Validation of an Arabic tool for assessing vaccination literacy: A factor and Rasch analysis

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Abstract

Vaccine literacy is a significant part of health literacy. Although several tools have been developed to assess vaccine literacy, such tools are lacking in Arabic. Validating an Arabic version of a tool that evaluates vaccine literacy is critically important, as it would aid in understanding the decision-making process regarding vaccinations among individuals in Arabic-speaking countries. Therefore, the current study aimed to validate an Arabic tool for assessing vaccine literacy in adult vaccination. An online questionnaire was distributed to people throughout Jordan by sharing the questionnaire link via various social media platforms. The reliability and validity of the Arabic version of the vaccination literacy assessment tool (HLVa-Ar) were evaluated using factor analysis and Rasch analyses. The two-factor model generated fit indices were in the acceptable range ($\chi 2/df = 2.48$, RMSEA = 0.06, SRMR = 0.05, GFI =0.94, CFI = 0.97, and TLI =0.96). Cronbach's alpha for functional Vaccination literacy (VL) and interactive/critical VL were 0.91 and 0.88 respectively. The Rasch analysis indicated acceptable infit/outfit values and high item and person separation reliabilities for the two factors (0.852, 0.868, and 0.771, 0.818 respectively). Overall, the 420 participants displayed a good understanding of the general benefits and importance of vaccination. The HLVa-Ar was shown to be a valid and reliable tool that portrayed a wide range of vaccination literacy levels in the studied sample and provided valuable insights into participants' vaccination knowledge. The findings emphasize the need for developing targeted strategies to improve vaccination literacy and increase vaccination rates.

keywords

Vaccination literacy; health literacy; Jordan; Validation; Knowledge; Practice; Arabic tool; Arabic

Introduction

Vaccines are biological agents that evoke an immune response to a particular pathogen-derived antigen that causes infectious diseases [1]. In the 21st century, the development of effective and safe vaccines against various diseases that could cause significant morbidity and mortality represents one of the greatest scientific advances. Approximately 6 million deaths are prevented annually by vaccines [2]. Vaccination is a cost-effective, prophylactic tool against infectious diseases. Variolation was introduced in the 17th century, and the subsequent concerted vaccination programs led to the global eradication of smallpox by 1980. Furthermore, vaccination has resulted in a reduction of more than 99% in polio disease[3]. In addition, vaccination has reduced cases of diphtheria, pertussis, measles, varicella, and tetanus, saving millions of lives from preventable diseases. Immunization has significantly improved public health in both developing and developed countries leading to a 200- to 2000-fold reduction in the incidence of common vaccine-preventable diseases as a result of the emergence of immunization strategies[4].

Despite the scientific consensus on the net benefits of vaccines, a significant part of the global population is considered vaccine-hesitant, defined as "a state of indecisiveness regarding a vaccination decision"[5] or "reluctance or uncertainty to vaccinate"[6]. A retrospective study conducted across 149 countries between September 2015 and December 2019, involving nearly 300,000 participants, found indications of growing confidence in vaccines in several EU member states, including Finland, France, Ireland, and Italy, although a decline in trust was noted in Poland. Conversely, confidence in the importance, safety, and effectiveness of vaccines diminished in countries such as Afghanistan, Indonesia, Pakistan, the Philippines, and South Korea. Additionally, there was a significant increase in the number of respondents who strongly disagreed with the safety of vaccines in Afghanistan, Azerbaijan, Indonesia, Nigeria, Pakistan, and Serbia[7]. Vaccine hesitancy and refusal contribute to numerous negative outcomes[8], including increased infection rates, particularly in areas with unvaccinated individuals[5]. In 2019, the World Health Organization (WHO) listed vaccine hesitancy as one of the top threats to global health. A lack of confidence, barriers to vaccine access, and inconvenience are prominent reasons behind vaccine hesitancy. Healthcare workers are the most trusted advisors influencing vaccination decisions, particularly in community settings; thus, it is essential to ensure consistent support for them to provide individuals with trusted information on vaccines[9].

A cross-sectional study carried out in Bangladesh to examine the population's behavior toward the COVID-19 vaccine, found that nearly half of the study sample exhibited vaccine hesitancy. [10]. Moreover, a cross-sectional study conducted

in Qatar reported that about 20% of the study sample was vaccine-hesitant [11]. Furthermore, a cross-sectional study performed in Jordan in 2021 over four months reported that the level of COVID-19 vaccine hesitancy was significant[12]. Despite under-vaccination resulting from various complex factors associated with vaccination access, vaccine hesitancy remains the primary reason underlying reduced vaccination rates and, consequently, outbreaks of vaccine-preventable diseases [13]. Considering the prevalence and consequences of vaccine hesitancy, it is necessary to address this issue[13,14].

The concept of health literacy (HL) emerged in 1970[15] and concerns the extent to which individuals can obtain, analyze, and understand basic health information and services needed to make appropriate health-related decisions [16,17]. Poor health literacy is associated with a higher frequency of hospitalization and mortality, increased healthcare costs, greater use of emergency care, a decreased ability to interpret health-related messages and labels, reduced utilization of preventive services, and a lower overall health status [18]. Moreover, low health literacy negatively affects disease self-management and individual health-related attitudes and behaviors, including adherence to interventions for smoking cessation and weight control, as well as compliance with cancer screening and prevention recommendations[19]. Therefore, individuals with inadequate health literacy are more vulnerable to presenting with late-stage or advanced illness, which leads to delay in diagnosis and treatment, in addition to poorer health outcomes[18].

