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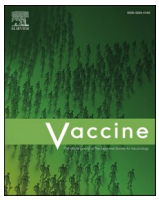

Validation of the Danish translation of the vaccination attitudes examination (VAX) scale

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ABSTRACT

Background and objectives: Short and valid instruments measuring vaccination attitudes across countries are limited. The recently developed 12-item Vaccination Attitudes Examination (VAX) scale measures vaccination hesitancy and consists of four subscales: (1) mistrust of vaccine benefits, (2) worries over unforeseen future effects, (3) concerns about commercial profiteering, and (4) preference for natural immunity. The original English version has been translated and validated in different languages. This study aimed to validate the Danish translation of the VAX scale.

Methods: The Danish translation of the VAX scale was distributed to Danish citizens using social media via the online survey system SurveyXact. Confirmatory factor analysis (CFA) examined the factor structure. Internal consistency reliability was evaluated for the entire scale and all subscales. Known group validity was tested using vaccination status. Criterion validity was assessed using the beliefs about medicines questionnaire (BMQ).

Results: Analysis of responses from 194 participants revealed an adequate four-subscale construct (GFI = 0.939, AGFI = 0.901, NFI = 0.955, TLI = 0.976, CFI = 0.982, RMSEA = 0.056, SRMR = 0.037, $p = 0.005$) and a high internal consistency reliability (Cronbach's α 0.934 for the entire scale, 0.920, 0.824, 0.833, and 0.899 for the four subscales, respectively). COVID-19 vaccinated participants showed significantly lower VAX scale scores (Mean(SD) = 2.36(0.83)) compared to non-vaccinated (Mean(SD) = 4.88(0.93)). A significant correlation was found with BMQ-general ($r = -0.716$, $p < 0.01$).

Conclusion: The Danish translation of the VAX scale demonstrated a well-defined four-factor structure with high internal consistency, known group validity, and criterion validity. It is a useful tool to measure vaccination hesitancy in Denmark.

1. Introduction

Vaccines reduce disease disability, risk of death, and inequity worldwide, and are considered a powerful tool in managing public health [1,2]. Since their discovery, vaccines have been crucial in the fight against many highly contagious diseases, including polio, hepatitis B, and influenza [3]. Their significance was highlighted during the COVID-19 pandemic, when at the same time, extended mistrust in the safety and effectiveness of vaccines was observed [4–6]. The pandemic period played a critical role in shaping vaccine attitudes and behaviors, influenced by concerns over the novel nature of COVID-19 vaccines, rapid vaccine development, safety perceptions, and public health policies implemented during this time [6–8]. Notably, the scientific literature indicated a rise in vaccine hesitancy and anti-vaccination attitudes, a trend observed since the influenza pandemic in 2009 [9]. Vaccine hesitancy – defined as the reluctance or refusal to vaccinate despite vaccines being available – is a global public health concern, even though there is abundant evidence that vaccines are effective [10]. It impacts not only herd immunity but also the adoption of new vaccines [11]. Numerous studies have revealed that vaccine hesitancy is a common global phenomenon, with various reasons cited for refusing vaccines [6,9,12,13]. The World Health Organization (WHO) even declared vaccine hesitancy as one of the top ten threats to global health in 2019 [10].

As vaccine hesitancy poses a significant challenge to the overall success of vaccination campaigns, measuring and understanding vaccine hesitancy is important for predicting vaccination behaviors and developing effective vaccination interventions or public health campaigns

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encouraging vaccination [14]. Given that vaccine hesitancy is a multifaceted phenomenon heavily influenced by cultural, social, and contextual factors, there is a clear need for culturally adapted tools [7,12,13]. Furthermore, because vaccine hesitancy is also influenced by the organization and delivery of vaccination programs, considerations of local vaccination strategies are necessary [7,15,16]. Therefore, a brief description of Denmark's vaccination campaign structure is warranted.

