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The validation of the Slovak vaccination attitudes examination (VAX) scale and pilot study

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ABSTRACT

Introduction: The resurgence of vaccine-preventable diseases poses a significant global public health challenge, exacerbated by the rise of anti-vaccination attitudes. The aim of this study was to validate the Slovak version of the Vaccination Attitudes Examination (VAX) questionnaire and to examine the attitudes towards vaccination in Slovakia.

Methods: The VAX scale questionnaire, translated into Slovak and validated, was used for the survey. The VAX scale uses 12 statements assessing anti-vaccination attitudes. Each statement is scored on a 6-point Likert scale, with higher total score indicates more negative attitudes towards vaccinations. Our questionnaire also included demographic questions (age, gender, residence, education level, profession, and economic activity). For validation, the questionnaire was translated into the Slovak using forward and backward translations. The validation survey was conducted on the sample size of 115 participants. Correlation was calculated using Pearson's correlation coefficient, internal consistency was tested. Confirmatory factor analysis (CFA) was performed to assess validity. Subsequently, a pilot study was conducted in March 2023 with a sample size of 473 participants.

Results: The VAX scale demonstrated strong internal consistency (Cronbach's alpha = 0.925) and reliability. The results of the CFA were comparable to findings from other languages versions. The pilot study revealed that parents, non-healthcare professionals, and older individuals exhibited higher anti-vaccination attitudes. In contrast, healthcare professionals had the lowest VAX scores, reflecting more pro-vaccination attitudes.

Conclusion: These findings highlight the need for targeted educational and communication strategies to address vaccine hesitancy. By identifying demographic patterns and potential hotspots of vaccine skepticism, public health initiatives can be better tailored to improve vaccination rates. The validated Slovak VAX scale provides a reliable tool for ongoing assessment and intervention efforts.

1. Introduction

Vaccination remains one of the most effective public health interventions for preventing infectious diseases, significantly reducing morbidity and mortality worldwide. Widespread immunization programs have led to the elimination or near-elimination of numerous vaccine-preventable diseases, such as measles, polio, and diphtheria, in many regions [1]. In recent years, the resurgence of vaccine-preventable diseases has become a significant public health challenge. A contributing factor is the rise in anti-vaccination attitudes or vaccine hesitancy, characterized by skepticism or outright rejection of vaccines. These attitudes threaten to reverse the progress made in disease prevention and control [2–5]. For example, in Slovakia, measles was eliminated, and this status was maintained from 1999 to 2018. Currently, however, Slovakia is among the countries experiencing renewed endemic spread, largely due to low vaccination coverage, which was at least partially caused by vaccine hesitancy [6,7].

The consequences of anti-vaccination sentiments are far-reaching

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and extend beyond the individual. In 2019, the World Health Organization identified vaccine hesitancy as one of the top ten global health threats, warning that it "threatens to reverse progress made in tackling vaccine-preventable diseases" [8]. A decline in vaccination rates jeopardizes herd immunity, which protects vulnerable populations such as infants, the elderly, and those with compromised immune systems. This phenomenon underscores the urgent need to investigate the prevalence of anti-vaccination attitudes and the factors contributing to their spread.

The COVID-19 pandemic further exacerbated this problem. The risk of a resurgence of vaccine-preventable diseases in the aftermath of COVID-19 is alarming, fueled by disruptions in healthcare systems and vaccination campaigns [9]. Concurrently, COVID-19 vaccine hesitancy hampers public health efforts, prolongs outbreaks, and risks the emergence of new variants [10]. While overcoming this hesitancy through education and transparent communication is essential for controlling the virus and achieving herd immunity [11–14], other studies suggest that the effectiveness of vaccine hesitancy interventions might be limited [15,16]. This highlights the importance of identifying trends in attitudes towards vaccination to detect potential problems in advance.

To address this need, researchers have developed various tools to assess attitudes towards vaccination. One such tool is the Vaccine Hesitancy Scale (VHS), developed by the SAGE Working Group in 2015 [17]. Another widely used instrument is the Vaccination Attitudes Examination (VAX) scale, developed by Martin, L.R., and Petrie, K.J. [18]. The VAX scale is a short and straightforward tool that has demonstrated strong associations with vaccination behaviors and intentions. It provides an efficient method for identifying individuals with vaccination resistance and, through its subscale scores, allows a more nuanced understanding of the underlying attitudes. For this study, we selected the VAX scale over the VHS because it better captures general vaccine attitudes across key domains relevant to the broader population, while the VHS is more narrowly focused on childhood vaccination and does not cover important factors such as beliefs in natural immunity or distrust of pharmaceutical motives. Another advantage of the VAX scale is its multilingual scope. At the time of writing, the questionnaire has been translated into twenty languages, including the original English version and our Slovak translation. Of these, nine translations have published validation studies: Arabic, UK English, South African English, Italian, Korean, Romanian, Spanish, Turkish, and Urdu. The remaining translations have not yet undergone published validation [19,20]. The aim of this study is to translate the original version of the VAX scale questionnaire, validate the VAX scale for use in the Slovak language, and verify its usability in a pilot study.

2. Methods

2.1. Validation survey of the VAX scale questionnaire

The Vaccination Attitudes Examination scale questionnaire, developed by Martin, L.R., and Petrie, K.J. [18], was translated, validated, and used for this survey.

The VAX scale consists of 12 statements designed to assess anti-vaccination attitudes. Each statement is rated on a 6-point Likert scale ranging from 1 = strongly disagree to ‘6 = strongly agree. The total VAX score ranges from 12 to 72 points, with higher score indicating more negative attitudes towards vaccinations. The scale is divided into four domains, each containing three statements.

The first domain "Mistrust of vaccine benefits" (D1: Mistrust) contains statements: "I feel safe after being vaccinated", "I can rely on vaccines to stop serious infectious diseases" and "I feel protected after getting vaccinated". Second domain "Worries over unforeseen future effects" (D2: Unknown effect) contains: "Although most vaccines appear to be safe, there may be problems that we have not yet discovered", "Vaccines can cause unforeseen problems in children" and "I worry about the unknown effects of vaccines in the future". Third domain "Concerns about commercial profits" (D3: Commercial profits) contains: "Vaccines make a lot of money for pharmaceutical companies, but do not do much for regular people", "Authorities promote vaccination for financial gain, not for people's health" and "Vaccination programs are a big con". Fourth and final domain "Preference for natural immunity" (D4: Natural Immunity) contains statements: "Natural immunity lasts longer than a vaccination", "Natural exposure to viruses and germs gives the safest protection" and "Being exposed to diseases naturally is safer for the immune system than being exposed through vaccination". Each domain score was calculated by summing its item values, with possible scores ranging from 3 to 18 points.