Vaccination literacy (VL) is a significant component of health literacy. Vaccination literacy was adopted following the concept of HL[20,21], and includes providing vaccine information, increasing individuals' engagement with vaccines, and building communication. VL comprises of four defining attributes: ' health literacy', ' immunization', ' disease prevention', and 'education' [20].

The concept of VL encompasses competence and motivation to engage with information about disease prevention, immunization, and health promotion, not merely knowledge about vaccines[22]. It has been defined as the capability to find, process, understand, and critically evaluate immunization-related information in order to make appropriate immunization decisions[23]. Health promotion and disease prevention share many overlapping goals, such as maintaining or enhancing health and health competencies within the population. The link between disease prevention and VL is evident, as vaccines aim to protect individuals from infectious diseases and prevent their spread within a population, thereby contributing to herd immunity[24]. Additionally, there is a relationship between VL and health promotion, a process that empowers people to increase control over their health. Vaccine literacy enables people to understand the reasons behind vaccination recommendations and to consider the consequences of their health-related actions. Therefore, both healthcare workers and the public need to be 'vaccine literate' to fully understand the effects and implications associated with both older and newer vaccines[23].

Although several tools have been developed to assess VL, such tools are lacking in Arabic. It is critically important to validate an Arabic version of a tool that assesses vaccine literacy in adult vaccination, as this would aid in understanding the decision-making process regarding vaccinations among individuals in Arabic-speaking countries, whether for themselves or their children. Therefore, the current study aimed to validate the Arabic-translated tool to assess VL using factor and Rasch analyses.

Materials and Methods

Based on previously published studies [25,26], an online questionnaire was constructed using Google Forms and distributed to people throughout Jordan. The questionnaire link was shared using various social media platforms (Instagram, Facebook, and WhatsApp). Responses were collected between March and April 2024. Individuals needed to be residents of Jordan and aged 18 years or older to be eligible to participate in the study. The questionnaire contained an introductory section that explained the objectives of the study and stated that participation was voluntary. It also assured respondents that all collected information would be kept confidential. Additionally, a question regarding consent to participate was included before the start of the questionnaire. To confirm that respondents met the inclusion criteria, questions about place of residency and age were incorporated into the questionnaire. If respondents declined to participate or did not meet the inclusion criteria, the website automatically submitted the questionnaire without it being filled in. The authors obtained ethical approval from the Institutional Review Board and the Deanship of

Research at Al-Zaytoonah University of Jordan on 10 September 2022 (Ref#20/09/2022-2023). This study followed the Declaration of Helsinki ethical guidelines.

2.1. Data collection and study instruments

The questionnaire was divided into six sections. The first section collected sociodemographic characteristics, including age, gender, educational level, marital status, monthly income, whether participants had children, whether they worked or studied in the medical field, and whether they had ever read vaccine-related materials such as leaflets or posters in doctors' offices or public health units recommending vaccinations. If participants answered “Yes” to the last question in the first section, they would be automatically directed to the next section. If they answered “No”, they would skip the second section and be directed to the third section.

A thorough literature review was performed as part of developing the questionnaire [15,16] and the Italian vaccine literacy in adulthood questionnaire (HLVa-IT) was adopted in this study[25]. HLVa-IT is a self-rated measure of VL in adults and is composed of three main scales: functional VL, interactive VL (communicative VL), and critical VL[26]. HLVa-IT is a widely used tool that has been translated and used in various languages, including Chinese [27] and Croatian [28], as well as in different countries such as the USA[29], India[30] and Thailand[31]. The HLVa-IT is based on the Ishikawa test for chronic non-communicable diseases. Functional VL evaluates semantic abilities, while interactive and critical VL assess more advanced cognitive efforts [32].

Section two entailed five Likert-type items designed to evaluate functional VL. Each item offers four possible responses. The scoring for this scale consisted of four points for “never”, three points for “rarely”, two points for “sometimes”, and one point for "often”.

Section three included a question asking if the participant had ever considered or been advised to get vaccinated against one or more diseases. If the answer was ‘Yes’, they were automatically directed to the next section; if ‘No’, they were directed to the fifth section, bypassing the fourth.

The fourth section was composed of nine items aimed at evaluating interactive and critical VL. Similar to section two, this used a four-point Likert scale. The scoring of this section ranged from one point for “never” to four points for "often”. The score was determined by the mean value of the answers on each scale, which ranges from 1 to 4. A higher HLVa-IT score indicated a higher level of VL.

The fifth section consisted of a vaccine quiz (VQ) comprising four items that assessed participants' knowledge about vaccines. In this section, one point was granted for each correct answer and zero points for incorrect answers.

The final section evaluated vaccination practices for COVID-19, influenza, pneumococcus, and tetanus. A practice score was computed based on the number of vaccines received by each participant.

2.2. Tool validation

Three infectious disease experts evaluated the HLVa-IT and confirmed its content validity. It was then translated from English to Arabic and back again by highly skilled translators to ensure accuracy. As a result, two comparable versions were produced. A pilot test was performed to ensure the clarity of the questionnaire with the Arabic version of the questionnaire (HLVa-Ar) being distributed to 30 participants to assess its face validity. The data from the pilot study was not included in the final analysis.

