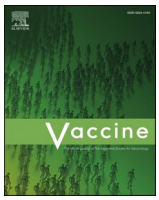
Vaccine 67 (2025) 127849

Contents lists available at ScienceDirect

Vaccine

journal homepage: www.elsevier.com/locate/vaccine



The state of vaccine confidence among the general public in Eastern Europe and Central Asia

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ARTICLE INFO

Keywords:
Vaccine confidence
Vaccination
Vaccine hesitancy
MMR
flu
HPV
COVID-19

ABSTRACT

Background: The COVID-19 pandemic brought global attention to challenges vaccination programs face in relation to public confidence and exposed important differences in vaccine acceptance worldwide—prompting renewed emphasis on monitoring of vaccine confidence. Most studies in Europe focus on the 27 European Union (EU) countries, with sparse evidence among the broader WHO European Region. This study extend coverage of vaccine confidence surveillance where such research is limited.

Methods: Members of the general public in North Macedonia, Bosnia and Herzegovina, Belarus, Armenia, Georgia, and Kazakhstan were surveyed between June and July of 2023 (n = 1000 per country) using the Vaccine Confidence Index (VCI) to measure confidence in the safety, importance, effectiveness of vaccines and their compatibility with personal beliefs. Levels of vaccine confidence for vaccines in general as well as for the measles-mumps-rubella (MMR), Human Papillomavirus (HPV), seasonal influenza (flu), and Covid-19 vaccine were assessed. Bi-variate logistic regressions explore the relationship between socio-demographic characteristics and vaccine confidence in each country.

Results: Across the 6 countries, the average for overall vaccine confidence was 43.7 %, lower than the 2022 EU-27 average of 49.97 %. Confidence in vaccines in general was lowest in Kazakhstan (35.5 %) and highest in Georgia (51.8 %). Confidence in specific vaccines varied greatly between the study countries, as did the levels of each dimension of confidence (perceived importance, safety, effectiveness, and compatibility with religious beliefs) and how they contributed to shaping confidence between and within each country. Relationships between socio-demographic variables were country-specific, highlighting the complexity of vaccine confidence.

Conclusion: With limited vaccine confidence evidence in Eastern European and Central Asian countries, more research is needed to better understand vaccine confidence levels, drivers, and trends over time. This could help inform tailored interventions to improve confidence and acceptance of existing and new vaccines.

1. Introduction

Vaccine confidence is complex and context specific, varying geographically and temporally as well as across different vaccines. Formed by a confluence of socio-demographic, social, societal, cultural, and political factors, vaccine confidence is dynamic in nature and requires a multifaceted approach to inform effective vaccination campaigns, communication strategies, or other needed interventions to increase vaccine uptake. Surveillance of vaccine confidence levels and trends over time can act as an early warning system—with confidence proven to be a good quantitative predictor of uptake, as drops in public confidence in vaccines can anticipate potential drops in vaccine uptake and allow time to build confidence before vaccine programs are disrupted [1].

At a glance, Europe is well served by routine vaccine confidence research—between 2016 and 2022, the European Commission sourced a

Abbreviations: MMR, measles, mumps, and rubella; flu, seasonal influenza; HPV, human papillomavirus; VCP, Vaccine Confidence Project; VCI, Vaccine Confidence Index; EU, European Union; ORs, odds ratios.

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https://doi.org/10.1016/j.vaccine.2025.127849
Received 24 October 2024; Received in revised form 30 September 2025; Accepted 6 October 2025
Available online 22 October 2025

bi-annual report on the state of vaccine confidence [2–4]. At the time, Europe was identified as being the region with the lowest levels of public confidence in the world [5]. This was later confirmed in follow up studies [6] and more recently in studies exploring public willingness to accept the Covid-19 vaccine [7,8]. Since then, course corrections have been made to address common concerns circulating across the EU, including fears of vaccine side effects, the belief that vaccines do not work, perceptions that vaccine preventable diseases are not severe or prevalent, or concerns that children receive too many vaccines at a young age [9]. Until 2020, vaccine confidence had improved across many EU-member states [3]. While the most recent report 'The State of Vaccine Confidence in the EU: 2022' shows a decrease in vaccine confidence post-pandemic, ongoing research in the region is dedicated to determining if findings from the report represent short-term fluctuations and reversible trends or more permanent shifts. However, this wealth of research represents less than half of the countries comprising the WHO European region.

Most studies in Europe focus solely on the 27 EU countries, with sparse evidence available among other European countries, in particular countries from Eastern Europe, the Balkans, Caucasus, and Central Asia. The little evidence available for these countries suggests vaccine confidence is low [6,10–12].

A range of factors, including cultural differences and historical events could be contributing to attitudes towards vaccines outside of the EU. There are reports of growing skepticism among healthcare professionals, with low-levels of vaccine confidence impacting trust, attitudes, and practice of physicians, medical students, and primary care providers in Eastern Europe, the Balkans, Caucasus, and Central Asia [13–15]. Additionally, low-levels of vaccine uptake across the region warrant expanded vaccine confidence research. North Macedonia and Bosnia & Herzegovina are both well below the 95 % WHO recommended MMR vaccine coverage rates for children: respectively 71 % and 58 % of children ages 12–23 months are vaccinated (2022) [16]. Georgia faces a high HPV-associated cancer burden and low HPV vaccine uptake [14]. A case study of HPV in Armenia also identified low-levels of HPV vaccine coverage and high levels of reported vaccine hesitancy [13]. Confidence towards the Covid-19 vaccine is low across Europe, among the general public and healthcare professionals, although confidence was highly variable over the pandemic years [15,17,18]. And while the urgency of getting vaccinated against COVID-19 has dwindled since the pandemic ended, insights towards what shaped people perceptions of the COVID-19 pandemic could help inform future roll-outs of new/novel vaccines, especially during times of crisis, and in preparation for future health crises.

This study aims to extend coverage of vaccine confidence surveillance in 6 countries of the WHO European Region outside of the EU: North Macedonia, Bosnia and Herzegovina (Balkans), Belarus (Eastern Europe), Armenia, Georgia (Caucasus), and Kazakhstan (Central Asia). Using a standardized tool, the Vaccine Confidence Index (VCI), comparisons can be made between the 6 selected countries, the 27 EU countries, and other countries or regions of the world.

This paper summarizes quantitative findings from surveys with the general public, and is part of a larger mixed-methods study that extends beyond the general public to explore vaccine confidence among healthcare professionals in the 6 countries, including a deep dive into attitudes and trust as well as an examination of training needs. Results of the healthcare professionals' surveys and qualitative interviews are published in a separate paper [19].

2. Methods

Six countries outside of the EU: North Macedonia, Bosnia and Herzegovina (Balkans), Belarus (Eastern Europe), Armenia, Georgia (Caucasus), and Kazakhstan (Central Asia) were selected to extend surveillance of vaccine confidence levels within the WHO European Region beyond the EU. Countries were selected based on the availability of local research partners facilitating recruitment of study participants and data collection.

Vaccine confidence is measured using the Vaccine Confidence Index™ tool (VCI). This short set of survey items was developed by the Vaccine Confidence Project™ to measure confidence in vaccines in general as well as confidence towards specific vaccines. Since 2015, the VCI has been used to map and monitor vaccine confidence around the globe.

Specific vaccines included in the VCI for this study were the measles, mumps, and rubella vaccine (MMR), the human papillomavirus vaccine (HPV), the seasonal influenza vaccine (flu), and the Covid-19 vaccine (COVID-19).

The VCI measures confidence across four dimensions: confidence in the importance of vaccines, confidence in their safety, confidence in the effectiveness of vaccines, and perceived compatibility of vaccines with religious or personal beliefs. A summary of all VCI items presented to the general public in the 6 countries is shown in Fig. 1. Respondents are able to respond to these items on a four-point Likert scale which ranges from "strongly agree" to "strongly disagree". Respondents can also report that they "do not know" or choose not to provide a response.