We obtained the authors' approval to translate the questionnaire into Slovak in accordance with standard procedures. The questionnaire was translated into Slovak language by two English expert translators. The draft version was then reviewed for comprehensibility by professionals in public health and vaccinology. The finalized questionnaire was back-translated into English by an independent translator unfamiliar with the original questionnaire. The two English versions were compared to check for discrepancies. After confirming the equivalence, permission to use the Slovak version was granted by the original authors.

Data collection for the validation survey was conducted in December 2022 and January 2023. Participants first completed the questionnaire in December 2022 (test), and again 14 days later (retest).

The survey was administered via both an online platform (www.docs.google.com/forms) and paper forms. The initial pool of participants consisted of students of general medicine and public health, who also assisted with distributing the questionnaire. Additional participants were recruited through social media, emails, and personal contacts, with the questionnaire being shared among family, friends, and coworkers, using a snowball sampling approach. Each distributed questionnaire included a request from the authors encouraging recipients to share it further. Participants were asked to provide a contact method (email) to enable retest administration and response matching. Once paired, all identifying information was deleted and the data anonymized. The questionnaire included a study description, its objectives, and assurance of confidentiality. Demographic questions were also collected (age, gender, residence, education level, profession, and economic activity). Inclusion criteria required participants to be at least 18 years old and to submit a fully completed questionnaire.

A total of 235 questionnaires were distributed, of which 115 were valid for the validation survey. Of the remaining forms, 31 were left blank, and 89 were filled out incorrectly (74 lacked contact for retest distribution, and 15 had missing answers). For the retest, all 115 valid forms were distributed, and 78 were returned. Of these, 6 were incomplete due to missing answers (Fig. 1).

2.2. Pilot study

The sample size for our survey was estimated to be 196 [21]. This was calculated using a 5 % margin of error and based on the proportion of the population with anti-vaccination attitudes according to the Eurobarometer report: Europeans' attitudes towards vaccination [22]. According to this report, 15 % of respondents in Slovakia disagreed with the statements: "It is important for everybody to have routine vaccinations?" and "Vaccines are important to protect not only yourself but also others." The sample size was calculated using the OpenEpi online calculator [23]. The target population consisted of adults aged 18 years and older. Inclusion criteria required participants to be at least 18 years old and to have submitted a correctly completed questionnaire.

Data for the prevalence survey on attitudes towards vaccination were collected from March 15 to March 21, 2023. The sampling strategy was the same as in the validation survey. As with the validation survey, the questionnaire included a description of the study and its objectives an assurance of anonymity, demographic questions (age, gender, residence, education level, profession, and economic activity) and a question about attitudes towards Slovakia's vaccination schedule.

A total of 504 participants completed the questionnaire. After

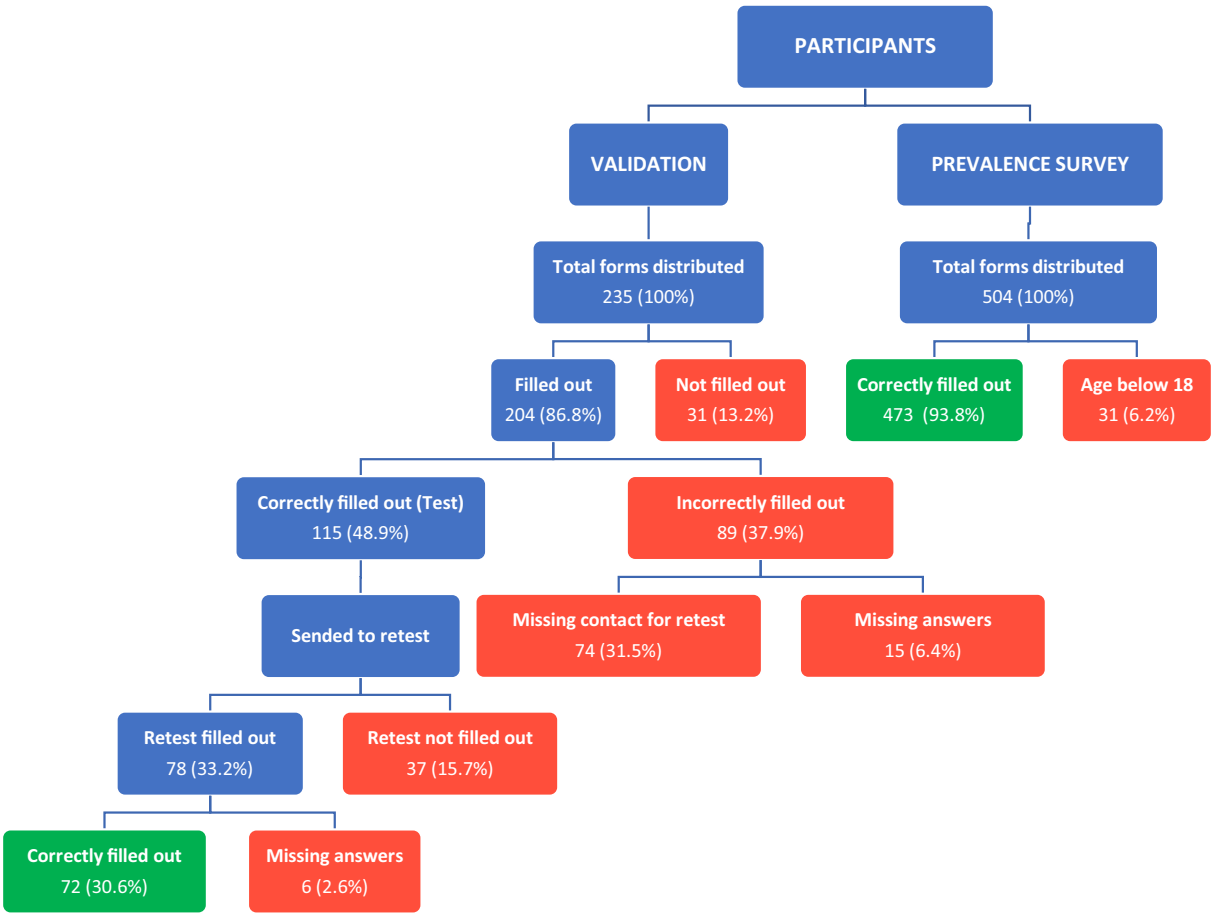

Fig. 1. Distribution of forms.