2.2.1 Confirmatory factor analysis

Confirmatory factor analysis (CFA) was applied to the original model to assess its suitability for the current data. To evaluate the goodness of fit, several indices were used, including the Comparative Fit Index (CFI), Goodness-of-Fit Index (GFI), minimum discrepancy ($\chi 2/df$), Root Mean Square Error of Approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), and Tucker-Lewis Index (TLI). CFI analyzes model fit by inspecting the disagreement between the data and the hypothesized model, while GFI assesses the fit between the hypothesized model and the observed covariance matrix. $\chi 2/df$ measures the fitness of the model by dividing the Chi-Square ($\chi 2$) by degrees of freedom (df), and compares the tested model to the independence model and the saturated model. RMSEA assesses the discrepancy between the observed covariance matrix and the hypothesized model while adjusting for model complexity. SRMR measures the average absolute deviation between the observed and hypothesized correlations in the model. TLI is a relative fit index that compares the chi-square values of the baseline and final models. Acceptable values for CMIN/DF are equal to or less than 3[33,34]. RMSEA values equal to or less than 0.08

indicate a reasonable fit[35]. Also, SRMR values equal to or less than 0.08 indicate an acceptable fit[36]. TLI values equal to one indicate a perfect fit and values close to one indicate a very good fit[37]. GFI and CFI values equal to one indicate a perfect fit, values equal to or greater than 0.95 indicate an excellent fit, and values equal to or greater than 0.9 indicate a reasonable fit[33,38]. The internal consistency of each factor was evaluated by computing Cronbach's alpha values.

2.2.2. Rasch analysis

A multi-factorial Rasch analysis for polytomous responses was carried out to verify the model's suitability. Person reliability and item separation reliability were assessed. Infit/outfit statistics were generated and mean square values (MSQ) of infit and outfit ranging between 0.6 and 1.4 were considered acceptable[39]. To assess each item, item locations and thresholds were computed, and a Wright map was generated. Differential Item Functioning (DIF) analysis between genders was conducted.

2.2.3. Predictive Validity

To evaluate predictive validity, it was assumed that higher VL scores would correlate with higher vaccination practice scores (indicative of acceptance) and higher VQ scores. Therefore, correlations were performed between the final score of the HLVa-Ar and the score of each factor with the VQ and practice scores.

2.3. Sample size calculations

The participant-to-item ratio method was applied to determine the required sample. The maximum suggested ratio is 20:1[40] (20 participants for each item) which was applied in this study. As the tool is composed of 14 items, the minimum required sample size was determined to be 280. Out of 630 participants, the final data analysis included only 420 participants who answered "Yes" to the following questions in the HLVa-Ar: "Have you ever read vaccine materials, such as leaflets or posters in doctor's or public health unit offices, recommending vaccinations? "and "Have you ever thought or been advised to vaccinate yourself against one or more diseases?"

2.4. Statistical analysis

Data analysis was conducted using the Statistical Package for the Social Sciences (SPSS) version 26 and R software version 4.3.3, specifically, the Test Analysis Modules (TAM) package version 4.1-4 and latent variable analysis (lavaan) version 0.6-17. SPSS was chosen for its productivity and ease of use, while R was utilized to perform tests that could not be conducted using SPSS. Categorical variables were presented as percentages and frequencies, and continuous variables were presented as the median (25-75 percentiles).

Results

Participants' sociodemographic characteristics are shown in Table 1. The median age was 29 (ranging from 24 to 37). Most participants (70%) were female. Most held university degrees (67.4%), and 47.1% earned 500-1000 Jordanian Dinars (JOD) per month.

Table 2 displays the reported responses toward the functional vaccination literacy domain of the HLVa-Ar questionnaire. This shows a high average functional vaccination literacy score among participants, indicating a strong foundational understanding of vaccine-related information. The predominant response in the functional VL domain was "Never," reflecting minimal challenges encountered by the participants in this area. Participants' responses to the interactive (communicative) and critical vaccination literacy items of the HLVa-Ar instrument are displayed in Table 3. Responses were predominantly "Often," signaling active engagement with the vaccination information. However, for items related to the practical application of information and discussions with health professionals, "Sometimes" was the most common response, suggesting variability in how participants use and communicate their knowledge.

The structural analysis of the vaccination literacy tool, as reported in Table 4, employed a two-factor model across 14 items, designed to evaluate both functional and interactive/critical dimensions of vaccine literacy. The factor loadings for functional vaccination literacy were robust, ranging from 0.76 to 0.86, indicating a strong alignment of items with this underlying construct. Conversely, the interactive/critical vaccination literacy displayed a wider range of loadings, from 0.55 to 0.76, displaying varied strengths in item correlations to the intended factor, yet all remained within acceptable limits.

All items distinctly loaded onto their designated factors without any cross-loadings, affirming the structural integrity of the questionnaire. The model's fit to the collected data was confirmed by satisfactory indices: a Chi-square-to-df ratio of 2.48, RMSEA at 0.06, SRMR at 0.05, along with GFI, CFI, and TLI values (0.94, 0.97, and 0.96 respectively), all indicating a good fit. Reliability measures further substantiated the tool's consistency, with Cronbach's alpha values of 0.91 for functional VL and 0.88 for interactive/critical VL, both reflecting high internal consistency within these domains.

The Rasch model analysis provided a detailed evaluation of the questionnaire's reliability and item functionality, as displayed in Table 5. This revealed that the item and person reliability indices for the functional VL were robust, with values of 0.852 and 0.868 respectively, indicating strong consistency across items and responses. Similarly, the interactive and critical VL components demonstrated good reliability, with indices of 0.771 and 0.818, supporting the tool's ability to consistently measure these more complex literacy aspects.

Table 5 also details the Infit and Outfit MSQ values, confirming that all item responses fit well within the model's expectations, without any significant deviations. This suggests that the items were appropriately challenging for the respondents, neither too difficult nor too trivial. Furthermore, the table presents the threshold data, illustrating that each item across both factors maintained ordered response categories. This validated that the response scale operated logically, where higher response options consistently reflected higher levels of vaccination literacy.