Using stratified random probability sampling, quotas were set for sex, age band, and sub-national region based off of national census data for each country so that nationally representative samples were obtained. All respondents participating were aged 18 or over. For each individual in the general public sample, additional individual level socio-demographic data was collected on respondents' gender, age, highest level of educational attainment, income, and religion. A target of 1000 responses per country was set. A sample size of $n = 1000$ is widely used in exploratory research. With random and representative selection, this size affords a margin of error of roughly ± 3 % with diminishing returns as sample size increases above $n = 1000$ [20,21]. All surveys were distributed online or by Computer-Assisted Telephone Interviewing (CATI) by ORB International via local panels providers in local languages. Participants were recruited through a variety of means: online portals, e-mails, social media, and other forms of online advertising.

For the analysis, responses to all survey items are grouped from their original four Likert scale categories into two. "Strongly agree" and "tend to agree" responses are recoded to "agree" and all remaining choices, including the "do not know" response or no response, are recoded to "disagree." This method of recoding prevents the loss of missing data and helps facilitate comparisons in vaccine confidence.

Using the binary response variables, levels of vaccine confidence towards vaccines in general and towards MMR, flu, HPV, and Covid-19 vaccine were measured for each of the 6 countries. A measure of overall vaccine confidence was created using the "agree" responses to vaccines in general as important, safe, effective, and compatible with beliefs. Overall vaccine confidence for the 6 countries was calculated using the same methodology employed in the State of Vaccine Confidence in the European Union: 2022 report and used to compare against existing EU-levels of vaccine confidence.

Within each country, bivariate logistic regressions were employed to explore associations between socio-demographic characteristics and vaccine confidence.

Data was collected by ORB International following strict industry standards laid down by the professional bodies they subscribe to, such as the World Association for Public Opinion Research (WAPOR). Ethical approval was received for this study from the University of Antwerp on 20/03/2023 (Project ID: 5265). Participants were informed that their participation was voluntary, and that they could refuse to answer questions during data collection. Verbal or written informed consent was required to take part in the study.

3. Results

A total of 6011 members of the general public were surveyed across the 6 countries between June 2 and July 12, 2023. In Belarus and North

Vaccine confidence survey items	
General vaccine confidence	Vaccines are important for children to have Vaccines are important for all ages to have Vaccines are safe Vaccines are effective Vaccines are compatible with religious, personal, or philosophical beliefs
MMR vaccine confidence	MMR vaccine is important for children MMR vaccine is safe MMR vaccine is effective MMR vaccine is compatible with religious, personal, or philosophical beliefs
Flu vaccine confidence	Flu vaccine is important Flu vaccine is safe Flu vaccine is effective Flu vaccine is compatible with religious, personal, or philosophical beliefs
HPV vaccine confidence	HPV vaccine is important HPV vaccines is safe HPV vaccine is effective HPV vaccine is compatible with religious, personal, or philosophical beliefs
COVID-19 vaccine confidence	COVID-19 vaccines are important COVID-19 vaccines are safe COVID-19 vaccines are effective COVID-19 vaccines are compatible with religious, personal, or philosophical beliefs

Fig. 1. VCI survey items for the general public.

Macedonia age quotas are skewed such that older age groups are underrepresented compared to the population. This is due to challenges reaching older age groups through online methods in both countries. Gender quotas were met. Socio-demographic characteristics of the study population can be seen in Fig. A in the appendix.

3.1. Vaccine confidence in general

Across the 6 countries, the regional average for overall vaccine confidence was 43.7 %. This is lower than the EU average of 49.97 % across the EU-27 member states from the 'State of Vaccine Confidence in the EU: 2022' report.

Across the 6 countries in the study, Kazakhstan had the lowest levels of vaccine confidence among the general public, with only 35.5 % of respondents agreeing that vaccines in general are important, safe, effective, and compatible with their beliefs. Belarus followed with 38 % of respondents agreeing. Bosnia & Herzegovina and Armenia were the middling countries with 42.1 % and 43.62 % agreeing respectively. North Macedonia and Georgia were the most confident countries with

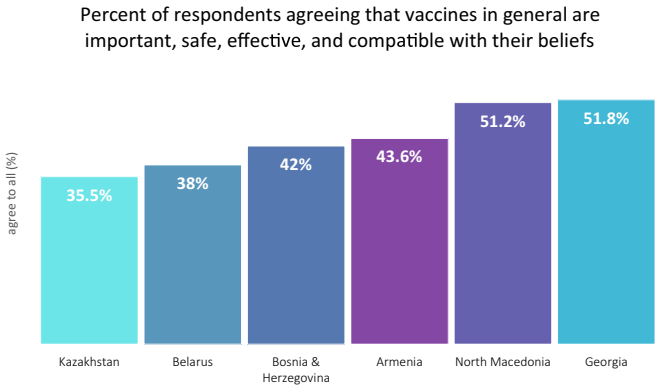

Fig. 2. Bar chart showing the percent of respondents agreeing that vaccines in general are important, safe, effective, and compatible with their beliefs.

51.2 % and 51.8 % of respondents agreeing (Fig. 2).

When fitting the 6-study countries (2023) in to the larger EU-27 member countries' (2022) ranking for comparison, 4 out of the 6 were in the lowest third of countries in terms of confidence. Kazakhstan notably is the third lowest ranking country, just above Latvia, which is the least confident country in the EU with only 29 % of respondents agreeing that vaccines in general are important, safe, effective, and compatible with beliefs, and Slovakia with 31 % [Fig. 3].

3.2. Dimensions of vaccine confidence

Fig. 4 provides a breakdown of the dimensions that make up the overall vaccine confidence measure: confidence in the importance of vaccines–with a breakdown of importance for children and importance for all ages, confidence in their safety, confidence in the effectiveness of vaccines, and compatibility of vaccines with religious or personal beliefs.

North Macedonia and Georgia have high levels of agreement across all dimensions. In North Macedonia, high levels of agreement that vaccines in general are important for children (83 %), important for people of all ages (77 %), and are effective (75.8 %) appear to be positive contributors to confidence, though levels of agreement in the safety (69 %) and compatibility (67.2 %) of vaccines are also high compared to the other study countries. In Georgia, agreement in the importance of vaccines in general for people of all ages (67 %) and safety (65 %) fall below agreement in their importance for children (76 %), their compatibility (71.9 %), and their effectiveness (69.1 %).

In all countries, agreement in the importance of vaccines for children is higher than agreement in the importance of vaccines for people of all ages.

3.3. Vaccine confidence by vaccine type

Additional radar charts for each specific vaccine are included in the appendix (see appendix, Figs. B, C, D, and E). Across all vaccines, compatibility is the highest ranked domain in Armenia. 89 % of respondents agree that the MMR vaccine is compatible with their beliefs, 82 % for flu, 76 % for HPV, and 75 % for Covid-19 vaccine. When looking at overall confidence for MMR by domains, while compatibility is the highest ranked, the other three domains—importance, safety, and effectives—rank close behind. However, there are large gaps between the compatibility domain and the next closest ranked domains for Flu, HPV, and COVID-19. There is a 22 percentage point gap between agreement that the flu vaccine is compatibility and safe, a 20 percentage point gap between agreement that the HPV vaccine is compatible and important, and a 27 percentage point gap in agreement that the Covid-