In Denmark, the Danish Childhood Vaccination Programme provides vaccination for ten infectious diseases to all children free of charge. Some diseases, such as influenza and pneumococci, also receive free vaccinations outside the program. Additionally, COVID-19 vaccination has been included since 2021. Vaccination in Denmark is voluntary, with no mandatory vaccination policies in place. Immunizations are provided free of cost, primarily through general practitioners, and public health efforts focus on information dissemination and accessibility rather than compulsion or financial incentives [17,18]. During the COVID-19 pandemic, as of October 20, 2021, COVID-19 vaccination coverage in Denmark reached an average of 87.1 %, with the lowest coverage among the youngest age groups [19]. However, a substantial decline in HPV vaccine uptake in Denmark was documented recently, indicating that attitudes towards vaccines may depend on vaccine type [20]. Thus, a comprehensive understanding of the causes and context of the dynamics in vaccine hesitancy is vital for developing effective strategies to address vaccine hesitancy even in countries of usually high vaccine uptake, such as Denmark [9].

Previous studies looking at vaccine hesitancy among the Danish population have mainly taken a qualitative approach [21], and a reason for this could be that Danish-validated questionnaires to measure vaccination attitudes were missing. Furthermore, despite the importance of measuring vaccination attitudes across different countries, there is currently a lack of consensus in the scientific community on which questionnaires to use to measure vaccine hesitancy. Examples of currently applied instruments include the *Attitudes and Behaviors Regarding Vaccination Decisions* [22], the *Parents Attitudes about Childhood Vaccines* survey [23], the *Vaccine Hesitancy Scale* [24], the *HIV Vaccine Attitudes Scale* [25], and the *Carolina HPV Immunization Attitudes and Beliefs Scale* [26]. It should be noted that most of these scales focus on parental decisions [22,23] or specific vaccine types [25,26]. Although attitudes towards vaccines may vary by vaccine type, there is reason to believe that vaccine hesitancy may co-occur across different types of vaccines [27]. Therefore, measuring vaccine hesitancy in general might be advantageous. To measure general vaccination hesitancy, the 12-item Vaccination Attitudes Examination (VAX) scale was recently developed by Martin et al. [14]. The original English version of the VAX scale has been translated into and validated in different languages (including Spanish, French, Italian, Turkish, Hebrew, Korean, Arabic) and is successfully applied in different countries [28–37], but a Danish translation of this questionnaire is still lacking to measure general vaccine hesitancy among Danish speakers.

1.1. Objective of the study

The study aimed to validate a Danish translation of the Vaccination Attitudes Examination (VAX) scale.

2. Materials and methods

2.1. Design and instruments

A cross-sectional online questionnaire survey was conducted in Denmark in April 2022. The first step of the online survey presented participants with detailed information about the study, including its purpose, data handling, and participants rights, so they could provide informed consent. Only after giving informed consent were participants allowed to initiate and complete the rest of the questionnaire. The self-administered questionnaire included the VAX scale [14], the Beliefs about Medicines Questionnaire (BMQ)-general [38–40], and items addressing age, gender, education level, guardianship over a child, vaccination statuses (whether participants and their children were COVID-19 vaccinated, and if participants had refused a vaccine from the recommended vaccination program for their children), and future vaccination intentions. The full questionnaire consisted of 29 questions that could be completed within 15 min and is found in the Supplementary Materials.

2.1.1. VAX scale

The VAX scale is a 12-item questionnaire originally in English, which consists of four subscales: 1. mistrust of vaccine benefits, 2. worries over unforeseen future effects, 3. concerns about commercial profiteering, and 4. preference for natural immunity. Participants express their level of agreement with each statement using a 6-point Likert scale, where 1 signifies complete disagreement and 6 signifies complete agreement. When analyzing the VAX scale, items 1, 2, and 3 were reverse-coded. Subsequently, scale and subscale scores were created by calculating the mean for the respective items, resulting in an overall scale range of 12–72. Higher scores on this scale indicate a more unfavorable general view of vaccines [14].

2.1.2. BMQ

The BMQ is a questionnaire originally developed in English, which is divided into two main components: the 10-item BMQ-specific, which assesses individuals' perceptions of their prescription medications, and the 8-item BMQ-general, which assesses beliefs about medicines in general [38]. The BMQ-general scale consists of two subscales with 4 items in each: 1. beliefs about the harmfulness (General-Harm) and 2. overuse (General-Overuse) of medicines [38]. Respondents express their level of agreement with each statement using a 5-point Likert scale, where 1 signifies strong agreement and 5 signifies strong disagreement. The scale scores were created by calculating the mean for the respective items, giving an overall scale range of 10–40, with higher scores indicating a more favorable perspective on medications in general [39]. The questionnaire is validated in English [38]. In this study, a Danish translation of the BMQ-general was used to survey participants [39,40].