excluding 31 individuals for being under the age of 18, the final sample size was 473.Based on the respondents' answers, those with a total VAX score of 37 or higher were considered to have a prevailing anti-vaccination attitude. This was because on the 6-point Likert scale, values 4, 5, and 6 indicated an anti-vaccination attitude, and the highest score respondents could have without expressing any anti-vaccination sentiment was 36 points. Respondents with a VAX score of 36 or lower were classified as having a prevailing pro-vaccination attitude. For calculating the odds ratio based on demographic and attitude factors, respondents were divided into two groups: those with a prevailing anti-vaccination attitude and those with a prevailing pro-vaccination attitude.

For the question on "Economic activity" respondents who reported being on parental leave, unemployed, or retired were grouped under "Others".

2.3. Statistical analysis

Statistical analyses were carried out using Epi Info 7, SPSS 24 and JASP (Version 0.19.3) [24]. The internal consistency of the scale scores was evaluated with Cronbach's alpha and reliability was investigated by Pearson's correlation coefficient. The Confirmatory Factor Analysis (CFA) was used to analyze the scale's validity on both samples (validation survey and pilot study) and fit indices were calculated. The fit indices were chi-square divided by the degrees of freedom ($\chi 2$/df), Comparative Fit Index (CFI), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), Goodness of Fit Index (GFI), and Root Mean Square Error of Approximation (RMSEA). A Student's *t*-test was used to compare means of two quantitative variables, and ANOVA with Bonferroni post hoc test was used for comparison between more than two means. A *p*-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Validation survey of the VAX scale questionnaire

The respondents to the validation questionnaire consisted of 85 females (73.9 %) and 30 males (26.1 %). The age of participants ranged from 20 to 71 years, with a mean age of 34.3 ± 12.86 years. Based on economic activity, majority of the respondents were employed (55.7 %), followed by students (37.4 %) and others (7.0 %). The most prominent area of employment or study among the participants was healthcare (60.9 %). Forty-nine participants (42.6 %) were parents.

A Cronbach's alpha value of 0.70 or higher is generally considered acceptable, with values above 0.90 indicating excellent internal consistency. In this study, the VAX scale was translated into Slovak and demonstrated excellent internal consistency (Cronbach's alpha = 0.925) (Table 1).

Reliability was assessed by examining reproducibility and internal consistency using the test-retest method. The VAX correlation

Table 1
Average VAX score and Cronbach's alpha for each domain and full questionnaire (Validation survey) (n = 115).

Questionnaire's categories	Score (±SD)	Cronbach's alpha
D1: Mistrust of vaccine benefit	7.13 (4.13)	0.942
D2: Worries over unforeseen future effects	10.45 (3.64)	0.763
D3: Concerns about commercial profiteering	6.08 (3.63)	0.932
D4: Preference for natural immunity	8.12 (3.66)	0.820
Total VAX scale	31.78 (12.54)	0.925

coefficients were calculated using Pearson's correlation coefficient. Results between 0.1 and 0.3 indicate small strength of association; between 0.3 and 0.5 indicate a medium strength of association; and values in the range of above 0.5 are considered large (strong). All domains and the full questionnaire show strong reliability (Table 2).

Table 3 shows that the confirmatory factor analysis (CFA) supported the four-factor structure of the Slovak VAX scale in both the validation and pilot study. In the validation survey, most fit indices were within acceptable ranges, although the RMSEA value exceeded the recommended threshold, suggesting a moderate model fit. The pilot study demonstrated an overall good model fit, with all indices meeting recommended cut-off values, indicating that the 4-factor model was robust in a general population sample. These results are comparable to other language adaptations of the VAX scale, which similarly reported acceptable to good model fits. Factor loadings of the CFA ranged from 0.563 to 0.987 in the validation survey (Fig. 2) and from 0.54 to 0.97 in the pilot study (Fig. 3). A factor loading of 0.7 or higher is considered a strong loading, while a loading between 0.4 and 0.7 is considered acceptable [35].

3.2. Pilot study

Table 4 shows the general characteristics of the respondents for questionnaire validation. The majority were female (70.2 %), employed (50.5 %), and from non-healthcare professions (64.9 %). The mean age of participants was 30.31 ± 11.64 years. Most participants had a positive attitude towards the Slovak vaccination schedule, with 72.5 % considering vaccination important.

Table 5 presents the calculated VAX scores for each population group in the questionnaire. Respondents with children had stronger anti-vaccination attitude (TVS = 43.44) than those without kids (TVS = 37.61). A similar pattern was observed for non-healthcare workers (TVS = 42.89) compared to healthcare workers (TVS = 33.85), as well as for older versus younger participants (TVS = 42.66 and 36.67, respectively). In all these cases, the differences were statistically significant ($p < 0.001$). No significant differences were found between parents when analyzed by age. ANOVA with a Bonferroni post hoc test also revealed significant differences in VAX scores by economic activity, attitudes towards Slovak vaccination schedule, and age groups. Students had the most pro-vaccination attitudes (TVS = 35.15) compared to the employed (TVS = 42.25) and others (TVS = 41.74) ($p < 0.001$). As expected, respondents with positive attitudes towards vaccination schedule had the lowest score (TVS = 33.36), those with neutral attitudes had intermediate score (TVS = 47.40), and those with negative attitudes had a highest score (TVS = 59.54) ($p < 0.001$).

Odds ratios based on the anti-vaccine attitudes (VAX score 37 and more) in different factors are presented in Table 6. Individuals working in healthcare had significantly lower odds of holding an anti-vaccination attitude compared with those outside the healthcare sector (OR = 0.36, $p < 0.0001$). Similarly, students were less likely than employed respondents to exhibit an anti-vaccination stance (OR = 0.56, $p = 0.0044$). As expected, respondents with a positive attitude towards the Slovak vaccination schedule were particularly unlikely to hold an anti-vaccination viewpoint (OR = 0.02, $p < 0.0001$), confirming the questionnaire's effectiveness in capturing vaccination attitudes. No significant associations were found for gender, residence, parental status, education level, or age.