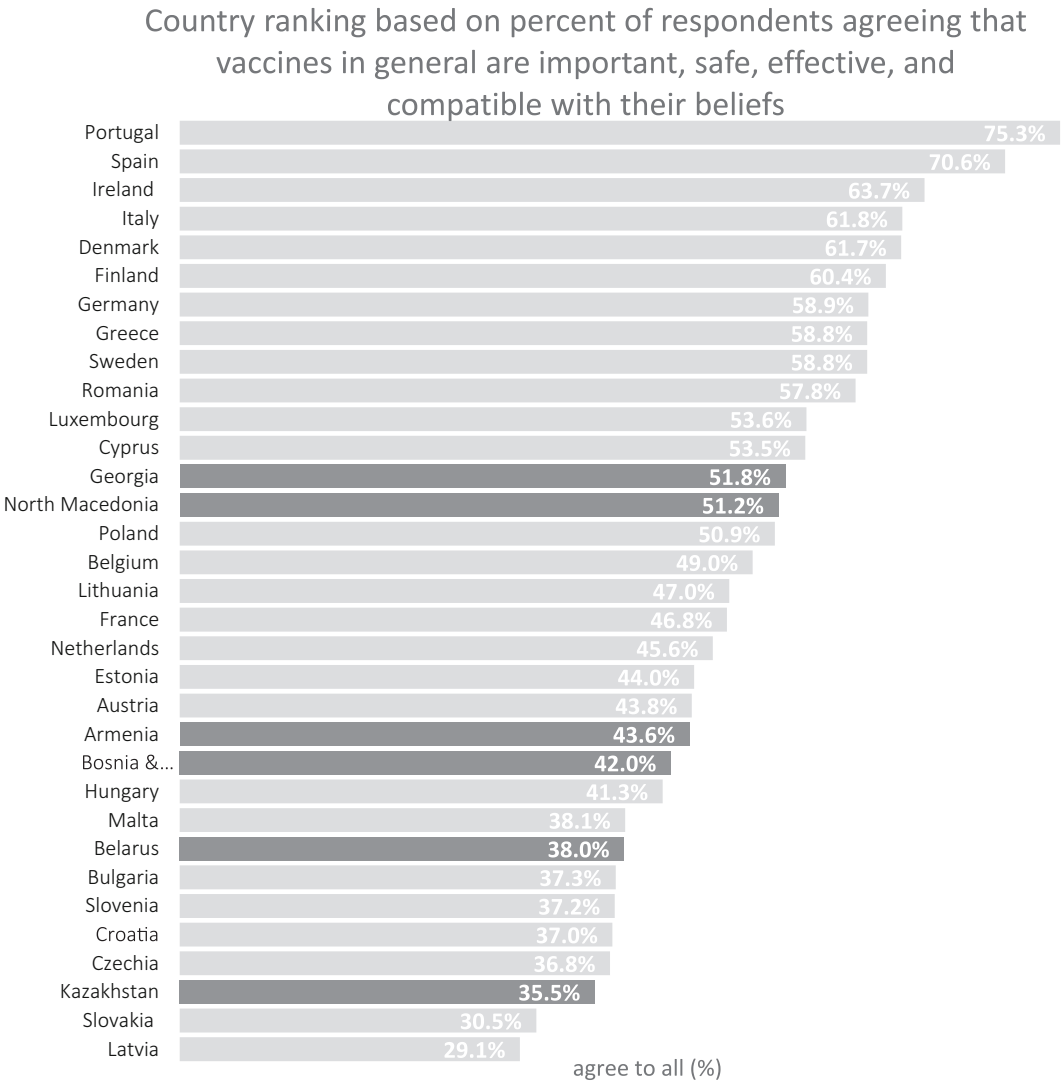

Fig. 3. Bar chart showing the ranking of the EU-27 member states (2022) and the 6 countries in the study (2022) based on percent of respondents agreeing that vaccines in general are important, safe, effective, and compatible with their beliefs.

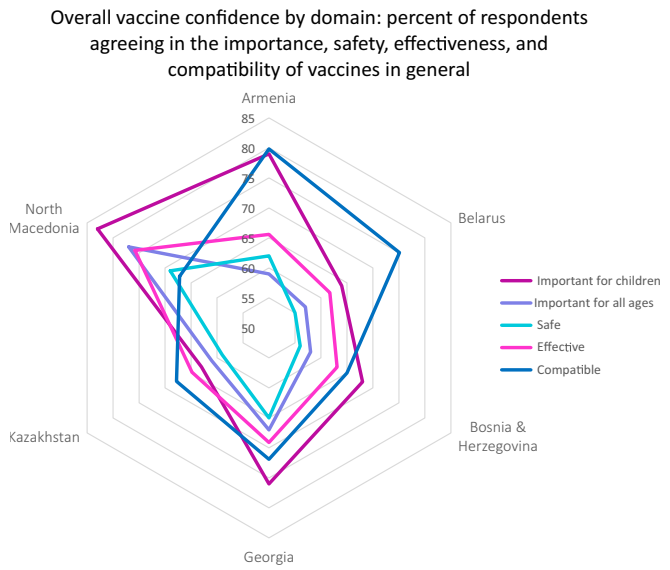

Fig. 4. Radar chart visualizing the domains of vaccine confidence by the percent of respondents agreeing to each domain [important, safe, effective, and compatible].

19 vaccine is compatible and important. The lowest commonly ranked domain in Armenia is agreement that vaccines are effective.

Compatibility also ranked high among respondents in Belarus. Safety and effectiveness are the lowest ranked domains across MMR, HPV, and Covid-19 vaccine, while for flu, agreement in the importance of the vaccine is tied with effectiveness as the lowest rank domain.

Importance is the highest ranked domain for MMR and HPV vaccines in Bosnia & Herzegovina, though all four domains have similar percentages of respondents agreeing. For example, 73 % of respondents in Bosnia & Herzegovina agree that the MMR vaccine is important, followed by 72 % agreeing that the MMR vaccine is effective, 72 % agree that it is compatible, and 71 % agree that it is safe. Agreement in the four domains for HPV and flu are similarly close in rank, though for the flu vaccine, compatibility is the highest ranked domain. Differences in the levels of agreement between compatibility, importance, safety, and effectiveness emerge when we look at overall confidence in the Covid-19 vaccine. While 47 % of respondents in Bosnia & Herzegovina agree that the Covid-19 vaccine is compatible with their beliefs, only 38 % agree that the Covid-19 vaccine is important, 36 % agree that they are safe, and 33 % agree that they are effective.

In Georgia, compatibility with beliefs is the highest ranked domain across vaccines with the exception of the MMR vaccine where compatibility is the lowest ranked domain. Across the flu, COVID-19, HPV vaccines, the lowest levels of agreement are in the safety and effectiveness of the vaccines.

In Kazakhstan, participants had the lowest levels of agreement in the safety of the MMR, HPV, and Covid-19 vaccine while the lowest ranked domain for the flu vaccines was importance.

North Macedonia was unique in that the importance and safety domains ranked high across vaccines. Importance was the highest ranked domain for MMR (78 % of respondents agreed that the MMR vaccine was important) and HPV (69 % of respondents agreed that the MMR vaccine was important) and safety was the highest ranked domain for flu (73 %). Compatibility was the lowest ranked domain for each of these vaccines (MMR, flu, and HPV), though only by a narrow margin. Compatibility was the highest ranked domain for COVID-19, with 51 % of respondents agreeing that the Covid-19 vaccine was compatible with their beliefs while in contrast only 40 % of respondents agreed that the Covid-19 vaccine was effective.

Confidence is highest in the MMR vaccine. This is true in each country, though Armenia (75 %) and Georgia (80 %) stand out as having the highest levels of confidence in the MMR vaccine. In Kazakhstan, while confidence is highest in the MMR vaccine (44 %) compared to other vaccines, it is only by a narrow margin and low levels of confidence appear consistent across all vaccines. Confidence in the Covid-19 vaccine is lowest across vaccines in each country, with the sole standout being Georgia, where confidence in HPV vaccines (30.7 %) is lower than confidence in the Covid-19 vaccine (37.1 %). In the other 5-study countries, confidence levels between HPV vaccines and Flu vaccines fluctuate (Fig. 5).