2.2. Translation and pilot testing

Permission to translate and validate the VAX scale was obtained from the original authors prior to commencing this study. The original VAX scale was translated from English to Danish. The translation was performed by applying the Principles of Good Practice for the Translation and Cultural Adaptation Process for Patient-Reported Outcomes Measures, describing both translation phases and cognitive debriefing phases [41]. Three authors, two bilingual native Danish speakers (CB, AA) and one bilingual native English speaker (JT), were involved in the translation phase.

Six native Danish speakers participated in the cognitive debriefing phase, or pilot testing of the scale. These individuals exhibited diverse demographic characteristics, reflecting an average age of 45.5 years (ranging from 24 to 77 years). Among the participants, 66.67 % were female, representing various occupations including two pharmacists, two students, one engineer, and one retired individual. During this phase, the translated Danish version was evaluated in terms of the clarity of the instructions, items, and response formats. Cognitive debriefing interviews were conducted using the 'think-aloud' method, as suggested by Tourangeau [42]. The results from the cognitive debriefing interviews were analyzed, and the questionnaire was modified by specifying the wording of questions and items brought up during the pilot testing, resulting in a final translated Danish version.

2.3. Data collection

The data collection was conducted using the online survey system,

SurveyXact. Participants were recruited through municipalities' Facebook groups, encouraging participants to also share the link to the questionnaire among their networks. The selection of municipalities was determined by their population size, ensuring a range of municipalities that encompassed both rural and urban areas. Only those municipalities in which Facebook groups allow and/or encourage the distribution of questionnaires were used. The links to the questionnaire were available for two weeks starting April 7, 2022; however, no new entries were observed after the first week of availability.

2.4. Data analysis

Only entries that provided informed consent as well as all demographic information and replied to the whole VAX scale were classified as valid and included in the analysis.

To validate the Danish translation of the VAX scale, first of all, internal consistency reliability was assessed by calculating Cronbach's α internal consistency for each subscale and for the overall scale. Structural, known group, and criterion validities were then examined. The VAX scale factor structure was examined using confirmatory factor analysis (CFA). The known group validity was analyzed by comparing vaccine hesitancy in the groups of respondents with different vaccination statuses using *t*-tests. Based on prior research [14,28–37] it was expected that VAX scale scores would be higher for participants who had not received the COVID-19 vaccine; participants with children who were not COVID-19 vaccinated; and participants who declined a vaccine in the recommended vaccination program for their children compared to participants who had received vaccines themselves and vaccinated their children. Criterion validity was examined by correlating VAX and the BMQ-general [38–40]. Based on previous studies [28–30], it was expected that higher vaccine hesitancy (higher VAX scale scores) would correlate with lower trust in medicines (lower BMQ-general scores).

The fit of the CFA model was evaluated using standard indices with the following criteria indicating acceptable model fit: Goodness of Fit (GFI) $\geq$ 0.95, Adjusted Goodness of Fit (AGFI) $\geq$ 0.95, Normed Fit Index (NFI) $\geq$ 0.95, Tucker Lewis Index (TLI) $\geq$ 0.95, and Comparative Fit Index (CFI) $\geq$ 0.95, Root Mean Square Error of Approximation (RMSEA) $<$ 0.08, and Standardized Root Mean Square Residual (SRMR) $<$ 0.08 [43,44].

Statistical significance was set at 0.05. Analyses were conducted using the IBM Statistical Package of Social Sciences (SPSS) version 28, and CFA was conducted using the IBM SPSS AMOS package version 28. Microsoft Excel 2016 was used for the graphical presentation of the descriptive results.

2.5. Ethical considerations

All respondents were informed about the aim of the study and their right to withdraw from the study and provided informed consent before participating in the study. Data was stored according to the policy of the University of Copenhagen, which follows the national legislation and the requirements of the General Data Protection Regulation (GDPR). According to Danish law, a formal ethical assessment was not necessary, as the study did not collect any biological material.