It was observed that the locations of the two genders were relatively close. The difference between the two genders on the logit scale was found to be 0.2 logits, which is less than the cutoff point of $\geqslant$ 0.43 logits, indicating that there was no significant difference between the genders. This confirms that the model was not biased between the genders. Figure 1 displays the Wright map, which shows that participants' responses were distributed across all difficulty levels for both factors. Additionally, the item thresholds varied among different difficulty levels, indicating diverse levels of challenge for the participants. The easiest items corresponded to the first threshold of item 3, whereas the most challenging item was at the last threshold of item 11.

Table 6 summarizes the responses to various vaccination-related knowledge questions. Notably, a significant proportion of participants indicated uncertainty regarding the existence of a vaccine for shingles, highlighting a gap in awareness about available vaccines. Additionally, while 34% incorrectly believed that pregnant women could not be vaccinated, this misconception was not held by the majority, indicating a better-than-expected understanding of vaccination safety during pregnancy among the cohort.

Contrastingly, the response to the statement about the severity of vaccine-preventable diseases showed a more informed perspective. Most participants rejected the notion that these diseases are not serious and would not require hospitalization or be fatal, demonstrating a realistic appreciation of the risks associated with non-vaccination. Furthermore, a strong consensus was observed in the recognition that vaccines are beneficial not only for children but also for adults. This response aligns with current health guidelines that advocate for lifelong vaccination to prevent a range of infectious diseases.

Table 7 details the vaccination practices among the study participants, revealing varied uptake across different vaccines. Notably, the majority (62.6%) reported having received the COVID-19 vaccine twice, illustrating high adherence to recent public health campaigns. In contrast, influenza vaccination rates were approximately 50%, suggesting moderate compliance with annual flu vaccination recommendations.

Pneumococcal vaccination rates were lower, with nearly half of the participants (47.6%) indicating they had never received this vaccine. This finding points to potential gaps in public health outreach or personal health prioritization for vaccines beyond those for acute, widespread outbreaks like influenza and COVID-19. Additionally, about two-thirds of participants (63.4%) reported receiving the tetanus vaccine, with the majority of these individuals having been vaccinated over ten years ago. This high rate reflects successful long-term immunization efforts but also highlights the need for booster awareness to maintain immunity over time.

Table 8 presents the Spearman's rank correlation results, highlighting significant positive relationships between various components of vaccination literacy and vaccination behaviors. There was a notable correlation between overall VL scores and both VQ and vaccination practice scores, with coefficients of 0.240 and 0.61, respectively, both significant at $p<0.001$. This suggests that higher literacy was associated with better knowledge and more consistent vaccination practices.

In the domain-specific analyses, the functional VL displayed significant positive correlations with both VQ and practice scores (coefficients of 0.21 and 0.37, respectively), indicating that a basic understanding of vaccine information positively influenced both knowledge and vaccination behavior.

Similarly, interactive/critical VL was also positively correlated with both VQ and practice scores (coefficients of 0.17 and 0.52, respectively). These findings underline the importance of engaging and critical approaches to vaccination literacy as predictors of both knowledge acquisition and practical vaccination actions.

Figure 2 depicts participants' main sources of vaccination and vaccine-related information. Search engines emerged as the predominant source, used by over half of the respondents (53.01%), which emphasizes the significant role of online resources in public health information dissemination. This was closely followed by consultations with general practitioners (GPs) or other health professionals, reported by 47.46% of participants, highlighting the trusted relationship between patients and healthcare providers in the context of vaccination decisions. Official vaccination campaigns also played a substantial role, serving as a key information source for 40% of the participants. In contrast, family members or social networks were the least frequently cited sources, with 30.63% of participants relying on these. This lower reliance may reflect a greater trust in professional and formal sources over informal ones when it comes to health-related decisions.

Discussion

The vaccination health literacy questionnaire (HLVa) is an important tool for evaluating the knowledge, motivation, and competence that drive individuals' decisions to get vaccinated [32]. It was developed in Italian and translated into Chinese and validated accordingly [25,27]. There is an urgent need to validate the Arabic-translated HLVa, as this would enhance understanding of how individuals in Arabic-speaking countries make vaccination decisions for themselves or their children. The participants' sociodemographic characteristics revealed a predominantly young, female, well-educated, and economically active sample, indicative of a potentially health-conscious demographic.

CFA and Rasch model results confirmed the reliability and validity of the HLVa-Ar and provided valuable insights into the structure of the tool. The CFA results supported the two-factor structure of the questionnaire, confirming that all items significantly contributed to their respective factors. The HLVa-Ar tool was found to have an identical structure to that observed in the Italian version HLVa-It[25], as well as that of the Chinese version[27]. Moreover, similar to the Chinese version [27], the items with the highest factor loading in the functional VL were items 3 and 4, however, in the interactive/critical factor the highest factor loadings in the Chinese version were for items 9 and 11, while in the present study the highest factor loadings were in items 14 and 12.

The functional VL factor loadings were robust, indicating that the items effectively captured the basic understanding of vaccine information. The loadings for the interactive and critical VL factor were also substantial, although slightly lower. This suggests that these items capture more nuanced aspects of vaccine literacy, including the ability to evaluate and use vaccine information critically. Thus, the translated items were strong indicators of their respective factors and supported the translated questionnaire's effectiveness in assessing both fundamental and advanced levels of vaccine literacy. The model fit indices fell within the acceptable range, indicating a good fit of the model to the collected data. Additionally, the high Cronbach's alpha values yielded for both the functional and interactive/critical VL factors suggest that the translated questionnaire had high internal consistency. Therefore, the items within each factor reliably measured the same underlying construct, further validating the tool's effectiveness in assessing different aspects of vaccine literacy.

