among 66.8%, 67.7%, and 85.3% of children aged 12 months and above in German, French, and Italian languages, respectively. The mean PACV score for the revised PACV-15 was 33.2 (± 28.0) and 39.1 (± 32.4) for the PACV-5. More than 50% of parents in each language region were not vaccine hesitant with PACV-15 and PACV-5 score of <50 (Table 1).

In Table 2 we provide descriptive statistics for the two PACV versions in the three languages. In German, French, and Italian languages, respectively, 27.8%, 28.4%, and 10.5% of participants indicated they had delayed having their child get a shot for reasons other than illness or allergy. In addition, 30.4%, 35.7%, and 8.2% of participants had ever decided not to have their child get a vaccine for reasons other than illness or allergy.

Approximately half the participants agreed that it was better for children to get fewer vaccines at the same time (47.9%, 54.3%, and 62.1% in German, French, and Italian, respectively) and considered themselves not hesitant about childhood vaccines (58.5%, 49.8%, and 85.1%, respectively). Over half of the participants indicated they trust the information they receive about vaccines (70.2%, 59.5%, and 87.5%, respectively).

PACV-15

The Kaiser Meyer-Olkin (KMO) test of sampling adequacy for the three language versions was above 0.8 and the Barlett's test of sphericity was below the 0.001 significance level, an indication that we could proceed with exploratory factor analysis. EFA identified three sub-domains (factors) with eigenvalues above 1, accounting for 59% of the overall variance in the German and French language versions. Items 1–7 and 11–13 made up factor 1 (general attitude), items 8–10 made up factor 2 (safety and efficacy), and items 14–15 made up factor 3 (behavior). In the Italian version, five factors with eigenvalues above 1 accounting for 65% of the overall variance were extracted. Items 1–6 and 11-13 made up factor 1, items 8–10 made up factor 2, and only item 14, made up factor 3. The remaining items 7 and 15 had cross loadings with other factors while also forming factors 4 and 5, respectively. We retained these two items under the newly formed factors where they had higher loadings.

MSA of the German and French versions of the PACV-15 each produced two sub-scales, and the Italian version had a single scale. We retained 14 items in German and French,

Table 2. PACV items and descriptive statistics of the PACV-15 and PACV-5 (N = 1,388).