Table 2
Pearson's correlation coefficient from test/retest for each domain and full questionnaire (Validation survey) ($n = 72$).

Items	Pearson's Correlation	*p* value
D1: Mistrust of vaccine benefit	0.57	<0.00001
D2: Worries over unforeseen future effects	0.78	<0.00001
D3: Concerns about commercial profiteering	0.82	<0.00001
D4: Preference for natural immunity	0.82	<0.00001
Total VAX scale	0.92	<0.00001

Table 3
Comparison of fit indices of Slovak VAX scale validation survey and Pilot study and other language versions.

VAX scale versions	χ2/df	CFI	NFI	TLI	GFI	RMSEA
Reference values [25,26]	≤3	≥0.90	≥0.90	≥0.95	≥0.95	≤ 0.06
Slovak - Validation survey	1.959	0.959	0.92	0.943	0.883	0.09
Slovak - Pilot study	2.859	0.983	0.975	0.977	0.954	0.06
Arabic [27]	–	0.954	–	0.936	–	0.97
English UK [28]	–	1.0	0.998	1.001	–	0.00
English – South Africa [20]	–	0.98	–	0.97	0.95	0.06
Italian [29]	–	0.98	–	0.975	–	0.05
Korean [30]	13.6	0.96	–	0.95	0.95	0.07
Romanian [31]	2.992	0.949	0.926	0.93	–	0.07
Spanish [32]	2.287	0.97	0.95	0.96	–	0.06
Turkish [33]	2.243	0.907	–	0.94	0.932	0.07
Urdu [34]	1.552	0.966	–	0.953	0.944	0.05

Notes: χ2/df = chi-square divided by the degrees of freedom, CFI = Comparative Fit Index, NFI = Normed Fit Index, TLI = Tucker-Lewis Index, GFI = Goodness of Fit Index, RMSEA = Root Mean Square Error of Approximation.

4. Discussion

Vaccines stand as one of the most remarkable achievements in modern medicine, effectively reducing the morbidity and mortality associated with infectious diseases. Despite their proven effectiveness, the success of vaccination campaigns largely depends on high public acceptance and participation. Over the past two decades, a concerning trend has emerged, with an increasing number of individuals and groups adopting anti-vaccination attitudes [36].

Since 2010, as part of World Immunization Week (WIW)-which has been announced annually since 2005 by the Office of the World Health Organization for Europe-we have been conducting surveys with public health students at the Jessenius Faculty of Medicine in Martin. Previous surveys were face-to-face, either in the streets of Martin or in pediatric clinics, focusing on selected aspects of the population's opinions on vaccination [37,38]. During the COVID-19 pandemic, from 2020 to 2022, we observed a significant increase in anti-vaccination attitudes among participants [39]. However, the questionnaire used in these surveys was not validated. This prompted us to translate and validate the VAX scale questionnaire. At the time of writing, there are twenty language versions of the questionnaire, including the original English version and our Slovak version [19]. This greatly enhances its accessibility, cultural relevance, data quality, and global applicability. Translating the scale into multiple languages increases accessibility by enabling participation from individuals not fluent in English and strengthens global applicability by allowing direct comparison of responses across countries.

Other translations of the VAX questionnaire have already produced published results that can be compared to ours. For example, in the study by Shacham et al. [29], the authors used the VAX scale to compare attitudes among dentists, dental hygienists, and the general population, where their total VAX scores were 25.19 (SD ± 9.59), 31.47 (SD ± 9.76), and 27.48 (SD ± 12.86), respectively, with a significant difference between dental hygienists and the other two groups. In our study, we divided the sample into non-healthcare and healthcare professions, whose total VAX scores were 42.89 (SD ± 16.14) and 33.85 (SD ± 14.25), respectively. This indicates that the attitudes of our healthcare-related respondents are less pro-vaccine compared to Shacham et al. The difference may be partly explained by timing: Shacham et al. conducted their study in late 2020 and early 2021, approximately one year into the COVID-19 pandemic, when COVID-19 vaccination in Israel had only just

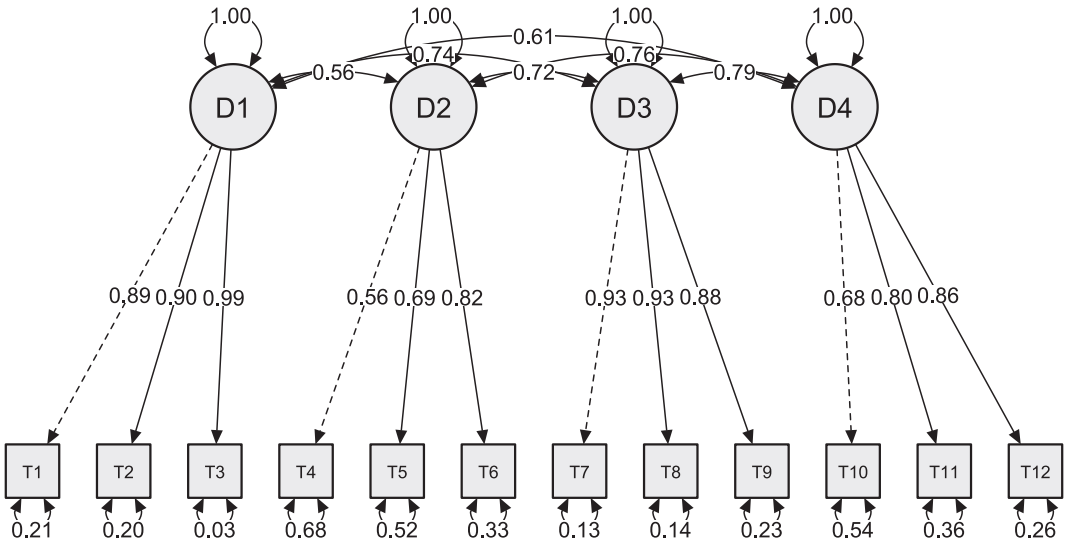

Fig. 2. Path model for VAX scale factors in Validation survey of the VAX Scale.