3.4. Demographic drivers of vaccine confidence

To explore associations between socio-demographic characteristics and vaccine confidence, bivariate logistic regression was employed. Regressions were run for each country and looked at the associations between gender, age, and education with confidence in vaccines in general as well as confidence in MMR, flu, HPV, and Covid-19 vaccine. Tables for each are located in the appendix (Figs. F, G, H, and I). Where the strength of association is less than or equal to $p = 0.05$, the corresponding cell is highlighted. Odds ratios (ORs), confidence intervals and p-values exceeding p = 0.05 are retained in the tables to show trends that emerge within socio-demographic characteristics.

Fig. 6 shows the ORs, confidence intervals and p-values between gender, age, education, and confidence in vaccines in general. Where the strength of association is less than or equal to p = 0.05, the corresponding cell in the table is highlighted.

In Armenia and North Macedonia, women appear more confident in vaccines in general compared to men (OR = 1.48, CI = 1.15–1.91, p = 0.002 and OR = 1.31, CI = 1.02–1.69.84, p = 0.032 respectively). Trends in age can be seen in Belarus, Kazakhstan and North Macedonia. In Belarus, respondents aged 65+ were more confident in vaccines in general than those aged 35–44 (OR = 2.43, CI = 1.18–5.0, $p = 0.015$). In North Macedonia, respondents aged 18–24 (OR = 0.55, CI = 0.36–0.84, $p = 0.006$) and 25–34 (OR = 0.63, CI = 0.45–0.90, $p = 0.012$) were less confident than the baseline group [35–44-year-olds], and while older age groups did not retain low p-values, their ORs show increasing confidence with age compared to the baseline group. Similarly, in Kazakhstan, younger age groups, in this case 18–24-year-olds (OR = 0.66, CI = 0.44–0.99, p = 0.048) are less confident than the baseline group while 55–64-year-olds (OR = 1.91, CI = 1.12–3.23, $p = 0.016$) are more confident than the same baseline group. No associations were retained for age in Armenia or Georgia, and the general age trend whereby older age groups are more confident than younger age groups is lost. When looking at education, respondents with lower levels of education [primary or below] are less confident in vaccines compared to those with secondary education [baseline]. Those with higher levels of education [university] are more confident. This is true across the 6-study countries though strength of association is retained in only Belarus, Kazakhstan, and North Macedonia.

When looking at associations between socio-demographic characteristics and confidence in specific vaccines, different patterns emerge, affirming that vaccine confidence varies across not just places and populations but also between different vaccines.

In Armenia, women continue to drive confidence when it comes to the MMR vaccine (OR = 1.53, CI = 1.15–2.04, p = 0.003) but the strength of association is lost when it comes to HPV and flu vaccines, and is reversed when considering the Covid-19 vaccine. Age plays a role in confidence towards the flu and Covid-19 vaccine, with 25–34-year-olds less confident in flu vaccines than the baseline [35–44-year-olds] (OR = 0.58, CI = 0.40–0.84, p = 0.005) and those aged 65+ being more confident in the Covid-19 vaccine than the baseline age group (OR = 1.89, CI = 1.16–3.08, p = 0.011). In Armenia, those with a university education were less confident in the flu and HPV vaccines compared to those with a secondary education (OR = 0.58, CI = 0.44–0.75, $p = 0.000$ and OR = 0.66, CI = 0.50–0.86, p = 0.036 respectively).

In Belarus, women are less confident than men when it comes to the

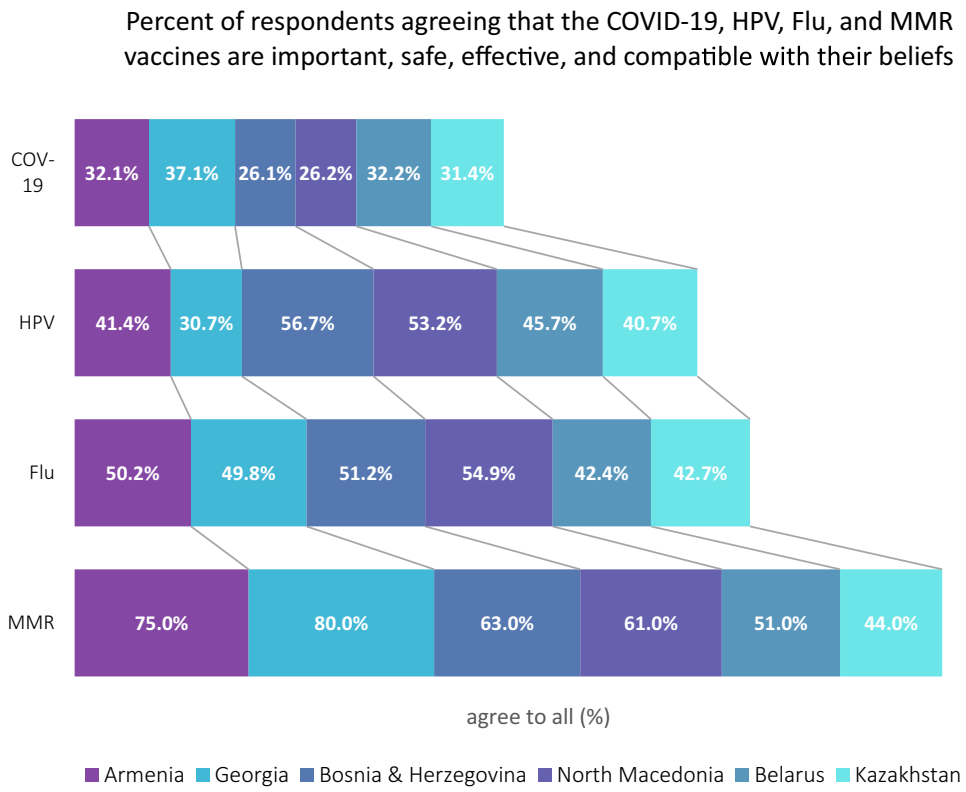

Fig. 5. Bar chart showing the percent of respondents agreeing that specific vaccines [COVID-19, HPV, Flu, and MMR] are important, safe, effective, and compatible.

flu vaccine (OR = 0.59, CI = 0.46–0.77, p = 0.000) and Covid-19 vaccine (OR = 0.51, CI = 0.39–0.67, p = 0.000). Younger age groups [18–24-year-olds and 25–34-year-olds] were less confident in the MMR vaccine compared to 35–34-year-olds (OR = 0.51, CI = 0.32–0.80, p = 0.004 and OR = 0.61, CI = 0.42–0.89, p = 0.011 respectively). Similar age trends are seen across other vaccines in Belarus with the exception of HPV, where, even though the strength of association is not retained, the age trend inverts, younger age groups have higher ORs than older age groups. Respondents from Belarus with a university education were more confident in the MMR vaccine (OR = 1.50, CI = 1.15–1.96, p = 0.002). Education does not appear to play a role in confidence towards flu, HPV, or Covid-19 vaccine.

In Kazakhstan, women were less confident than men in the flu, HPV, and Covid-19 vaccine. 18–24-year-olds were less confident in the MMR vaccine than those aged 35–44 (OR = 0.67, CI = 0.45–0.97, p = 0.038). Education was a big driver of confidence in Kazakhstan. Respondents with a primary education or below were less confidence in the MMR (OR = 0.46, CI = 0.21–0.97, p = 0.042), flu (OR = 0.42, CI = 0.19–0.89, p = 0.024), HPV (OR = 0.41, CI = 0.19–0.89, p = 0.025), and Covid-19 vaccine (OR = 0.36, CI = 0.14–0.89, p = 0.027) compared to their counterparts with a secondary education.