The results from the Rasch model further support the reliability and validity of the translated questionnaire. The item separation and person reliabilities for both the functional and interactive/critical vaccine literacy factors were

reasonably high, demonstrating a strong degree of reliability. The Infit and Outfit MSQ values for all items fell within the acceptable range, suggesting that the items were appropriately fitting within the model. Additionally, the ordered response categories for all items indicate that the response options were functioning as intended, further confirming that the questionnaire effectively measured what it was designed to assess. The Wright map showed that the translated questionnaire successfully captured a wide range of vaccine literacy levels among participants. The varying difficulty levels of the translated items posed different challenges, demonstrating the questionnaire's sensitivity to differences in vaccine literacy. Overall, the HLV-Ar effectively discerned the varied levels of understanding, indicating its robustness and utility in measuring vaccine literacy.

The observed functional VL among the study population was found to be good with a score similar to that observed in a previously conducted study in Italy (both were 3.23)[25,41]. Moreover, the findings revealed that the participants had relatively good interactive vaccination literacy when compared to the levels observed in Italy and Tunisia [30]. However, there is still room for improvement in both scales as the means were 3.23 and 3.1 out of the maximum possible score of 4

Furthermore, our findings suggest that the study participants were more adept at basic skills, including reading and writing (functional VL), compared to more advanced skills such as decision-making and problem-solving (interactive and critical VL) [42]. This contrasts with the results from China and Italy among staff of nursing homes [43], where participants exhibited better interactive/critical scores compared to functional VL [27]. The discrepancy can be attributed to the socio-economic diversity of the population in China, which likely introduces a wider range of educational backgrounds and access to information, thus affecting literacy outcomes differently. In contrast, our study's more homogeneous population may not display such pronounced variations, potentially due to similar levels of education and access to health information across the group. This suggests the need for tailored health communication strategies that consider the socio-economic uniformity or diversity of the target population

These findings highlight the importance of effective communication strategies in promoting vaccination literacy. The high level of education among the participants suggests a capacity to understand scientific health information about vaccination. However, the difficulties in reading and understanding vaccine materials reported by participants indicate a need for these materials to be more user-friendly and accessible. Furthermore, the deviation in responses to the interactive and critical vaccination literacy items indicates a need for more effective strategies in providing information and facilitating its use and conversation, such as discussing vaccination information with healthcare professionals or peers and ensuring that it is relevant to the individual's condition.

The responses to vaccination-related knowledge items revealed intriguing findings. Most participants reported they did not know if there was a vaccine for shingles, suggesting a knowledge gap, which is contrary to results from cross-sectional studies conducted in the USA [44] and in Al-Ahsa, Saudi Arabia [45]. However, most recognized that pregnant women can be vaccinated, which is in line with findings from a cross-sectional study conducted in Riyadh, Saudi Arabia[46]. Furthermore, most respondents understood that vaccine-preventable diseases could be serious, require hospitalization, or even be fatal. This indicates a good understanding of the general benefits and importance of vaccination and corresponds to findings from a cross-sectional study conducted in Italy among schoolteachers[47]. Most participants also correctly identified that vaccines were not only for children but could also help adults maintain good health.

Most participants had received the COVID-19 vaccine twice, indicating good uptake of the vaccine, while nearly two-thirds were vaccinated against tetanus. However, a significant proportion of participants had never received the pneumococcal vaccine and low influenza vaccine uptake in Jordan has been reported in previous studies [48,49,50] . This potentially reflects differing practices and perceptions regarding the importance of vaccines. The high rate of COVID-19 vaccination uptake suggests a strong public response to pandemic-driven vaccination efforts. This high uptake could be attributed to widespread public health campaigns and the perceived urgency of protecting against COVID-19. Furthermore, COVID-19 and tetanus vaccinations were mandatory and available free of charge for the Jordanian population, unlike other vaccines, including the influenza vaccine[51]. The low uptake of pneumococcal and influenza

vaccines suggests gaps in public health messaging or accessibility, which may be attributed to a lack of awareness. This finding is consistent with previously published research conducted in Germany[52].

The present findings indicated a positive relationship between individuals' vaccination literacy and their vaccination knowledge and practice score, which is in line with previous findings [25,27] and emphasizes the importance of health literacy to improve vaccination practices.

4.1. Strengths, limitations, and future directions

A notable strength of the present study lies in its contribution to knowledge. Although Jordan and other countries in the Middle East region have been the subject of studies on health literacy, vaccine acceptance, and vaccine avoidance, the present study is distinct as it specifically focuses on vaccine literacy. Previous research in Jordan and the Middle East has primarily centered on vaccine acceptance rates and the factors influencing vaccine hesitancy among different demographics [53,54,55]. The present study developed and validated the first Arabic tool for assessing vaccine literacy, thus bridging a critical gap by enabling a more detailed understanding and targeted improvement of vaccine-related decision-making processes among Arabic-speaking populations. Unlike general health literacy or studies merely quantifying vaccine acceptance or avoidance, this vaccine literacy tool evaluates both functional and interactive/critical vaccine literacy. This detailed assessment allows for identifying specific educational and communicative interventions needed to improve vaccination rates effectively. Moreover, the inclusion of participants from different geographical areas in Jordan contributes to the validity of the study results and underlines the potential utility of this vaccine literacy tool in other Arabic-speaking countries. By providing such a tool, this study paves the way for similar assessments across the region. Such tools are essential for identifying specific educational needs and enhancing vaccination campaigns, which can significantly improve public health outcomes in diverse Arabic-speaking communities.

Furthermore, this study validated a tool to assess vaccination literacy in adults in Arabic-speaking populations. This contribution is important considering the lack of previous studies in this area. Moreover, the inclusion of participants from different geographical areas in Jordan contributes to the validity of the study results.