3. Results

A total of 244 people started to respond to the questionnaire, and 194 had valid entries. The majority of the respondents were female (83 %), and the age ranged from 19 to 83 years. The distribution of respondents across age and educational background categories was relatively even, with the largest age group consisting of participants under 30 years old (24.7 %), and the most prevalent educational group having completed higher education of 3–4 years (37.1 %). The majority of participants (84.0 %) reported being COVID-19 vaccinated (Table 1).

Table 1
Demographic characteristics and descriptive information for the total sample (N = 194).

Demographics			Frequency	Percentage
Gender				
Male			33	17.0
Female			161	83.0
Age groups (years)				
Under 30			48	24.7
30–39			25	12.9
40–49			34	17.5
50–59			30	15.5
60–69			31	16.0
70–79			24	12.4
Over 80			2	1.0
Education				
Primary school			8	4.1
Vocational training			19	9.8
High school			29	14.9
Higher education (under 3 years)			20	10.3
Higher education (3–4 years)			72	37.1
Higher education (5 years or more)			37	19.1
Researcher education (PhD)			6	3.1
Other			3	1.5
COVID-19 vaccine				
Not vaccinated			21	10.8
Vaccinated, but not fully vaccinated			10	5.2
Fully vaccinated			163	84.0
Child COVID-19 vaccine[a]				
Vaccinated child			21	50.0
Not vaccinated child			21	50.0
Children vaccination program[a]				
No to vaccine			5	11.9
Yes to vaccine			37	88.1
	Mean	**SD**	**Min.**	**Max.**
Age	46.8	17.9	19	83

[a] subsample of 42 participants who were legal guardians of children under 15 years old. SD standard deviation.

3.1. Internal consistency

For the overall VAX scale, a Cronbach's α value of 0.934 was obtained, demonstrating excellent internal consistency [43]. Subscales' internal consistency was also excellent: (1) for mistrust of vaccine benefits, Cronbach's α = 0.920; (2) for worries over unforeseen future effects, Cronbach's α = 0.824; (3) for concerns about commercial profiteering, Cronbach's α = 0.833; (4) for preference for natural immunity, Cronbach's α = 0.899. The internal consistency of the BMQ scale was, Cronbach's α = 0.850.

3.2. CFA findings

CFA was conducted on all 12 VAX items using the four predetermined subscales. The model showed good fit: Chi-square = 77.268, p = 0.005; GFI = 0.939; AGFI = 0.901; NFI = 0.955; TLI = 0.976, CFI = 0.982; RMSEA = 0.056; and SRMR = 0.037.

The CFA factor loadings for all items exceeded 0.70, signifying strong associations within the subscales [43]. Subscale covariance between 0.63 and 0.83 indicated a strong correlation between the subscales (Fig. 1) [45].

3.3. Known group validity

The total VAX scores and VAX subscale scores were significantly lower ($p < 0.001$) for people who were COVID-19 vaccinated and whose children, if any, were COVID-19 vaccinated compared to those who were not COVID-19 vaccinated and whose children, if any, were not COVID-19 vaccinated (Table 2), meaning that vaccination hesitancy was lower