S/N	PACV Items	Parent responses	German N (%)	French N (%)	Italian N (%)	Total N (%)
1	Have you ever delayed having your child get a shot for reasons other than illness or allergy?	No	624 (72.3)	184 (71.6)	221 (89.5)	1029 (75.7)
		Yes	231 (27.0)	73 (28.4)	26 (10.5)	330 (24.3)
2	Have you ever decided not to have your child get a shot for reasons other than illness or allergy?	No	592 (69.6)	166 (64.3)	228 (91.9)	986 (72.7)
		Yes	259 (30.4)	92 (35.7)	20 (8.1)	371 (27.3)
3	How sure are you that following the recommended immunization schedule is a good idea for your child?[d]	0–5	705 (81.3)	203 (77.8)	236 (95.2)	1144 (83.1)
		6–7	59 (6.8)	8 (3.1)	2 (0.8)	69 (5.0)
		8–10	103 (11.9)	50 (19.2)	10 (4)	163 (11.8)
4	"Children get more shots than are good for them"[a]	Disagree	441 (50.9)	97 (37.3)	174 (70.2)	712 (51.8)
		Agree	297 (34.3)	129 (49.6)	45 (18.2)	471 (34.3)
		Not sure	127 (14.7)	45 (18.2)	29 (11.7)	190 (13.8)
5	I believe that many of the illnesses that shots prevent are severe.[a]	Disagree	81 (9.4)	37 (14.3)	16 (6.5)	134 (9.8)
		Agree	695 (80.4)	177 (68.3)	217 (87.5)	1089 (79.4)
		Not sure	89 (10.3)	45 (17.4)	15 (6.1)	149 (10.9)
6	It is better for my child to develop immunity by getting sick than to get a shot.[a]	Disagree	450 (53.1)	109 (42.3)	182 (73.1)	741 (54.7)
		Agree	215 (25.4)	107 (41.5)	34 (13.7)	356 (26.3)
		Not sure	183 (21.6)	42 (16.3)	33 (13.3)	258 (19.0)
7	It is better for children to get fewer vaccines at the same time.[a]	Disagree	224 (26.6)	56 (21.7)	36 (14.5)	316 (23.4)
		Agree	404 (47.9)	140 (54.3)	154 (62.1)	698 (51.8)
		Not sure	214 (25.4)	62 (24.4)	58 (23.4)	334 (24.8)
8	How concerned are you that your child might have a serious side effect from a shot?[c]	Not concerned	331 (38.4)	173 (66.5)	117 (46.9)	621 (45.3)
		Concerned	457 (52.9)	79 (30.4)	126 (50.6)	662 (48.3)
		Not sure	75 (8.7)	8 (3.1)	6 (2.4)	89 (6.5)
9	How concerned are you that any one of the childhood shots might not be safe?[c]	Not concerned	552 (64.5)	112 (43.6)	140 (56.2)	804 (59.0)
		Concerned	209 (24.4)	129 (50.2)	97 (38.9)	435 (31.9)
		Not sure	95 (11.1)	16 (6.2)	12 (4.8)	123 (9.0)
10	How concerned are you that a shot might not prevent the disease?[c]	Not concerned	176 (20.4)	89 (34.5)	91 (36.6)	356 (25.9)
		Concerned	612 (70.9)	149 (57.8)	148 (59.4)	909 (66.4)
		Not sure	75 (8.7)	20 (7.8)	10 (4.0)	105 (7.7)
11	If you had another infant today, would you want him/her to get all the recommended shots?	No	243 (28.1)	96 (36.9)	20 (8.0)	359 (26.1)
		Yes	602 (69.6)	161 (61.9)	226 (90.8)	989 (71.9)
		Don't know	20 (2.3)	3 (1.1)	3 (1.2)	26 (1.9)
12	Overall, how hesitant about childhood shots would you consider yourself to be?[b]	Not hesitant	501 (58.5)	130 (49.8)	212 (85.1)	843 (61.7)
		Hesitant	235 (27.4)	116 (44.4)	34 (13.7)	385 (28.2)
		Not sure	121 (14.1)	15 (5.8)	3 (1.2)	139 (10.2)
13	I trust the information I receive about shots.[a]	Disagree	100 (11.7)	50 (19.5)	18 (7.3)	168 (12.4)
		Agree	599 (70.2)	153 (59.5)	217 (87.5)	969 (71.4)
		Not sure	154 (18.1)	54 (21.0)	13 (5.2)	221 (12.3)
14	I am able to openly discuss my concerns about shots with my child's doctor.[a]	Disagree	13 (1.5)	2 (0.8)	3 (1.2)	18 (1.3)
		Agree	807 (96.1)	254 (97.7)	243 (98.4)	1327 (96.9)
		Not sure	19 (2.2)	4 (1.5)	1 (0.4)	24 (1.8)
15	All things considered, how much do you trust your child's doctor?"	0–5	839 (97.9)	259 (99.6)	244 (99.2)	1342 (98.5)
		6–7	16 (1.9)	1 (0.4)	1 (0.4)	18 (1.3)
		8–10	2 (0.2)	0	1 (0.4)	3 (0.2)

Items highlighted blue indicate the items included in the short PACV version (PACV-5). All values shown indicate numbers (%) unless stated otherwise.
[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'

with item 10 being dropped in German and item 14 in French. We retained 11 items in Italian, with items 1, 7, 10, and 14 being dropped. In German, the first sub-scale extracted consisted of all retained items except 5, 7, and 11, which made up the second sub-scale. In French, the first sub-scale consisted of all retained items except 1, 2, 4, 5, and 11, which made up the second sub-scale. In Italian, the single Mokken scale included all retained items. The scalability coefficient was 0.5 for each sub-scale in French and German and 0.6 for the scale in Italian (Appendices 1, 2, and 3, respectively). In line with previous studies,[47] the items that did not fit into the Italian version were reassessed to check their viability in forming another sub-scale, but their scalability coefficients remained below the acceptable threshold.