However, some limitations need to be acknowledged. The findings are based on self-reported data, which can be subject to recall and social desirability biases. Furthermore, individuals interested in the study could have felt more motivated to complete the questionnaire, potentially leading to selection bias. However, it is important to note that online questionnaires offer a secure and private environment that may encourage participants to respond accurately to questions, thereby reducing social desirability biases. Additionally, online questionnaires facilitate access to individuals who might otherwise be difficult to reach [56].

In light of the limitations of the present study, future research would benefit from incorporating a more diverse participant base to enhance the generalizability of the findings across different Arabic-speaking regions. Additionally, considering the predominantly young, female, and highly educated demographic of the study sample, future research should aim to include a more representative cross-section of the population. This would involve targeting older adults, males, and those with varying educational backgrounds to ensure the findings apply to a broader segment of the Arabic-speaking population. This would provide a more comprehensive understanding of vaccine literacy across different societal groups, potentially uncovering unique challenges and needs not captured in the current study.

Given the findings that emphasize the importance of effective communication strategies and the observed difficulties participants faced with existing vaccine materials, future research should explore the development and testing of enhanced educational tools tailored to various literacy levels. This could involve creating visually engaging, simplified vaccine information that minimizes medical jargon and is available in multiple formats to accommodate different learning preferences. Studies could also evaluate the effectiveness of these redesigned materials in improving comprehension and engagement with vaccine-related information, particularly in populations with lower health literacy. Such research would support the creation of more accessible vaccine education as well as potentially increase vaccine uptake by making the information more approachable and understandable for a wider audience.

Conclusions

The present study provides valuable insights into Jordanians' vaccination literacy. It highlights the need for tailored questionnaires and tools that consider the sociodemographic characteristics and literacy needs of the target population. Furthermore, the HLVa-Ar questionnaire developed as part of this study appears to be a robust tool for measuring vaccination literacy among Arabic-speaking populations. In the current study, the questionnaire effectively captured a wide range of vaccination literacy levels in the sample and provided valuable insights into the participants' vaccination knowledge and practices. These findings emphasize the need for developing targeted strategies to improve vaccine literacy and increase vaccination rates. Future research should strive for greater diversity in participant demographics across different Arabic-speaking regions and create more accessible, user-friendly vaccine education materials tailored to various literacy levels. These efforts would enhance the generalizability of findings and could significantly improve vaccine literacy and uptake.

Authorship contribution statement

"Conceptualization, W.Q., A.A., and A.J.; methodology, W.Q., and A.A.; software, J.E.; validation, W.Q., and A.J.; formal analysis, W.Q.; investigation, R.O., and L.A.; resources, A.A., A.H., and R.Z.; data curation, W.Q. , R.O., L.A., A.H., and R.Z.; writing—original draft preparation, A.A., J.E., A.J, R.O., L.A., and F.A.; writing—review and editing, W.Q., R.O., and L.A.; visualization, W.Q., A.H., R.Z. and A.A.; supervision, A.J.; project administration, F.A.; funding acquisition, F.A. All authors have read and agreed to the published version of the manuscript."

Ethics approval

The authors have obtained ethical approval from the Institutional Review Board and the Deanship of Research at Al-Zaytoonah University of Jordan. This study followed the Declaration of Helsinki's ethical guidelines. Ethical approval was secured from Al-Zaytoonah University of Jordan on 10 September 2022 (Ref#20/09/2022-2023). Written informed consent has been obtained from the participant(s) to publish this paper.

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Data availability statement

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Short biographical note

Dr. Walid Al-Qerem obtained PhD of Clinical pharmacy from the University of Sunderland, UK. He is an associate professor at Al-Zaytoonah University of Jordan.

Dr. Al-Qerem's research area covers improving the diagnosis and management of different diseases. This includes validation and formulation of spirometic equations to improve the diagnosis and management of many respiratory diseases including asthma and COPD, developing population specific growth charts to improve the tracking of

children's growth, and to identify undiagnosed conditions and validate different instruments used to evaluate health-related quality of life and adherence to medication.

Dr. Al-Qerem's research also covers the study of different variables that influence the outcomes of different diseases.

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Table 1. Participants' sociodemographic profile

		Median (25-75) or frequency (%)
Age		**29 (24-37)**
Gender	Female	294 (70%)
	Male	126 (30%)
Governorate	Amman	140 (35%)
	Zarqa	92 (23%)
	Irbid and North Region	68 (17%)
	Central Region (Balqa and Madaba)	40 (10%)
	South Region (Karak, Tafila, Ma'an and Aqaba)	60 (15%)
Educational Level	Elementary school	40 (9.5%)
	Diploma degree	34 (8.1%)
	University degree	283 (67.4%)
	Postgraduate	63 (15%)
Income	Less than 500JOD*	90 (21.4%)
	500-1000JOD*	198 (47.1%)
	More than 1000JOD*	132 (31.4%)
Marital status	Single	227 (54%)
	Married	193 (46%)
Having children	No	240 (57.1%)
	Yes	180 (42.9%)

*JOD: Jordanian dinar (1 JOD = 1.41 USD)

Table 2. Participants' responses to the functional vaccination literacy of the HLVa-Ar instrument.