In Bosnia & Herzegovina, 18–24-year-olds (OR = 0.57, CI = 0.39–0.82, p = 0.003) were less confident in the MMR vaccine compared to 35–44-year-olds while 45–54 (OR = 1.87, CI = 1.24–2.81, p = 0.002) and 55–64-year-olds (OR = 2.84, CI = 1.47–5.47, p = 0.002) were more confident. The strength of association between age and confidence was not retained across other vaccines. Those with a university education were more confident in the HPV vaccine (OR = 1.33, CI = 1.03–1.71, p = 0.027) compared to respondents with a secondary education.

The strength of association between gender and confidence was lost when looking at specific vaccines in North Macedonia. Age was a big driver of confidence among respondents in North Macedonia, with confidence increasing with age for confidence in MMR, flu, and Covid-19 vaccine. This can be seen in the number of cells highlighted in the specific vaccine tables across age groups. Education too played a role—respondents with a university education had higher confidence in the MMR (1.40, CI = 1.40–1.83, p = 0.011), flu (OR = 1.31, CI-1.01-1.71, p = 0.037), and HPV (1.42, CI = 1.09, p = 0.008) vaccines.

In Georgia, the country with the lowest levels of confidence in the HPV vaccine, older age groups appear less confident in the vaccine: 55–64-year-olds (OR = 0.56, CI = 0.36–0.88, p = 0.013) and those aged 65+ (OR = 0.33, CI = 0.21–0.52, p = 0.000) were both less likely than those aged 35–44 to agree that the HPV vaccine was important, safe, effective, and compatible with beliefs. However, all other age groups also had ORs less than 1 but the strength of association was not retained. Younger age groups, 18–24-year-olds, were less confident in the MMR vaccine (OR = 0.47, CI = 0.25–0.89, p = 0.021) compared to 35–44-year-olds while those with a university education were more likely to agree that the MMR vaccine was important, safe, effective, and compatible compared to those with a secondary education in Georgia (OR = 1.40, CI = 1.02–1.92, p = 0.033). Women in Georgia were less confident than male respondents in terms of the flu and Covid-19 vaccine.

In five of the six study countries (Belarus, Kazakhstan, Bosnia & Herzegovina, North Macedonia, and Georgia) age was a primary driver of confidence in the MMR vaccine, with lower age groups less likely to agree that the MMR vaccine is important, safe, effective, and compatible with their beliefs.

4. Discussion

The findings of this study shed light on the state of vaccine confidence among the general public in Eastern Europe and Central Asia, regions that have received limited attention in previous vaccine confidence research. The study revealed notable differences in vaccine confidence levels across the six countries examined, and compared to levels of confidence in the EU, highlighting the need for expanded vaccine confidence surveillance across the region.

Across the six countries studied, vaccine confidence levels varied significantly, with Kazakhstan exhibiting the lowest overall confidence

	Armenia	Belarus	Kazakhstan	Bosnia & Herzegovina	North Macedonia	Georgia
Gender						
Male [base]	1	1	1	1	1	1
Female	1.48 (1.15-1.91) p=0.002	.87 (.67-1.12) p=0.300	.88 (.68-1.14) p=.360	1.006 (.78-1.29) p=0.92	1.31 (1.02-1.69) p=0.032	1.2 (.93-1.54) p=0.145
Age						
18-24	1.02 (.63-1.64) p=0.914	.85 (.53-1.37) p=0.518	.66 (.44-.99) p=0.048	.70 (.48-1.02) p=0.067	.55 (.36-.844) p=0.006	.85 (.50-1.44) p=0.557
25-34	1.13 (.78-1.64) p=0.487	.92 (.62-1.36) p=0.708	.78 (.54-1.12) p=0.189	.84 (.58-1.23) p=0.390	.63 (.45-.90) p=0.012	.88 (.57-1.37) p=0.597
35-44 [base]	1	1	1	1	1	1
45-54	1.05 (.71-1.56) p=0.795	1.39 (.95-2.02) p=0.082	1.02 (.68-1.54) p=0.898	1.06 (.73-1.54) p=0.73	1.08 (.76-1.55) p=0.641	.936 (.61-1.42) p=0.760
55-64	1.38 (.92-2.08) p=0.111	1.24 (.83-1.84) p=0.280	1.91 (1.12-3.23) p=0.016	1.37 (.81-2.32) p=0.230	1.18 (.75-1.84) p=0.465	.91 (.59-1.39) p=0.675
65+	1.15 (.71-1.85) p=0.555	2.43 (1.18-5.0) p=0.015	.50 (.15-1.58) p=0.241	.95 (.32-2.84) p=0.933	2.88 (.58-14.12) p=0.192	.90 (.60-1.34) p=0.610
Education						
Primary or below	.81 (.44-1.47) p=0.498	(sample too small)	.41 (.17-.97) p=0.043	.91 (.21-3.87) p=0.906	.98 (.32-3.00) p=0.986	.91 (.20-4.15) p=0.911
Secondary [base]	1	1	1	1	1	1
University	1.03 (.79-1.33) p=0.813	1.53 (1.17-2.02) p=0.002	1.21 (.92-1.60) p=0.159	1.25 (.97-1.61) p=0.083	1.36 (1.05-1.77) p=0.019	1.57 (1.22-2.03) p=0.001
DK/Refused	.42 (.11-1.59) p=0.207	.98 (.56-1.73) p=0.960	.28 (.11-.75) p=0.012	2.03 (.45-9.19) p=0.355	.76 (.12-4.66) p=0.776	1.22 (.17-8.76) p=0.841

Fig. 6. Table showing results of bi-variate logistic regressions exploring the associations between vaccine confidence and gender, age, and education. Highlighted cells denote statistical significance.

and Georgia demonstrating the highest. Vaccine confidence in specific vaccines varied too. While in general, confidence levels were highest in the MMR vaccine across the six countries, and confidence levels in COVID-19 were lowest, Georgia stands out as the sole country where confidence levels were higher in the Covid-19 vaccine than HPV. While there is little research exploring attitudes towards the HPV vaccine in Georgia, WHO original research around new vaccine introduction highlights misinformation and rumours around infertility, concerns for vaccine safety, and suspicions of children in Georgia being used as test subjects in their illustrative quotes from focus group and in-depth individual interviews [14]. These variations—between countries, specific vaccines, and the domains that shape vaccine confidence—underscore the importance of considering country-specific factors that influence public attitudes towards vaccination. While factors such as historical vaccine coverage rates, healthcare infrastructure, and political contexts may contribute to these differences, further research is needed to explore the underlying drivers of vaccine confidence in each country and how levels change over time.

In all countries, agreement in the importance of vaccines for children is higher than agreement in the importance of vaccines for people of all ages. It is interesting to note that Armenia, which ranked in the middle of the 6 countries in terms of overall vaccine confidence, has the second highest level of agreement that vaccines are important for children and the highest levels of compatibility with beliefs. A large gap of nearly 13 percentage points separates agreement in importance of vaccines for children (79 %) and agreement in the effectiveness of vaccines in general (65.6 %); suggesting that low vaccine confidence may be driven by lack of confidence in the safety and effectiveness of vaccines and low-levels of agreement in the importance of vaccines for adults compared to children. In Georgia, agreement in the importance of vaccines in general for people of all ages as well as safety ranked below agreement in their importance for children, their compatibility, and their effectiveness—suggesting areas for improvement in Georgia could be to bolster promotion of the importance of vaccines for people of all ages, not just children, and to focus communication efforts around the safety of vaccines for the general public. In Kazakhstan, the need for improvement in

each domain is evident, with an emphasis on increasing perceived importance (63 % of respondents agree that vaccines in general are important for children and 61 % agree that vaccines in general are important for all ages) and safety (59 %) of vaccines to increase vaccine confidence in the general public.

Low-levels of agreement in the safety of the MMR vaccine could be a holdover of the long lingering autism rumour first spurred by Andrew Wakefield's Lancet article [22]. Though later retracted, the article has continued to fuel skepticism in Europe and across the globe, and continues to have long-term implications, threating MMR coverage rates in many countries, leading to increases in measles outbreaks [23,24]. MMR coverage rates are high in Belarus, toggling between 97 and 98 % according to the most recent WHO and UNICEF surveillance data [16]. Continuing to map and monitor vaccine confidence in the country could help detect early warning signs that might threaten MMR uptake, especially if concerns grow around safety of the vaccine.