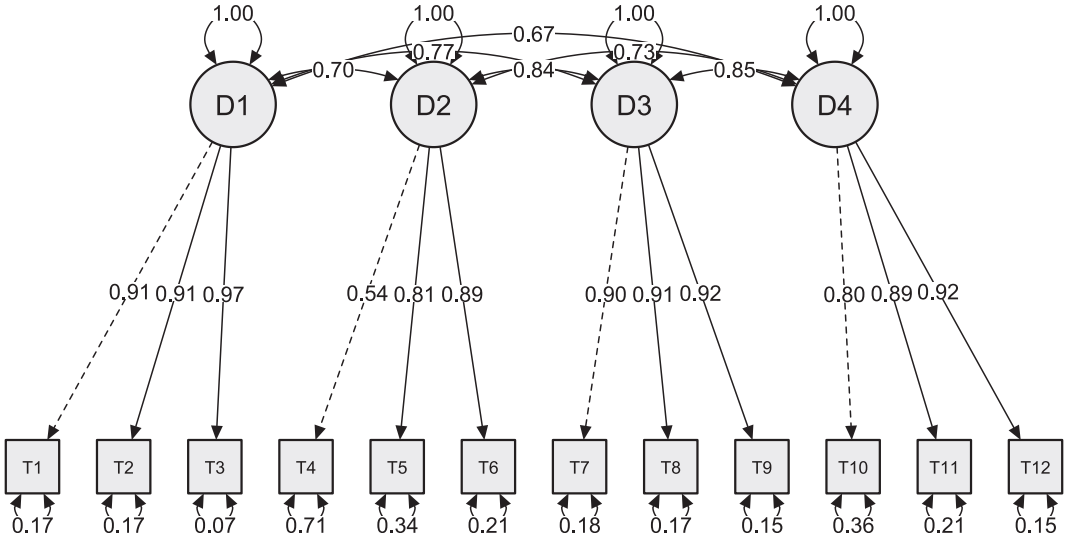

Fig. 3. Path model for VAX scale factors in Pilot study.

begun. In contrast, our data collection took place in 2023, after vaccination campaigns had been implemented in Slovakia for two years. This temporal gap may have influenced the level of vaccine hesitancy in the population.

Other studies assessed the VAX score as an average of all statements rather than a sum, as in our study. However, the results can be compared after recalculating. In an Italian study, a significant difference in average VAX scores between genders was found (women 2.74, SD ± 1.11, and men 2.22, SD ± 1.83) [18]. In our study, women had a score of 3.27 (SD ± 1.30), and men had a score of 3.38 (SD ± 1.42), indicating that the attitudes of our respondents were less favorable than those in the Italian study. In a Korean study, the average VAX score of respondents was 3.28 (SD ± 0.75), which is comparable to the score of respondents in our pilot study, which was 3.30 (SD ± 1.34) after recalculation [19]. However, since the focus and population samples differed across these studies, these comparisons are not fully representative, though they may still provide useful context for future research.

Our pilot study revealed that certain demographic groups exhibited stronger anti-vaccination attitudes. For example, parents and non-healthcare professionals scored higher on the VAX scale compared to their counterparts. This highlights parents an important demographic since their attitudes towards vaccination directly impact their children [40,41]. Reasons for parental vaccine hesitancy are varied and may include religious or philosophical beliefs, personal convictions, safety concerns, a desire for more information from healthcare providers, and the influence of widespread misinformation—particularly on social media—which may be especially impactful for parents on parental leave [42,43]. It is also positive to note that physicians and healthcare workers had lower VAX scores than non-healthcare workers, reflecting more pro-vaccination attitudes. This is important because healthcare professionals play a significant role in influencing vaccination decisions and can serve as advocates for vaccines within the general public. Maintaining a positive attitude towards vaccination among healthcare professionals can significantly enhance patient trust and compliance with immunization schedules [44–47]. Similarly, other studies have shown that a decrease in vaccine uptake among nurses is correlated with a decrease in patient vaccine uptake [13]. Additionally, older individuals showed more skepticism than younger ones. While a precise assessment of these factors is beyond the scope of this article, the VAX scale can facilitate future studies aimed at clarifying these underlying reasons.

Our study also shows us that about 20 % of participants did not agree with the Slovak vaccination schedule. That is concerning, as if one-fifth

Table 4
Demographics of the pilot study group ($n = 473$).

	N	%
Gender		
Female	332	70.2
Male	141	29.8
Residence		
Urban	254	53.7
Rural	219	46.3
Parents		
Parents	166	35.1
Not parents	307	64.9
Education		
Without finished primary education	2	0.4
Primary	5	1.1
Secondary	270	57.1
Tertiary	196	41.4
Economic activity		
Student	168	35.5
Employed	239	50.5
Other	66	14.0
Profession		
Healthcare	169	35.7
Non-healthcare	304	64.3
Attitude towards Slovak vaccination schedule		
Positive	343	72.5
Neutral	35	7.4
Negative	95	20.1
Age – divided by median (25)		
Younger (18–25 years old)	237	50.1
Older (26+ years old)	236	49.9

of the population were unvaccinated for diseases such as measles or polio, it could lead to large-scale epidemics. A decline in vaccination coverage has already resulted contributed to a measles epidemic in Slovakia [7]. More recently, between January 2022 and August 2023, there was a spike in diphtheria cases in Europe, including nine cases from Slovakia [48]. Pertussis is another vaccine-preventable disease that has shown increased incidence over the past year and a half, not only in Slovakia but across Europe [49]. In the pre-pandemic years, the annual number of pertussis cases in Slovakia was only a few hundreds, while in the first 26 weeks of 2024, the number had already reached 1369 [50].

In today's interconnected world, comparing vaccination attitudes

Table 6
Odds ratio based on VAX score of 37 and more (Pilot study) ($n = 473$).

Factors	Odds ratio (95 % CI)	p value
Gender (female/male)	0.85 (0.57, 1.25)	0.4033
Residence (urban/rural)	0.95 (0.66, 1.37)	0.7939
Parents (yes/no)	1.37 (0.94, 2.00)	0.1051
Healthcare profession (yes/no)	0.36 (0.24, 0.53)	<0.0001
Education (secondary/tertiary)	1.35 (0.93, 1.95)	0.1117
Economic activity(student/employed)	0.56 (0.38, 0.83)	0.0044
Attitude towards the Slovak vaccination schedule (positive/negative)	0.02 (0.01, 0.07)	<0.0001
Age (18–25 years old/ 26+ years old)	0.72 (0.50, 1.03)	0.0731

Table 5
VAX score differences among the study participants based on the pilot study variables ($n = 473$).