In each language, we removed all items that did not fit, including item 1 ("Have you ever delayed having your child get a shot for reasons other than illness or allergy?"), item 7 ("It is better for children to get fewer vaccines at the same time"), item 10 ("How concerned are you that a shot might not prevent the disease?"), and item 14 ("I am able to openly discuss my concerns about shots with my child's doctor"). This gave us an 11-item scale in Italian and a 14-item scale in German and French.

PACV-5

The Kaiser Meyer-Olkin (KMO) test of sampling adequacy for the three language versions was above 0.7, and the Barlett's test of sphericity was below the 0.001 significance level. All PACV-5 items were retained under a single factor accounting for 61%, 61%, and 48% of overall variance in German, French, and Italian, respectively. A single Mokken scale was extracted in the three language versions with scalability coefficients: 0.69, 0.65, and 0.54 in German, French, and Italian, respectively (Table 3).

Internal consistency reliability

Reliability estimates for the overall PACV-15 ranged from 0.81 to 0.89 across the three language versions with slight variations within the sub-domains. For the PACV-5, the overall reliability estimates ranged 0.70 to 0.85 across the three language versions.

Association of parent PACV score with child measles vaccination status

For the revised PACV-15 (with 14 items in German and French, and 11 items in Italian), children of VHPs had 20.7 (95% CI 12.9–33.4), 21.3 (95% CI 9.5–47.3), and 8.3-fold (95% CI 2.8–24.7) higher odds of non-timely receipt of the first dose of measles in German, French, and Italian languages, respectively. For the PACV-5, children of VHPs (PACV score ≥50) had 15.3 (95% CI 9.6–24.3), 14.5 (95% CI 6.5–31.8) and 5.8-fold (95% CI 2.2–15.4) higher odds of non-timely receipt of the first dose of measles in German, French, and Italian languages, respectively.

Discussion

In this study, we validated the PACV-15 and PACV-5 in three languages in Switzerland, a multilingual European country by showing that children of VHPs (PACV score $\geq$50) have higher odds of non-timely receipt of the first dose of measles vaccine. We confirmed that both the PACV-15 and PACV-5 have a good initial structure with good reliability estimates for the three language versions. In addition, through MSA, we found that the PACV-15 and PACV-5 are unidimensional, and the scores obtained can be used to identify VHPs, thus augmenting the findings of EFA.

EFA of the PACV-15 in German and French gave factor-loading structures similar to those obtained in the original English PACV-15 but with slight variations in sub-domain item loadings.[55] The Italian version was quite different, with items 7 and 15 forming unknown factors. Looking back at the values obtained from the Italian EFA inter-correlation matrix, both items were on the borderline, with correlation values of 0.25 and 0.26, respectively. These differences are not unexpected because Opel and colleagues highlighted the need for further validation of the PACV in other settings.[21]

Similar to our findings, a study that validated the Malay PACV-15 version and another study that assessed the relationship between PACV scores and future child immunization status both dropped PACV-15 item 7, "It is better for children to get fewer vaccines at the same time" because it did not statistically discriminate between hesitant and non-hesitant responses.[22,26] Abd Halim and colleagues similarly observed a different factor structure in the validation of the PACV in Malay. They reported four factors with a new sub-domain labeled "Schedule and Immunity" including PACV items 6, 8, and 9.[26]

The PACV-15 had good reliability estimates across the three languages (ranging from 0.81 to 0.89). Reliability was slightly lower than the estimate of 0.96 reported by Napolitano et al. but higher than 0.79 and 0.77 reported by Abd Halim et al. and Mohd Azizi et al., respectively.[1,25,26] The PACV-5 was as reliable as the PACV-15 across the three languages, comparable to what was observed in the PACV-15 in English.[21,25]

MSA of the PACV-15 in German, French, and Italian led us to retain 14 items each in German as well as French and 11 items in Italian. Retained items in each scale had scalability coefficients above the threshold of 0.3 recommended in literature.[45,48] This suggests that the PACV-15 items were sufficiently homogenous to comprise scales and sub-scales in all three languages. In addition, the medium to strong Mokken scalability coefficients (0.5 in German and French and 0.6 in the Italian) suggest sufficient homogeneity for the PACV-15 to be considered a measure of VH. No items were dropped based on MSA of the PACV-5, and the scalability coefficients similarly demonstrate homogeneity and strong scalability for these items.