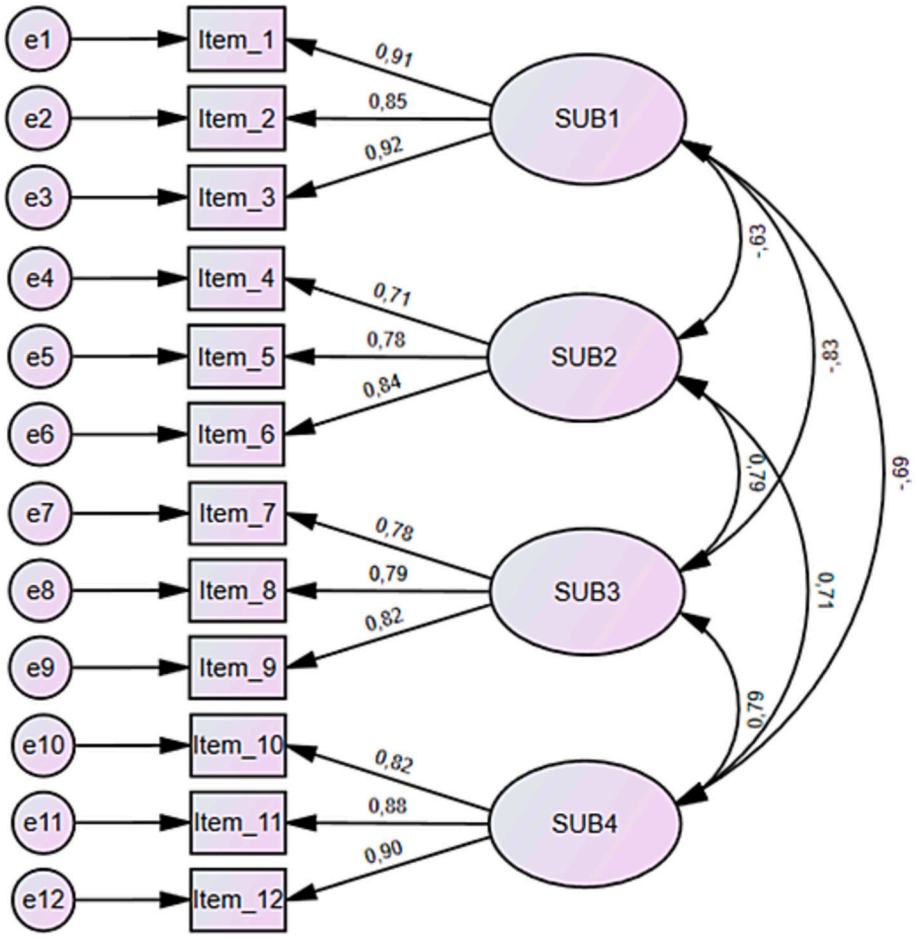

Fig. 1. Confirmatory factor analysis (CFA) model showing the factor loadings and covariance for the Danish translation of the VAX scale. SUB1: mistrust of vaccine benefits, SUB2: worries over unforeseen future effects, SUB3: concerns about commercial profiteering, and SUB4: preference for natural immunity.

Table 2
Comparison of means (SD), t-values, and *p*-values, for participants based on vaccination status and child vaccination status (N = 194).

		VAX	VAXsub1	VAXsub2	VAXsub3	VAXsub4
All (n = 194)	Mean (SD)	2.72 (1.17)	2.38 (1.41)	3.56 (1.36)	2.03 (1.44)	2.91 (1.44)
COVID-19 vaccinated (*n* = 163)	Mean (SD)	2.39 (0.83)	2.00 (1.00)	3.30 (1.23)	1.67 (0.88)	2.59 (1.21)
Not COVID-19 vaccinated (n = 21)	Mean (SD)	4.88 (0.93)	4.63 (1.49)	5.35 (0.89)	4.37 (1.23)	5.19 (0.91)
	t-value[1]	11.666	7.909	9.437	9.73	11.833
	P-value[1]	<0.001	<0.001	<0.001	<0.001	<0.001
Child COVID-19 vaccinators (*n* = 21)	Mean (SD)	2.10 (0.71)	1.86 (0.59)	2.76 (1.26)	1.48 (0.68)	2.29 (1.14)
	Mean (SD)	3.83 (1.47)	3.68 (1.67)	4.57 (1.37)	3.00 (1.78)	4.06 (1.62)
	t-value[1]	−4.855	−4.717	−4.459	−3.671	−4.114
Child COVID-19 non vaccinators (n = 21)	P-value[1]	<0.001	<0.001	<0.001	0.001	<0.001
Childhood vaccination program vaccinator (*n* = 37)	Mean (SD)	2.72 (1.24)	2.53 (1.37)	3.50 (1.54)	1.93 (1.19)	2.93 (1.50)
	Mean (SD)	4.75 (1.73)	4.53 (1.79)	4.93 (1.53)	4.53 (1.97)	5.00 (1.73)
	t-value[1]	2.542	2.409	1.966	2.892	2.549
Childhood vaccination program non-vaccinator (*n* = 5)	P-value[1]	0.056	0.065	0.105	0.04	0.053

[1] Equal variance not assumed. VAX = Vaccination Attitudes Examination Scale, VAXsub1 = subscale 1 mistrust of vaccine benefits, VAXsub2 = subscale 2 worries over unforeseen future effects, VAXsub3 = subscale 3 concerns about commercial profiteering, VAXsub 4 = subscale 4 preference for natural immunity.

among vaccinated respondents.