Factors	D1: Mistrust (±SD)	D2: Unknown effects (±SD)	D3: Commercial profits (±SD)	D4: Natural immunity (±SD)	Total VAX scale-TVS (±SD)
Gender					
Female ($n = 332$)	8.45 (4.64)	11.95 (3.94)	8.77 (5.00)	10.09 (4.50)	39.26 (15.63)
Male ($n = 141$)	9.31 (4.92)	11.66 (4.08)	9.16 (5.28)	10.47 (4.79)	40.60 (17.08)
Residence					
Urban ($n = 254$)	8.73 (5.04)	11.91 (4.16)	9.12 (5.31)	10.29 (4.86)	40.04 (17.06)
Rural ($n = 219$)	8.68 (4.36)	11.82 (3.77)	8.61 (4.80)	10.10 (4.26)	39.21 (14.87)
Parents					
Yes ($n = 166$)	9.48 (5.08)**	12.58 (4.11)**	10.18 (5.55)***	11.20 (4.88)***	43.44 (17.48)***
No ($n = 307$)	8.29 (4.49)	11.48 (3.86)	8.18 (4.67)	9.66 (4.34)	37.61 (14.89)
Profession					
Healthcare ($n = 169$)	6.94 (4.07)	11.35 (3.66)	6.88 (4.39)	8.68 (4.37)	33.85 (14.25)
Non-healthcare ($n = 304$)	9.69 (4.80)***	12.15 (4.13)*	10.00 (5.11)***	11.05 (4.50)***	42.89 (16.14)***
Education					
Primary ($n = 5$)	10.40 (5.55)	12.80 (3.11)	8.60 (5.50)	9.80 (4.66)	41.60 (16.89)
Secondary ($n = 270$)	8.66 (4.39)	11.82 (3.88)	8.97 (4.95)	10.45 (4.48)	39.91 (15.27)
Tertiary ($n = 196$)	8.77 (5.17)	11.91 (4.18)	8.77 (5.27)	9.85 (4.74)	39.30 (17.17)
Economic activity[x]					
Student[(S)] ($n = 168$)	7.54 (3.98)	11.10 (3.72)	7.33 (4.23)	9.20 (4.06)	35.15 (13.44)
Employed[(E)] ($n = 239$)	9.38 (4.97)**	12.32 (4.08)**	9.80 (5.28)**	10.74 (4.78)	42.25 (16.89)**
Others[(O)] ($n = 66$)	9.24 (5.09)	12.18 (4.01)	9.52 (5.45)	10.80 (4.79)**	41.74 (16.57)
Attitude towards the Slovak vaccination schedule[xx]					
Positive[(A)] ($n = 343$)	6.84 (3.46)	10.72 (3.45)	7.00 (3.91)	8.80 (4.02)	33.36 (11.96)
Neutral[(B)] ($n = 35$)	10.69 (3.60)	13.37 (4.19)	11.54 (4.33)	11.80 (3.70)	47.40 (13.45)
Negative[(C)] ($n = 95$)	14.73 (3.67)**	15.44 (3.38)**	14.71 (4.19)**	14.66 (3.70)**	59.54 (12.04)**
Age – divided by median (25)					
Younger (18–25) ($n = 237$)	7.92 (4.12)	11.39 (3.71)	7.85 (4.38)	9.51 (4.05)	36.67 (13.66)
Older (26+) ($n = 236$)	9.50 (5.17)***	12.34 (4.18)**	9.92 (5.52)***	10.90 (4.98)***	42.66 (17.70)***
Parents – divided by age median (25)					
Younger (18–25) (n = 9)	8.22 (2.54)	13.44 (2.96)	11.22 (4.15)	12.00 (4.21)	44.89 (11.38)
Older (26+) ($n = 157$)	9.55 (5.19)	12.53 (4.17)	10.12 (5.63)	11.16 (4.92)	43.36 (17.78)

Notes:
Asterisks highlight difference between subgroups within variables and are added to highest TVS.
*$p < 0.05$, **$p < 0.01$, ***p < 0.001 (t-test for two groups, ANOVA for more than two groups).
[x]Bonferroni post hoc test: E > S (D1, D2, D3, D4, TVS), O > S (D1, D3, D4. TVS), [xx]Bonferroni post hoc test: C > B > A (D1, D2, D3, D4, TVS),
D1 = Mistrust of vaccine benefits, D2 = Worries over unforeseen future effects, D3 = Concerns about commercial profits, D4 Preference for natural immunity.

across countries is essential for ensuring global public health. Using a consistent tool for these comparisons is critical, and the VAX scale is particularly well-suited for this purpose due to its availability in multiple languages. Widespread use of the VAX scale across different regions supports public health by providing a reliable method to assess and monitor vaccination attitudes on a global scale. The VAX scale can help us identify population groups at risk for anti-vaccination behavior, allowing targeted educational interventions to promote more favorable attitudes towards vaccination.

5. Limitations

The sample was collected electronically, and the initial pool of participants consisted of students, which resulted in a predominance of younger respondents. This may limit the generalizability of the findings, as certain demographic groups may be underrepresented.

6. Conclusion

Addressing the factors that contribute to anti-vaccination sentiments, such as misinformation and distrust, is essential for improving vaccination rates and maintaining herd immunity. Public health initiatives should prioritize education and transparent communication to counteract these attitudes and protect vulnerable populations from preventable diseases. The validated Slovak translation of the VAX scale offers a reliable tool for assessing attitudes and identifying demographic groups at higher risk of vaccine skepticism.

Statements

Participants were informed about the research goal, that the information provided would be used for research purposes only, and that participation was voluntary.

CRediT authorship contribution statement

Martin Novák: Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Jana Zibolenová:** Writing – review & editing, Methodology, Formal analysis. **Peter Vyšehradský:** Writing – review & editing, Investigation. **Romana Ulbrichtová:** Methodology, Investigation, Formal analysis. **Eva Malobická:** Writing – review & editing, Visualization, Formal analysis. **Eliška Štefanová:** Writing – review & editing, Visualization. **Ján Mikas:** Supervision. **Adriana Mečochová:** Supervision. **Henrieta Hudečková:** Writing – review & editing, Supervision, Conceptualization. **Viera Švihrová:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Formal analysis, Conceptualization.