Have you ever read vaccine materials, such as leaflets or posters in doctor's or public health unit offices, recommending vaccinations? (Yes/No)				
If the answer is yes:	**Frequency (%)**			
	Never	**Rarely**	**Sometimes**	**Often**
Did you find that the material as a whole (texts and/or images) was difficult to read?	195 (46.4%)	122 (29%)	89 (21.2%)	14 (3.3%)
Did you find words you didn't know?	165 (39.3%)	141 (33.6%)	101 (24%)	13 (3.1%)
Did you find that the texts were difficult to understand?	196 (46.7%)	134 (31.9%)	81 (19.3%)	9 (2.1%)
Did you need much time to understand them?	224 (53.3%)	119 (28.3%)	68 (16.2%)	9 (2.1%)
Did you or would you have needed someone to help you understand them?	238 (56.7%)	89 (21.2%)	81 (19.3%)	12 (2.9%)

Table 3. Participants' responses to the interactive and critical vaccination literacy items of the HLVa-Ar instrument.

Have you ever thought of or been advised to vaccinate yourself against one or more diseases? (Yes/No)				
	Frequency (%)			
If the answer is "Yes":	**Never**	**Rarely**	**Sometimes**	**Often**
Have you consulted more than one source of information?	31 (7.4%)	60 (14.3%)	139 (33.1%)	190 (45.2%)
Did you find the information you were looking for?	15 (3.6%)	56 (13.3%)	174 (41.4%)	175 (41.7%)
Did you understand the information found?	16 (3.8%)	36 (8.6%)	133 (31.7%)	235 (56%)
Have you had the opportunity to use the information?	26 (6.2%)	92 (21.9%)	172 (41%)	130 (31%)
Did you discuss what you understood about vaccinations with your doctor or other people?	46 (11%)	94 (22.4%)	143 (34%)	137 (32.6%)
Did you consider whether the information collected was about your condition?	32 (7.6%)	83 (19.8%)	178 (42.4%)	127 (30.2%)
Have you considered the credibility of the sources?	38 (9%)	87 (20.7%)	133 (31.7%)	162 (38.6%)
Did you check whether the information was correct?	40 (9.5%)	70 (16.7%)	139 (33.1%)	171 (40.7%)
Did you find any useful information to make a decision on whether or not to get vaccinated?	36 (8.6%)	64 (15.2%)	147 (35%)	173 (41.2%)

Table 4. Confirmatory factor analysis of the HLVa-Ar.

Factors/items	Standardized factor loading	Standard error
Functional VL		
Did you find that the material as a whole (texts and/or images) was difficult to read?	0.76	0.00
Did you find words you didn't know?	0.81	0.06
Did you find that the texts were difficult to understand?	0.86	0.06
Did you need much time to understand them?	0.85	0.06
Did you or would you have needed someone to help you understand them?	0.81	0.06
Interactive and critical VL		
Have you consulted more than one source of information?	0.55	0.00
Did you find the information you were looking for?	0.64	0.10
Did you understand the information found?	0.65	0.10
Have you had the opportunity to use the information?	0.71	0.12
Did you discuss what you understood about vaccinations with your doctor or other people?	0.62	0.13
Did you consider whether the information collected was about your condition?	0.59	0.11
Have you considered the credibility of the sources?	0.72	0.13
Did you check whether the information was correct?	0.71	0.13
Did you find any useful information to make a decision on whether or not to get vaccinated?	0.76	0.13

Table 5. Outfits, infits, and thresholds of the HLVa-Ar items

Item	Outfit	Infit	Thresholds		
			1	2	3
Functional VL					
Did you find that the material as a whole (texts and/or images) was difficult to read?	1.00	1.11	-5.29	-1.96	0.19
Did you find words you didn't know?	0.92	0.95	-5.43	-1.76	0.77
Did you find that the texts were difficult to understand?	0.71	0.82	-5.85	-2.27	0.19
Did you need much time to understand them?	0.68	0.83	-5.80	-2.56	-0.33
Did you or would you have needed someone to help you understand them?	0.92	0.98	-5.49	-2.12	-0.60
Interactive and critical VL					
Have you consulted more than one source of information?	1.38	1.25	-2.55	-1.39	0.14
Did you find the information you were looking for?	0.98	1.01	-3.39	-1.80	0.36
Did you understand the information found?	0.94	0.98	-3.16	-2.06	-0.38
Have you had the opportunity to use the information?	0.93	0.96	-2.92	-1.10	0.93
Did you discuss what you understood about vaccinations with your doctor or other people?	1.13	1.11	-2.23	-0.80	0.79
Did you consider whether the information collected was about your condition?	1.10	1.12	-2.63	-1.14	0.98
Have you considered the credibility of the sources?	0.80	0.85	-2.43	-0.96	0.46
Did you check whether the information was correct?	0.83	0.88	-2.30	-1.14	0.36
Did you find any useful information to make a decision on whether or not to get vaccinated?	0.86	0.92	-2.40	-1.28	0.35

Table 6. Frequency of responses to vaccination-related knowledge items

	Frequency (%)		
	No	**Don't know**	**Yes**
There is no vaccine for shingles.	105 (25%) *	237 (56.4%)	78 (18.6%)
Pregnant women cannot be vaccinated.	143 (34%) *	140 (33.3%)	137 (32.6%)
Vaccine-preventable diseases are not serious and cannot require hospitalization or be fatal.	284 (67.6%) *	63 (15%)	73 (17.4%)
Vaccines are not only for children. They can also help adults to maintain good health.	24 (5.7%)	37 (8.8%)	359 (85.5%) *

"*" indicates the correct answer

Table7. Frequency of responses to vaccination-related practice items

		Frequency (%)
How many times have you previously received the COVID-19 vaccine?	**Did not receive a COVID-19 vaccine**	23 (5.5%)
	Once	34 (8.1%)
	Twice	263 (62.6%)
	Three times	95 (22.6%)
	4 times or more	5 (1.2%)
Have you been vaccinated against influenza?	**No, never**	142 (33.8%)
	Don't remember	70 (16.7%)
	Yes	208 (49.5%)
Have you been vaccinated against pneumococcus?	**No, never**	200 (47.6%)
	Don't remember	159 (37.9%)
	Yes	61 (14.5%)
Have you been vaccinated against tetanus?	**No, never**	44 (10.5%)
	Don't remember	110 (26.2%)
	Yes, in the past10 years	120 (28.6%)
	Yes, more than 10 years ago	146 (34.8%)

Table 8. Spearman's rank correlations between vaccine literacy (VL), vaccine quiz (VQ), and practice scores.