The results of MSA showed that the PACV-15 and PACV-5 have satisfactory content validity, and the items retained adequately represent the previously identified sub-

Table 3. PACV-5 exploratory factor analysis and Mokken H coefficients (N = 1,388).

		EFA Factor Loadings (>.3)			Loevinger's H coeff. (>.3)		
S/N	Items	German (N = 877)	French (N = 262)	Italian (N = 249)	German (N = 877)	French (N = 262)	Italian (N = 249)
1	"Children get more shots than are good for them."	0.8	0.7	0.7	0.7	0.5	0.5
2	"It is better for my child to develop immunity by getting sick than to get a shot."	0.8	0.7	0.7	0.6	0.6	0.5
3	"It is better for children to get fewer vaccines at the same time."	0.6	0.7	0.4	0.6	0.6	0.5
4	"Overall, how hesitant about childhood shots would you consider yourself to be?"	0.8	0.8	0.7	0.7	0.6	0.6
5	"I trust the information I receive about shots."	0.7	0.8	0.6	0.7	0.7	0.5
					0.7	0.7	0.5

domains (general attitude, safety, and efficacy, behavior) and measure VH.[21] The differences observed between this study and the original PACV in English as well as other translations of the PACV in terms of factor structure, item loadings and number of items retained can be attributed to methodological (the use of the NIRT Mokken scaling model), language and cross-cultural differences. This further highlights the need for continuous adaptation of the PACV depending on the setting where it is applied.[26,56]

Our results confirmed the construct validity of the revised PACV-15 and PACV-5 as a scale for measuring VH by showing that PACV score ≥50 was associated with significantly increased odd of not receiving the first measles dose on time. This is consistent with the findings of the US study that validated the original PACV-15, where higher parent PACV scores were associated with children's under-immunization.[21,40]

The PACV-5 was as good as the PACV-15 in structure, reliability, and in measuring vaccine hesitancy in our dataset. This is similar to the findings of Gust and colleagues in their comparative analysis of the PACV-5 and the five categories of Vaccine Acceptance Scale, where they reported that higher PACV-5 scores were associated with increased parental VH, which is important for identification and classification of VH parents.[57]

In this study, the PACV-5 had consistent items across all target languages, making results more comparable than with the revised PACV-15. In addition, as a shorter instrument, the PACV-5 can reduce parent burden and is easier to use as a screening which identifies, measures, and categorizes parents in terms of VH at their first pediatric visit in clinical research settings.[24,57] As such, we consider the PACV-5 a better scale.

This study has some limitations. One is that we recruited the study participants through providers (biomedical and CAM). This means that parents who do not regularly see providers or have access to healthcare may not be included, creating selection bias, and meaning that the results are not representative for Switzerland as a whole. In addition, we interviewed parents via telephone rather than using the self-administered design. This may have introduced social desirability bias. In addition, we were not able to collect vaccination booklets from parents who were not willing or able to share their children's vaccination records, making it impossible to match some children's vaccination cards to parent's PACV scores.

Conclusion

This study validates the PACV in German, French, and Italian using EFA and MSA. This gives confidence in the integrity and precision of the scale in identifying and categorizing parents based on their PACV scores. Importantly, we find that the short version PACV-5 is a valid, reliable, and unidimensional scale, which can be used to design tailored interventions that address the specific needs of VHPs in the Swiss population. This could improve vaccine uptake and timely receipt because of significant reduction in VH and improved vaccine confidence among parents. In addition, the consistency of the shorter PACV-5 items across the language versions makes it useful in measuring VH across different language and geographical settings in a comparable way. We recommend further adaptation and evaluation of the PACV-5 in other languages and geographical settings; this may contribute to its adoption as a standardized tool for measuring VH.

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