Ethical approval

The study protocol was approved by the Ethics Committee at the Comenius University in Bratislava, Jessenius Faculty of Medicine in Martin (reference no. EK UNM 71/2022).

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Write full Revise and Chat-GPT in order to improve wording, correct grammar, and proofread the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

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.

Data availability

Data will be made available on request.

References

[1] Winter AK, Lambert B, Klein D, Klepac P, Papadopoulos T, Truelove S, et al. Feasibility of measles and rubella vaccination programmes for disease elimination: a modelling study. Lancet Glob Health 2022;10:e1412–22. https://doi.org/10.1016/S2214-109X(22)00335-7.
[2] Papachrisanthou MM, Davis RL. The resurgence of measles, mumps, and pertussis. J Nurse Pract 2019;15:391–5. https://doi.org/10.1016/j.nurpra.2018.12.028.
[3] Siani A. Measles outbreaks in Italy: a paradigm of the re-emergence of vaccine-preventable diseases in developed countries. Prev Med 2019;121:99–104. https://doi.org/10.1016/j.ypmed.2019.02.011.
[4] Dubé E, Laberge C, Guay M, Bramadat P, Roy R, Bettinger JA. Vaccine hesitancy: an overview. Hum Vaccin Immunother 2013;9:1763–73. https://doi.org/10.4161/hv.24657.
[5] Nuwarda RF, Ramzan I, Weekes L, Kayser V. Vaccine hesitancy: contemporary issues and historical background. Vaccines 2022;10:1595. https://doi.org/10.3390/vaccines10101595.
[6] Hudečková H, Ulbrichtová R, Novák M, Tatarková M, Malobická E, Mikas J, et al. Why is there a threat of the emergence and spread of measles in Slovakia? Vakcinologie 2023;17:15–22.
[7] Hudečková H, Stašková J, Mikas J, Mečochová A, Staroňová E, Polčičová A, et al. Measles outbreak in a Roma Community in the Eastern Region of Slovakia, may to October 2018. Zdr Varst 2020;59:219–26. https://doi.org/10.2478/sjph-2020-0028.
[8] Ten health issues WHO will tackle this year n.d. https://www.who.int/news-room/spotlight/ten-threats-to-global-health-in-2019 (accessed August 7, 2025).
[9] Increases in vaccine-preventable disease outbreaks threaten years of progress, warn WHO, UNICEF, Gavi n.d. https://www.who.int/news/item/24-04-2025-increases-in-vaccine-preventable-disease-outbreaks-threaten-years-of-progress–warn-who–unicef–gavi (accessed August 8, 2025).
[10] Peters MDJ. Addressing vaccine hesitancy and resistance for COVID-19 vaccines. Int J Nurs Stud 2022;131:104241. https://doi.org/10.1016/j.ijnurstu.2022.104241.
[11] McGrath E. Emergence of vaccine-preventable diseases: the perfect storm of hesitancy, refusal, a pandemic, and war. Pediatr Ann 2022;51:e426–30. https://doi.org/10.3928/19382359-20220913-03.
[12] Khatiwada AP, Shrestha N, Shrestha S. Will COVID-19 Lead to a resurgence of vaccine-preventable diseases? Infect Drug Resist 2021;14:119–24. https://doi.org/10.2147/IDR.S276362.
[13] Dror AA, Eisenbach N, Taiber S, Morozov NG, Mizrachi M, Zigron A, et al. Vaccine hesitancy: the next challenge in the fight against COVID-19. Eur J Epidemiol 2020;35:775–9. https://doi.org/10.1007/s10654-020-00671-y.
[14] Troiano G, Nardi A. Vaccine hesitancy in the era of COVID-19. Public Health 2021;194:245–51. https://doi.org/10.1016/j.puhe.2021.02.025.
[15] Dubé E, Gagnon D, MacDonald NE. Strategies intended to address vaccine hesitancy: review of published reviews. Vaccine 2015;33:4191–203. https://doi.org/10.1016/j.vaccine.2015.04.041.
[16] Ryan J, Malinga T. Interventions for vaccine hesitancy. Curr Opin Immunol 2021;71:89–91. https://doi.org/10.1016/j.coi.2021.05.003.
[17] Larson HJ, Jarrett C, Schulz WS, Chaudhuri M, Zhou Y, Dube E, et al. Measuring vaccine hesitancy: the development of a survey tool. Vaccine 2015;33:4165–75. https://doi.org/10.1016/j.vaccine.2015.04.037.
[18] Martin LR, Petrie KJ. Understanding the dimensions of anti-vaccination attitudes: the vaccination attitudes examination (VAX) scale. Ann Behav Med 2017;51:652–60. https://doi.org/10.1007/s12160-017-9888-y.
[19] Services: Vaccination Attitudes Examination (VAX) Scale 2023. https://www.vax-scale.com/services/ (accessed July 8, 2024).
[20] Padmanabhanunni A, Pretorius TB, Isaacs SA. Validation of the vaccination attitudes examination scale in a south African context in relation to the COVID-19 vaccine: quantifying dimensionality with bifactor indices. BMC Public Health 2023;23:1872. https://doi.org/10.1186/s12889-023-16803-4.
[21] Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med 2013;35:121–6. https://doi.org/10.4103/0253-7176.116232.
[22] European Commission. Directorate General for Health and Food Safety. European Commission. Directorate General for Communication. Kantar. Europeans' attitudes towards vaccination: report. LU: Publications Office; 2019.
[23] OpenEpi:Sample Size for X-Sectional,Cohort,and Clinical Trials n.d. https://www.openepi.com/SampleSize/SSCohort.htm (accessed August 13, 2025).
[24] JASP Team (2024). JASP (Version 0.95.1)[Computer software].