The study explored several socio-demographic factors associated with vaccine confidence, including gender, age, and education. Gender played a role in confidence though varied across the study countries and between specific vaccines—both validating and challenging previous research highlighting gender differences in health seeking behavior during the Covid-19 pandemic [25–27]. Where women were less confident in specific vaccines, namely the Covid-19 vaccine, this aligned with previous research in the EU-27 into gender-based determinants of vaccination during the pandemic which identified women as being more hesitant towards the Covid-19 vaccine, expressing lower levels of intent to receive a vaccine [28]. This trend eased over time, with women becoming more confident in the Covid-19 vaccine, even outperforming men as COVID-19 vaccine coverage rates were reported later in the pandemic [29].

Age emerged as a significant predictor of vaccine confidence, with older age groups, in general, displaying higher levels of confidence than younger age groups in most countries. While not all *p*-values are retained for each age group and confidence intervals cross over 1, the presence of this trend as seen in the ORs aligns with recent research revealing trends that indicate widening age gap in vaccine confidence, with younger populations exhibiting increased hesitancy [4,30,31]. This is a particularly concerning trend when considering these age groups contain the majority of childbearing years, and are the next cohort of parents or soon to be parents, responsible for making decisions around routine immunization for their children, including the decision to vaccinate against MMR. Education also played a role, with higher levels of education associated with greater vaccine confidence in some countries. However, in Armenia, higher education was identified as a potential barrier to vaccine confidence; those with a university education were less confidence in the flu and HPV vaccines compared to those with a secondary education. Still, the relationship between education and confidence varied across different vaccines and between different countries, highlighting the nuanced dynamics of vaccine confidence and warranting further investigation.

5. Limitations

A key limitation of this study is the underrepresentation of older age groups in Belarus and North Macedonia. Although quotas were established for both gender and age, challenges inherent to online recruitment restricted participation from older populations. As a result, the findings may be less representative of, and less generalizable to, the broader public in these two countries. Similarly, small sample sizes of university educated respondents in the bi-variate regression for the flu vaccine requires caution when interpreting results and undermines generalizability.

6. Conclusion

The observed differences in vaccine confidence underscore the importance of expanding vaccine confidence surveillance in Europe beyond the EU-27 member states to include the broader European region—aiding in the identification and understanding of the unique challenges within countries as well as to paint a more representative picture of vaccine confidence in the region as a whole.

By identifying country-specific factors influencing vaccine confidence, we can better understand and address vaccine confidence as a critical determinant of vaccine uptake. While this study contributed to the foundation of extending routine mapping and monitoring of vaccine confidence beyond the EU countries, additional research dedicated to routine surveillance of vaccine confidence is needed to understand levels and trends over time, and to provide contextual insights for countries where confidence is low. Extending vaccine confidence research into countries where little evidence is available to date, and sustaining research efforts over time can help inform and empower policy makers, health systems, and healthcare professionals to better design effective vaccination campaigns, communication strategies, and interventions to increase uptake during the rollout of new vaccines or improve or sustain coverage rates under national immunization programs.

CRediT authorship contribution statement

Rachel L. Eagan: Writing – original draft, Visualization, Formal analysis. **Toni Claessens:** Writing – review & editing. **Greet Hendrickx:** Writing – review & editing. **Heidi J. Larson:** Writing – review & editing. **Emilie Karafillakis:** Writing – review & editing, Funding acquisition, Conceptualization.

Funding

The authors disclose receipt of the following financial support for the research, authorship, and/or publication of this article: this project was funded by MSD.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The Vaccine Confidence Project (RLE, HJL, and EK) has received research funding from GSK, Merck and J&J.

Appendix A. Appendices

	Armenia (n=1,011)	Belarus (n=1,000)	Kazakhstan (n=1,000)	North Macedonia (n=1,000)	Bosnia & Herzegovina (n=1,000)	Georgia (n=1,000)
Sex						
Men	42.8	45.5	49.0	44.4	48.8	47.2
Women	57.2	54.4	49.5	55.0	51.0	52.8
Other	0	0.1	1.5	0.6	0.2	0.0
Age group						
18-24	10.0	11.3	22.0	14.1	23.3	8.6
25-34	23.5	20.5	29.0	24.7	22.5	15.7
35-44	22.9	24.9	22.1	26.8	22.5	16.7
45-54	17.8	21.5	17.6	22.3	22.8	17.8
55-64	15.9	18.3	7.6	11.2	7.5	18.2
65+	9.8	3.5	1.7	0.9	1.4	23.0
Muslim	0.1	0.0	35.8	5.2	47.7	5.8
Jewish	0.0	0.2	1.0	0.1	0.0	0.1
Other religion	88.6	0.9	2.0	1.4	1.2	71.2
Agnostic/Atheist	2.8	10.5	11.4	4.9	6.2	0.6
DK/Refused	4.5	3.7	9.2	18.5	6.5	0.5
Roman Catholic	0.5	7.8	4.9	3.3	6.8	0.9
Protestant	0.6	1.5	1.7	1.0	0.2	0.1
Russian/Eastern Orthodox	1.1	74.6	29.9	45.3	27.7	19.0
Other	1.9	0.8	4.1	20.3	3.7	1.8
Muslim	0.1	0.0	35.8	5.2	47.7	5.8
Jewish	0.0	0.2	1.0	0.1	0.0	0.1
Other religion	88.6	0.9	2.0	1.4	1.2	71.2
Agnostic/Atheist	2.8	10.5	11.4	4.9	6.2	0.6
DK/Refused	4.5	3.7	9.2	18.5	6.5	0.5

Fig. A. Socio-demographic characteristics of the study population.

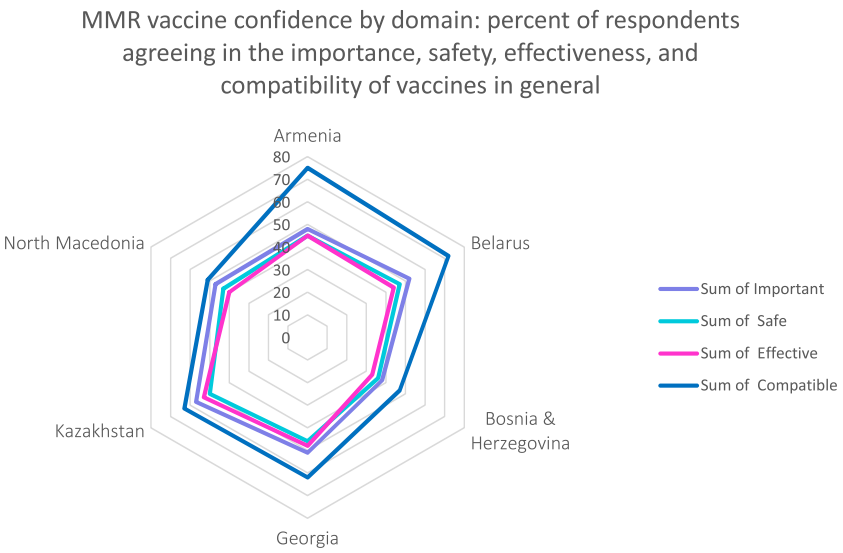

Fig. B. MMR vaccine confidence by domain.