The VAX scale and subscales scores were also higher in those who refused childhood vaccines for their children compared to those who accepted this vaccine, meaning that vaccination hesitancy was higher among those refusing vaccination. The difference was statistically significant for one of the VAX subscales, i.e., subscale 3 (concerns about commercial profiteering) (Table 2).

3.4. Criterion validity

The correlation matrix between the VAX scale and four subscales, and the BMQ-general scale and two subscales were positive within each scale, and negative when correlating these scales against each other, meaning that more positive attitudes towards medicines were correlated with less hesitancy towards vaccines (Table 3).

Table 3
Correlation matrix showing associations between mean VAX scale scores and BMQ-general scores, including correlations between subscales.

Measure	VAX	BMQ-general	VAXsub1	VAXsub2	VAXsub3	VAXsub4	BMQsub1	BMQsub2
VAX		−0.716**					−0.665**	−0.672**
BMQ-general	−0.716**							
VAXsub1				0.539**	0.725**	0.635**	−0.635**	−0.634**
VAXsub2			0.539**		0.650**	0.615**	−0.516**	−0.458**
VAXsub3			0.725**	0.650**		0.678**	−0.572**	−0.617**
VAXsub4			0.635**	0.615**	0.678**		−0.547**	−0.577**
BMQsub1 ($n = 191$)	−0.665**		−0.635**	−0.516**	−0.572**	−0.547**		0.722**
BMQsub2 ($n = 190$)	−0.672**		−0.634**	−0.458**	−0.617**	−0.577**	0.722**	

VAX = Vaccination Attitudes Examination Scale, BMQ-general = Beliefs About Medicines Questionnaire, general, VAXsub1 = subscale 1 mistrust of vaccine benefits, VAXsub2 = subscale 2 worries over unforeseen future effects, VAXsub3 = subscale 3 concerns about commercial profiteering, VAXsub 4 = subscale 4 preference for natural immunity, BMQsub1 = subscale 1 general-overuse, BMQsub2 = subscale 2 general-harm. ** $p < 0.01$.

4. Discussion

The goal of this study was to validate a Danish translation of the VAX scale. The Danish translation of the 12-item VAX scale demonstrated very high internal consistency for both the overall scale as well as the subscales. High internal consistency for the scale has also been reported for previous translations (0.92 English [28], 0.83 Spanish translation [29], 0.94 and 0.89 Italian translations [31,32], 0.818 Turkish translation [33], 0.93 Hebrew translation [34], and 0.93 Arabic translation [37]).

Using CFA, this study found that the four VAX-subscales in the Danish translation were distinct but highly correlated (covariance between 0.63 and 0.83) with each other – a pattern, which was also observed by the developers of the original English scale (0.61–0.78) [14], in an Italian translation (0.514–0.812) [31], and a French translation (0.62–0.78) [30], whereas lower correlations between the subscales were observed in a Korean translation (0.22–0.64) [35], and Spanish translation (0.383–0.675) [36]. According to Brown [45], correlations exceeding 0.80 or 0.85 are often used as a criterion for poor discriminant validity, where a combination of factors/subscales should be considered. The two subscales of the Danish translation, namely "mistrust of vaccine benefits" and "concerns about commercial profiteering", correlated at 0.83. If a cutoff of 0.85 is chosen for acceptable differentiation between subscales, we can still consider these two subscales as separate entities. However, if a cutoff of 0.8 is chosen, the correlation in this study is just above the threshold to consider these subscales as separate. The content of the subscales indeed suggests that these two could reflect very similar attitudes; individuals who doubt the health benefits of the vaccine may perceive economic reasons as the primary motivation for vaccine production. Taking into consideration the fairly strong correlations between all four subscales, for added caution, it would be advisable to rely on the overall VAX scale score of the Danish translation as the measure of general vaccination hesitancy. Using the subscale scores, on the other hand, could help specify problems that need special attention.