[25] Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives. Struct Equ Model 1999;6:1–55. https://doi.org/10.1080/10705519909540118.
[26] Iacobucci D. Structural equations modeling: fit indices, sample size, and advanced topics. J Consum Psychol 2010;20:90–8. https://doi.org/10.1016/j.jcps.2009.09.003.
[27] Alansari KDH, Buhl C, Thabit AK, Badr AF, Jaad L, Jacobsen R. Validation of the Arabic translation of the vaccination attitudes examination (VAX) scale. Vaccine 2024;42:126411. https://doi.org/10.1016/j.vaccine.2024.126411.
[28] Wood L, Smith M, Miller CB, O'Carroll RE. The internal consistency and validity of the vaccination attitudes examination scale: a replication study. Ann Behav Med 2019;53:109–14. https://doi.org/10.1093/abm/kay043.
[29] Bruno F, Laganà V, Pistininzi R, Tarantino F, Martin L, Servidio R. Validation and psychometric properties of the Italian vaccination attitudes examination (VAX-I) scale. Curr Psychol 2022:1–11. https://doi.org/10.1007/s12144-022-03209-5.
[30] Kim J, Han K, Chung SJ, Kim C. Psychometric validation of the Korean versions of the vaccine hesitancy scale and vaccination attitudes examination scale. Vaccine 2023;41:4685–92. https://doi.org/10.1016/j.vaccine.2023.06.046.
[31] Huza G. The psychometric properties of a Romanian version of the vaccination attitudes examination (VAX) scale. Int J HIV/AIDS Prev Educ Behav Sci 2020;6:25–31. https://doi.org/10.11648/j.ijhpebs.20200601.14.
[32] Paredes B, Cárdaba MÁ, Cuesta U, Martinez L. Validity of the Spanish version of the vaccination attitudes examination scale. Vaccines (Basel) 2021;9:1237. https://doi.org/10.3390/vaccines9111237.
[33] Yildiz E, Gungormus Z, Dayapoglu N. Assessment of validity and reliability of the turkish version of the vaccination attitudes examination (VAX) scale. Int J Caring Sci 2021;14:261–8.
[34] Naqvi AA, Islam MA, Jahangir A, Rizvi M, Iffat W, Aftab MT, et al. Cross-cultural adaptation and validation of an Urdu version of the vaccine attitudes examination (VAX-U) scale. PLoS ONE 2024;19:e0312459. https://doi.org/10.1371/journal.pone.0312459.
[35] Cheung GW, Cooper-Thomas HD, Lau RS, Wang LC. Reporting reliability, convergent and discriminant validity with structural equation modeling: a review and best-practice recommendations. Asia Pac J Manag 2024;41:745–83. https://doi.org/10.1007/s10490-023-09871-y.
[36] Carpiano RM, Callaghan T, DiResta R, Brewer NT, Clinton C, Galvani AP, et al. Confronting the evolution and expansion of anti-vaccine activism in the USA in the COVID-19 era. Lancet 2023;401:967–70. https://doi.org/10.1016/S0140-6736(23)00136-8.
[37] Novák M, Baška T, Švihrová V, Hudečková H. Prieskum postojov a názorov rodičov na očkovanie v meste Martin za roky 2017 a 2018. Pediatria 2018;13(4):173–6.
[38] Novák M, Baška T, Malobická E, Švihrová V, Hudečková H. Názory obyvateľov mesta Martin na očkovanie, vykonávané v rámci Európskeho imunizačného týždňa v rokoch 2010 až 2016. Zdravotnícke listy 2018;6(3):12–6.
[39] Novák M, Ulbrichtová R, Štefanovvá E, Hudečková H. Analysis of changes in attitudes towards vaccination during the COVID-19 pandemic in 2020 to 2022 in Slovakia on the occasion of the world immunization week. Zdravotnícke listy 2024;12(2):31–7.
[40] Demir Pervane V, Erten Bucaktepe PG, Yıldız İ, Kardaş S, Tekay SE, Atik Y, et al. Parents' attitudes about childhood vaccines before and after the COVID-19 pandemic: a cross-sectional study. Medicina (Kaunas) 2025;61:421. https://doi.org/10.3390/medicina61030421.
[41] Obohwemu K, Jong FC, Ling J. Parental childhood vaccine hesitancy and predicting uptake of vaccinations: a systematic review. Prim Health Care Res Dev 2022;23:e68. https://doi.org/10.1017/S1463423622000512.
[42] Cagnotta C, Lettera N, Cardillo M, Pirozzi D, Catalán-Matamoros D, Capuano A, et al. Parental vaccine hesitancy: recent evidences support the need to implement targeted communication strategies. J Infect Public Health 2025;18:102648. https://doi.org/10.1016/j.jiph.2024.102648.
[43] McKee C, Bohannon K. Exploring the reasons behind parental refusal of vaccines. J Pediatr Pharmacol Ther 2016;21:104–9. https://doi.org/10.5863/1551-6776-21.2.104.
[44] Altman JD, Miner DS, Lee AA, Asay AE, Nielson BU, Rose AM, et al. Factors affecting vaccine attitudes influenced by the COVID-19 pandemic. Vaccines 2023;11:516. https://doi.org/10.3390/vaccines11030516.
[45] Leask J, Kinnersley P, Jackson C, Cheater F, Bedford H, Rowles G. Communicating with parents about vaccination: a framework for health professionals. BMC Pediatr 2012;12:154. https://doi.org/10.1186/1471-2431-12-154.
[46] Prieto-Campo Á, García-Álvarez RM, López-Durán A, Roque F, Herdeiro MT, Figueiras A, et al. Understanding primary care physician vaccination behaviour: a systematic review. Int J Environ Res Public Health 2022;19:13872. https://doi.org/10.3390/ijerph192113872.
[47] Godoy P, Castilla J, Mayoral JM, Martín V, Astray J, Torner N, et al. Influenza vaccination of primary healthcare physicians may be associated with vaccination in their patients: a vaccination coverage study. BMC Fam Pract 2015;16:44. https://doi.org/10.1186/s12875-015-0259-0.
[48] Epidemiological update: Diphtheria cases in Europe 2023. https://www.ecdc.europa.eu/en/news-events/epidemiological-update-diphtheria-cases-europe (accessed July 2, 2024).
[49] European Centre for Disease Prevention and Control. Increase of pertussis cases in the EU/EEA: 8 May 2024. LU: Publications Office; 2024.
[50] Public Health Authority of the Slovak Republic. Available online: https://www.uvzsr.sk/web/uvz/grafy (accessed on July 8, 2024).