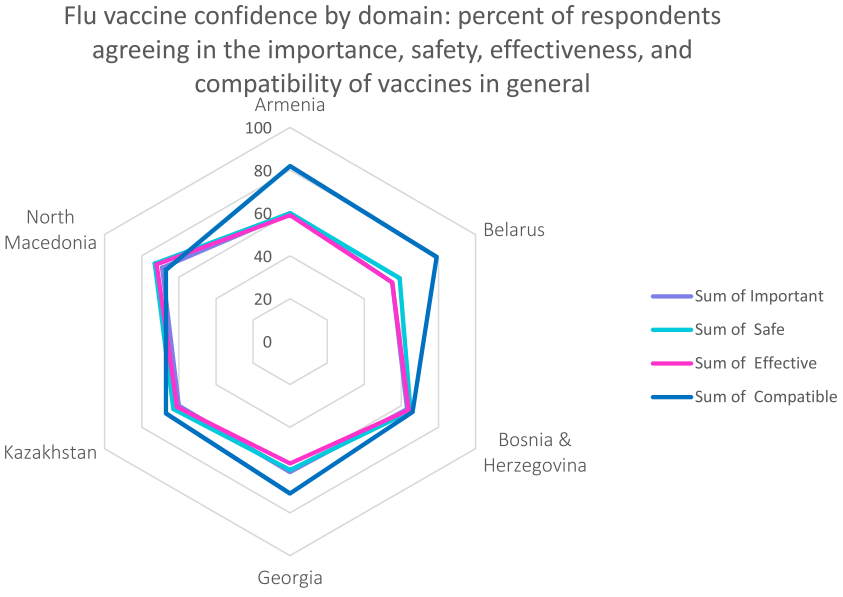

Fig. C. Flu vaccine confidence by domain.

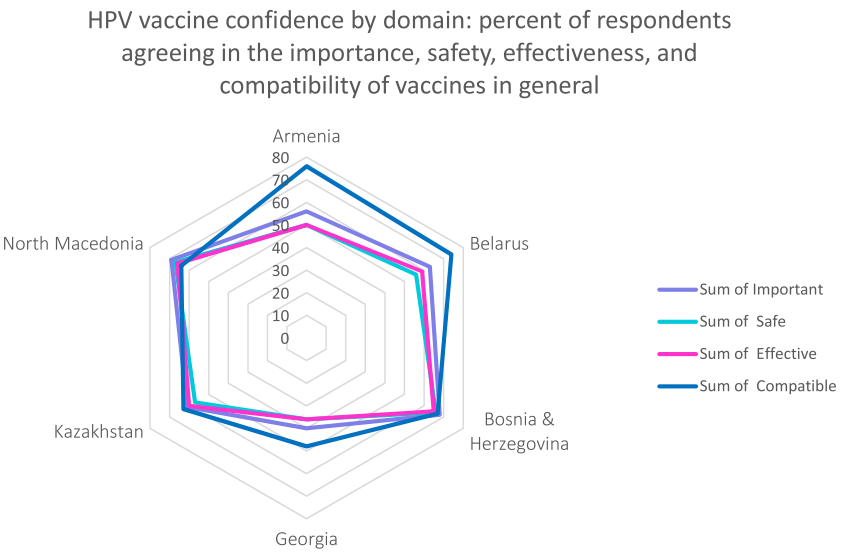

Fig. D. HPV vaccine confidence by domain.

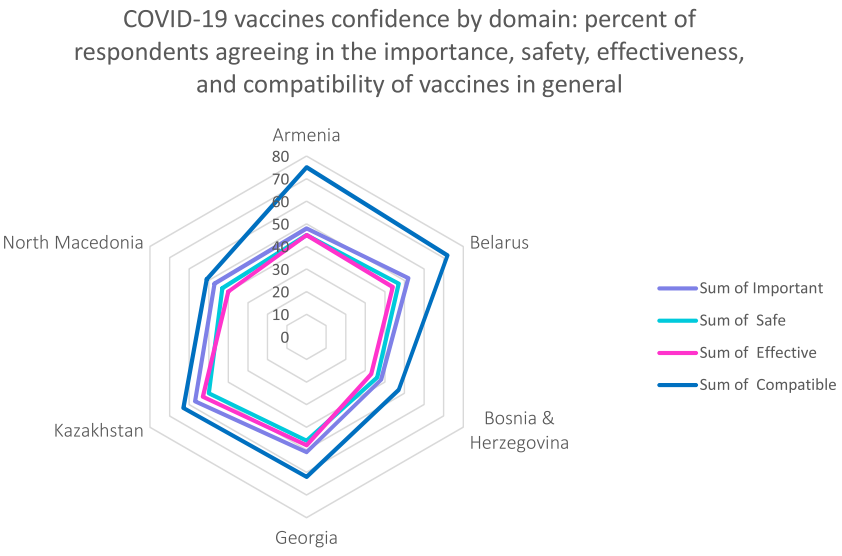

Fig. E. COVID-19 vaccine confidence by domain.

	Armenia	Belarus	Kazakhstan	Bosnia & Herzegovina	North Macedonia	Georgia
Gender						
Male [base]	1	1	1	1	1	1
Female	1.53 (1.15-2.04) p=0.003	1.08 (.84-1.39) p=0.502	.86 (.66-1.10) p=0.243	1.09 (.84-1.41) p=0.504	1.12 (.87-1.45) p=0.368	1.33 (.98-1.82) p=0.066
Age						
18-24	.67 (.40-1.11) p=0.125	.51 (3.2-.80) p=0.004	.67 (.45-.97) p=0.038	.57 (.39-.82) p=0.003	.58 (.38-.87) p=0.010	.47 (.25-.89) p=0.021
25-34	1.01 (.66-1.53) p=0.956	.61 (.42-.89) p=0.011	.77 (.54-1.10) p=0.16	.80 (.54-1.16) p=0.248	.68 (.48-.96) p=0.033	.59 (.34-1.04) p=0.071
35-44 [base]	1	1	1	1	1	1
45-54	1.27 (.80-2.02) p=0.306	1.03 (.71-1.49) p=0.853	.96 (.65-1.43) p=0.872	1.87 (1.24-2.81) p=0.002	1.36 (.93-1.98) p=0.104	.90 (.51-1.61) p=0.746
55-64	1.27 (.78-2.05) p=0.323	.84 (.57-1.49) p=0.404	1.14 (.67-1.92) p=0.614	2.84 (1.47-5.47) p=0.002	1.70 (1.05-2.77) p=0.031	.97 (.51-1.73) p=0.925
65+	1.00 (.58-1.73) p=0.973	1.75 (.82-3.73) p=0.145	.75 (.27-2.06) p=0.590	.79 (.26-2.36) p=0.680	4.99 (.61-40.51) p=0.132	.57 (.34-.95) p=0.034
Education						
Primary or below	.46 (.25-.85) p=0.013	(sample too small)	.46 (.21-.97) p=0.042	.66 (.16-2.68) p=0.566	.93 (.30-2.86) p=0.905	.40 (.08-1.85) p=0.245
Secondary [base]	1	1	1	1	1	1
University	.87 (.64-1.18) p=0.399	1.50 (1.15-1.96) p=0.002	1.18 (.90-1.53) p=0.219	1.27 (.98-1.65) p=0.066	1.40 (1.07-1.83) p=0.011	1.40 (1.02-1.92) p=0.033
DK/Refused	.29 (.09-.92) p=0.037	1.09 (.64-1.85) p=0.73	.61 (.30-1.25) p=0.184	3.98 (.47-33.35) p=0.202	.53 (.08-3.23) p=0.495	.91 (.09-8.91) p=0.940

Fig. F. MMR vaccine confidence regressions.