The Danish translation of the VAX scale has proven to be a valid instrument for predicting the vaccination status of participants. As expected, COVID-19 vaccinated participants exhibited lower total VAX scale scores than non-vaccinated participants ($p < 0.001$), aligning with findings from other studies [29,30] that explored the known group validity of the VAX scale based on COVID-19 vaccination status. Moreover, the expected associations, and therefore known group validity, were confirmed when known groups were defined based on the COVID-19 vaccination status of participants' children. However, only one Danish VAX subscale score significantly differentiated between participants refusing a vaccine from the nationally recommended vaccination program for children and those who vaccinated their children with all recommended vaccines. This could be attributed to a lack of statistical power, as only five participants had not vaccinated their children with at least one vaccine from the national children vaccination program. This suggests that COVID-19 vaccines, being relatively new, prompt individuals with generally pro-vaccination attitudes to harbor some skepticism towards COVID-19 vaccination, especially regarding vaccination for children who may not be perceived as highly vulnerable to the disease. Consequently, a larger proportion of people may reject COVID-19 vaccination for children (and for themselves), resulting in a larger sample of those rejecting, thereby strengthening the statistical power for known group validity based on COVID-19 vaccination status.

In this study, a correlation was found between the newly translated Danish VAX scale, including its subscales, and the well-tested Danish BMQ-general scale, as well as its two subscales. These findings align with previous studies validating the VAX scale, where the BMQ was employed to assess criterion validity [28–30]. The correlations suggest that participants who exhibit vaccine hesitancy also tend to have lower trust in medicines in general.

Several methodological considerations of the study have to be noted. First, the validity of the translated instrument from the very start was supported by strict translation and cognitive debriefing procedures, which, alongside equivalence in meaning, also ensured good comprehensibility and culturally acceptable language of the translation. The online dissemination of the questionnaire could represent a potential source of bias, as some participants may not have fully understood its content. On the other hand, this approach avoids the possibility of participants being influenced by the presence of an interviewer. Moreover, the pilot testing and thorough translation process of the scale, as well as using a previously translated version of the BMQ, should mitigate this potential bias. A previous study by Saloniki et al. (2019) demonstrates that face-to-face and internet surveys may lead to fairly similar results when controlling for sample differences [46].

Second, psychometric validation of the translated instrument was based on an adequate in size and a seemingly representative sample. The sample size met the rule of thumb of at least 10 respondents per item of the scale [47]. Although a size over 200 is generally preferred for CFA to ensure stable estimates, the 194 participants in this study is acceptable given the short VAX scale and good model fit [45]. Nevertheless, this relatively small sample size remains a key limitation that may affect statistical power and generalizability. Regarding representativeness, the percentage of COVID-19 vaccinated respondents in our study was similar to that of the general population at the time of the study [19]. There was, however, a larger proportion of women than men in the study population compared to that in Denmark, which could be considered a limitation, as some gender gaps in COVID-19 vaccination hesitancy between men and women have been documented [48]. However, in this study, the overall hesitancy (VAX scale scores) did not differ between genders, so this previously documented gap in hesitancy was not applicable here.

Building on these findings, it is important to recognize the critical role of healthcare workers as trusted sources of information who strongly influence patients' vaccine attitudes and decisions. Their attitudes directly impact public confidence and adherence to vaccination programs [49–52]. This role is particularly significant in Denmark, where the vaccination program is voluntary and relies on education,

accessibility, and effective communication rather than mandates or direct incentives [17,18]. The validated Danish VAX scale provides a valuable tool to assess vaccine attitudes among both the general public and healthcare workers, facilitating future research to uncover barriers and develop targeted strategies that enhance vaccine confidence and improve public health outcomes.

5. Conclusion

The Danish translation of the VAX scale showed an adequate four-subscale structure with high internal consistency, known group, and criterion validity. It could be a useful tool when evaluating attitudes towards vaccines in Denmark. Given the relatively strong correlations between subscales, it could be recommended to use the overall scale score as a measure of general vaccination hesitancy.

CRediT authorship contribution statement

Caroline Buhl: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ramune Jacobsen:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization. **Janine Marie Traulsen:** Writing – review & editing, Validation, Methodology. **Armin Andersen:** Writing – review & editing, Validation, Methodology, Investigation. **Anna Birna Almarsdóttir:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2025.127620.

Data availability

Data will be made available on request.

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