		VQ score	practice score
VL	**Correlation Coefficient**	0.24	0.61
	P value	<0.001	<0.001
Functional VL	**Correlation Coefficient**	0.21	0.37
	P value	<0.001	<0.001
Interactive/ critical VL	**Correlation Coefficient**	0.17	0.52
	P value	0.001	<0.001

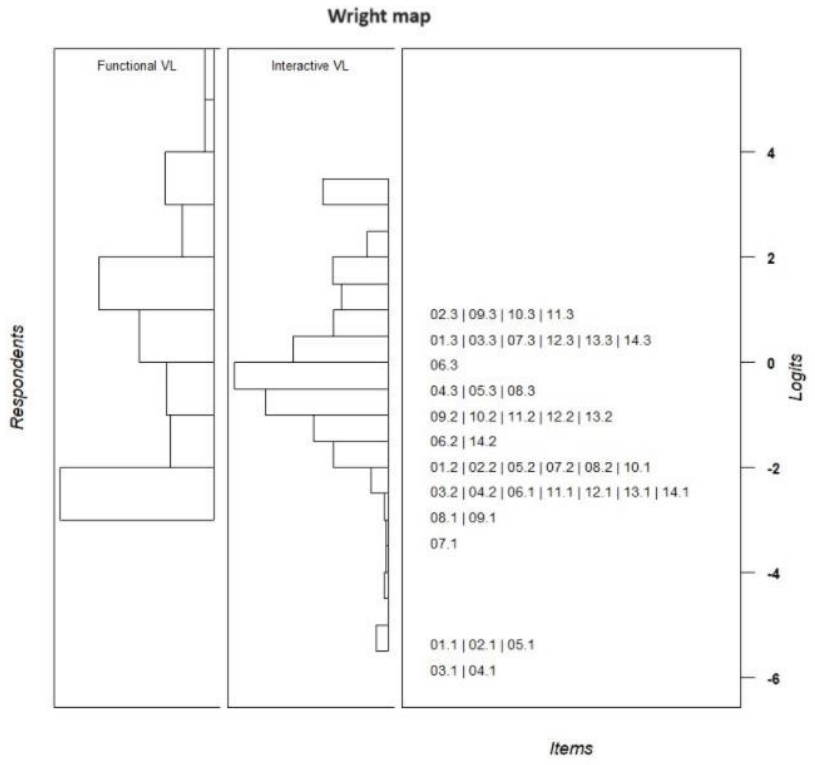
Wright map
Functional VL
Interactive VL
Respondents
Logits
Items
4
2
0
-2
-4
-6
02.3 | 09.3 | 10.3 | 11.3
01.3 | 03.3 | 07.3 | 12.3 | 13.3 | 14.3
06.3
04.3 | 05.3 | 08.3
09.2 | 10.2 | 11.2 | 12.2 | 13.2
06.2 | 14.2
01.2 | 02.2 | 05.2 | 07.2 | 08.2 | 10.1
03.2 | 04.2 | 06.1 | 11.1 | 12.1 | 13.1 | 14.1
08.1 | 09.1
07.1
01.1 | 02.1 | 05.1
03.1 | 04.1

Figure 1. Wright map of the Rasch analysis. The left panel displays the ability level area of the respondents for both factors, while the right panel shows the item difficulty level area.

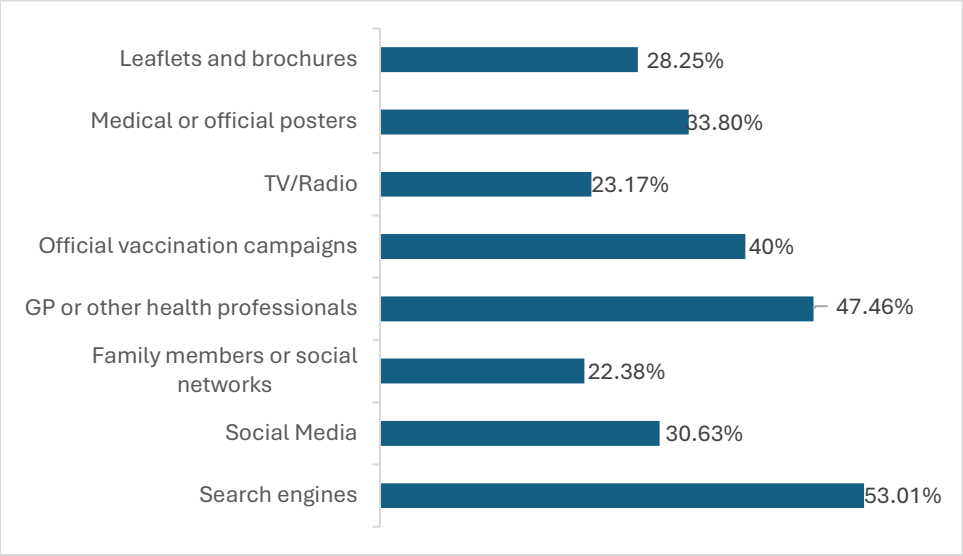

Figure 2. Participants' main sources of vaccination and vaccine-related information.