	Armenia	Belarus	Kazakhstan	Bosnia & Herzegovina	North Macedonia	Georgia
Gender						
Male [base]	1	1	1	1	1	1
Female	1.19 (.92-1.53) p=0.178	1.00 (.78-1.28) p=0.985	.73 (.57-.95) p=0.020	1.13 (.88-1.45) p=0.321	.97 (.75-1.24) p=0.827	1.20 (.92-1.58) p=0.174
Age						
18-24	1.38 (.86-2.21) p=0.176	1.20 (.77-1.88) p=0.403	.77 (.53-1.13) p=0.191	.70 (.49-1.02) p=0.069	.68 (.45-1.02) p=0.068	.72 (.41-1.24) p=0.240
25-34	.83 (.57-1.20) p=0.329	.91 (.63-1.32) p=0.640	.73 (.51-1.05) p=0.096	.89 (.61-1.30) p=0.567	.97 (.69-1.38) p=0.903	.80 (.51-1.26) p=0.345
35-44 [base]	1	1	1	1	1	1
45-54	1.17 (.79-1.74) p=0.424	.90 (.62-1.30) p=0.605	.83 (.56-1.25) p=0.386	1.04 (.71-1.51) p=0.832	.82 (.57-1.17) p=0.276	.85 (.55-1.32) p=0.492
55-64	1.10 (.73-1.65) p=0.643	.87 (.59-1.27) p=0.481	.97 (.58-1.65) p=0.938	1.16 (.67-1.98) p=0.586	1.10 (.70-1.72) p=0.662	.56 (.36-.88) p=0.013
65+	1.03 (.64-1.67) p=0.879	1.21 (.59-2.46) p=0.591	.50 (.17-1.47) p=0.212	.38 (.12-1.18) p=0.096	.63 (.16-2.43) p=0.511	.33 (.21-.52) p=0.000
Education						
Primary or below	1.76 (.97-3.20) p=0.060	.27 (.03-2.33) p=0.235	.41 (.19-.89) p=0.025	.28 (.05-1.43) p=0.128	.93 (.30-2.08) p=0.908	1.00 (.19-5.24) p=0.998
Secondary [base]	1	1	1	1	1	1
University	.66 (.50-.86) p=0.002	1.24 (.95-1.62) p=0.104	1.00 (.76-1.30) p=0.987	1.33 (1.03-1.71) p=0.027	1.42 (1.09-1.84) p=0.008	1.17 (.89-1.55) p=0.248
DK/Refused	.11 (.01-.86) p=0.036	1.23 (.72-2.09) p=0.437	.49 (.23-1.04) p=0.065	1.14 (.25-5.16) p=.860	.72 (.12-4.41) p=.730	2.5 (.34-17.99) p=0.362

Fig. G. Flu vaccine confidence regressions.

	Armenia	Belarus	Kazakhstan	Bosnia & Herzegovina	North Macedonia	Georgia
Gender						
Male [base]	1	1	1	1	1	1
Female	1.06 (.83-1.37) p=0.599	.59 (.46-.77) p=0.000	.70 (.54-.90) p=0.007	.93 (.73-1.19) p=0.601	1.01 (.78-1.30) p=0.909	.77 (.60-.99) p=0.044
Age						
18-24	1.50 (.93-2..43) p=0.090	1.17 (.75-1.85) p=0.472	.85 (.58-1.24) p=0.410	1.27 (.88-1.84) p=0.190	.66 (.44-1.00) p=0.051	.83 (.49-1.40) p=0.498
25-34	.58 (.40-.84) p=0.005	.85 (.58-1.85) p=0.412	.85 (.60-1.22) p=0.394	1.11 (.76-1.61) p=0.571	.72 (.51-1.03) p=0.074	.74 (.48-1.15) p=0.186
35-44 [base]	1	1	1	1	1	1
45-54	1.13 (.76-1.67) p=0.525	1.17 (.81-1.70) p=0.395	.91 (.61-1.36) p=0.663	1.33 (.92-1.93) p=0.122	1.26 (.88-1.81) p=0.205	.68 (.44-1.04) p=0.077
55-64	.96 (.76-1.67) p=0.848	1.49 (1.01-2.19) p=0.042	1.29 (.77-1.36) p=0.326	1.53 (.90-2.60) p=0.111	2.24 (1.38-3.64) p=0.001	.89 (.58-1.35) p=.595
65+	1.23 (.77-1.98) p=0.379	2.31 (1.12-4.75) p=0.023	.51 (.17-1.50) p=0.225	1.14 (.38-3.36) p=0.809	1.64 (.40-6.72) p=0.487	.84 (.56-1.26) p=0.425
Education						
Primary or below	1.26 (.69-2.30) p=0.440	.73 (.13-4.08) p=0.728	.42 (.19-.89) p=0.24	.33 (.06-1.68) p=0.185	1.56 (.50-4.87) p=0.440	.45 (.08-2.34) p=0.344
Secondary [base]	1	1	1	1	1	1
University	.58 (.44-.75) p=0.000 (caution)	1.17 (.90-1.53) p=0.233	.92 (.71-1.20) p=0.580	1.16 (.90-1.50) p=0.225	1.31 (1.01-1.71) p=0.037	1.21 (.93-1.56) p=0.141
DK/Refused	.26 (.07-.99) p=0.050	.92 (.90-1.58) p=0.772	.56 (.27-1.15) p=0.116	.75 (.16-3.42) p=0.719	.65 (.10-3.94) p=0.642	1.12 (.15-8.07) p=0.906

Fig. H. HPV vaccine confidence regressions.

	Armenia	Belarus	Kazakhstan	Bosnia & Herzegovina	North Macedonia	Georgia
Gender						
Male [base]	1	1	1	1	1	1
Female	.89 (.68-1.16) p=0.396	.51 (.39-.67) p=0.000	.76 (.58-1.00) p=0.050	.89 (.61-1.08) p=0.155	.79 (.59-1.05) p=0.115	.77 (.59-1.00) p=0.051
Age						
18-24	1.54 (.94-2.53) p=0.081	1.42 (.89-2.27) p=0.137	.90 (.60-1.35) p=0.634	.95 (.61-1.47) p=0.839	.82 (.49-1.35) p=0.448	1.29 (.75-2.22) p=0.345
25-34	.88 (.59-1.32) p=0.560	.74 (.49-1.13) p=0.174	.95 (.65-1.38) p=0.799	1.20 (.78-1.85) p=0.383	.86 (.56-1.31) p=0.496	.98 (.61-1.55) p=0.937
35-44 [base]	1	1	1	1	1	1
45-54	1.02 (.66-1.57) p=0.900	1.14 (.77-1.69) p=0.502	.64 (.41-1.00) p=0.050	1.38 (.90-2.10) p=.130	1.48 (.99-2.22) p=0.052	.88 (.56-1.39) p=0.601
55-64	1.42 (.92-2.18) p=0.105	1.27 (.85-1.91) p=0.237	1.36 (.80-2.33) p=0.251	1.66 (.93-2.94) p=0.081	2.40 (1.50-3.84) p=0.000	1.32 (.85-2.055) p=0.204
65+	1.89 (1.16-3.08) p=0.011	2.45 (1.20-5.02) p=0.014	.42 (.11-1.25) p=.0190	1.84 (.59-5.75) p=0.289	4.15 (1.08-15.94) p=0.038	1.55 (1.02-2.34) p=0.037
Education						
Primary or below	1.48 (.82-2.67) p=0.189	(sample too small)	.36 (.14-.89) p=0.027	.43 (.05-3.59) p=0.442	1.08 (.32-3.60) p=0.891	.31 (.03-2.66) p=0.290
Secondary [base]	1	1	1	1	1	1
University	.83 (.63-1.10) p=0.205	.86 (.65-1.14) p=0.304	.95 (.72-1.26) p=0.746)	.18 (.89-1.58) p=0.235	.78 (.58-1.05) p=0.11	1.21 (.93-1.58) p=0.148
DK/Refused	(sample too small)	.66 (.36-1.20) p=0.177	.37 (.15-.92) p=0.032	2.3 (.50-10.41) p=0.279	1.63 (.26-9.90) p=0.595	1.90 (.26-13.66) p=0.522

Fig. I. COVID-19 vaccine confidence regressions.

Data availability

Data will be made available on request.

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