

The role of health systems in shaping vaccine decisions: Insights from Italy, Mexico, the United Kingdom, and the United States

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ABSTRACT

Background: The demographic drivers of vaccine uptake and confidence have been well-documented in diverse contexts. However, the role of health systems in improving vaccine uptake and confidence has been less discussed particularly in the post-pandemic period.

Methods: Using nationally representative surveys of adults conducted between December 2022 and April 2023 in Italy, Mexico, the United Kingdom (UK), and the United States (US), we examined demographic, health, and health system determinants of vaccine confidence and uptake of four vaccines for adult respondents or their children: COVID-19, influenza, human papillomavirus (HPV), and measles, mumps, and rubella (MMR). Logistic and linear regression models explored associations between predictors of interest and vaccine outcomes, with coefficients reported on the risk difference and risk ratio scales.

Findings: A total of 5180 respondents were surveyed, one-third of whom had at least one child aged 1–18 years. Having received at least three other preventive health services in the last year was associated with COVID-19 and Flu vaccination in all countries (Risk ratio (RR) 1.04–1.54) and with vaccine confidence in the US (RR 1.10). Having at least three health care visits in the last year and having a regular health provider were also associated with a higher likelihood of vaccine uptake and confidence in some countries. Being confident in one's ability to obtain and afford quality care (i.e. "health security") had a positive association with at least one outcome in all countries except Mexico (RR 1.07–1.36) and with children COVID vaccination in multi-country regression. Having a regular provider was associated with a higher probability of HPV vaccination for children. Health system engagement and health security showed stronger associations with Flu than COVID-19 vaccination and with vaccine uptake compared to vaccine confidence, although these associations varied across countries. Trust in scientists and trusting the national public health agency were also strongly correlated with several vaccine outcomes.

Interpretation: Our findings highlight the links between health system engagement, health security, and vaccination rates. Health system engagement may be particularly important to mitigate barriers to vaccination related to 'complacency' and 'convenience'.

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1. Background

Vaccines are an essential public health tool, protecting individuals against diseases and reducing transmission within communities through herd immunity (1). However, the potential benefits of vaccines are reduced by the increasing problem of vaccine hesitancy, defined by the World Health Organization (WHO) as the “delay in acceptance or refusal of vaccines despite the availability of vaccination services” (1). More recently, vaccine hesitancy has also been described as “a state of indecisiveness regarding vaccination decision,” encompassing cognitive and emotional responses, behavioral patterns, and decision-making dimensions (2). Recognized by the World Health Organization as one of the top ten threats to global health in 2019, vaccine hesitancy presents a critical barrier to maximizing coverage (3).

In 2012, the WHO’s Strategic Advisory Group of Experts on Immunization (SAGE) introduced the **3C model of Vaccine Hesitancy**, identifying three interrelated drivers: “**confidence**”, “**complacency**”, and “**convenience**” (1,4). Vaccine confidence reflects trust in the safety and effectiveness of vaccines, while complacency and convenience respectively relate to perceptions on the importance of vaccines and the ease of accessing vaccines. The **Vaccine Confidence Index (VCI)**, developed by Larson and colleagues in 2015, remains the only validated tool for assessing vaccine confidence globally. In 2015, Larson and colleagues published estimates of VCI for multiple countries, repeated in 2019 by Figueiredo and colleagues. (5,6) The two studies painted an inconsistent picture, with increases in vaccine confidence in some countries and decreases in others, indicating a diverse and dynamic global landscape (6).

In the COVID-19 era, public trust in vaccines has been increasingly strained due to politicization of vaccines and subsequent generation and spread of disinformation, leading to declining confidence in scientific expertise and public health authorities and increasing support for alternative health beliefs (7–9). These phenomena have been particularly pronounced in some high-income countries, where disinformation has gained widespread traction (4,10). At the same time, it has been documented that the pandemic caused severe disruptions to routine immunization services (11,12). For example, between 2019 and 2021, it is estimated that 67 million children missed out entirely or partially on routine vaccination (12). As public risk perception of COVID-19 declined during the later stages of the pandemic, COVID-19 vaccine uptake may have also been impacted. In light of these shifts, there is a pressing need to generate updated evidence on vaccine hesitancy that reflects the current landscape—one shaped by vaccine politicization, misinformation, disruptions in routine immunization, and changing perceptions of COVID-19 risk. A 2014 systematic review highlighted the nuanced nature of vaccine hesitancy, showing that some individuals may accept certain vaccines while refusing others, demonstrating how hesitancy can be vaccine-specific (5). Nonetheless, few studies have compared hesitancy and uptake of different vaccines. One that did, found a strong association between prior flu vaccination and increased likelihood of receiving the COVID-19 vaccine, while another noted an increase in routine childhood vaccination confidence during the COVID-19 pandemic (13,14). Parental hesitancy may differ with respect to adult and childhood vaccines, although these differences may vary with context (15,16).

The demographic drivers of vaccine confidence and uptake have been well-documented in diverse contexts, with factors such as education, age, occupation, gender, and income being associated with vaccine acceptance, although the relationship may vary across space, time, and vaccine (6,13,17,18). Experiences within the healthcare system may also influence uptake and shape general perceptions of vaccine importance and safety. Previously studied determinants of vaccine confidence include trust in the health care system, in government bodies and public health agencies, and in other members of one’s community (10,13,17,18). Few studies have investigated the contributions of the health care system in addressing vaccine hesitancy (19,20). Health care

accessibility, frequency of use, and quality could have an important role in improving vaccine uptake and confidence. Improved accessibility to health care services could improve access to vaccines and information about vaccines and address the “convenience” barriers to vaccine uptake. Similarly, more frequent interactions with high-quality health care may contribute to higher vaccination rates, as more frequent and positive healthcare experiences can increase patient trust in health interventions. Perceptions of high-quality care and frequent exposure to quality person-centered care may also improve confidence and acceptability of health care interventions (20–22). For example, some research found that those who rely on the health system for health information have higher vaccine uptake than those relying on other sources (23). High-quality health care may also reduce “complacency” and increase “convenience” by improving health literacy, encouraging people to seek vaccines, or facilitate vaccine provision. These mechanisms may be influenced by country-specific health system characteristics, such as single and multi-payer systems and whether the country provides universal health coverage. In a recent study, we showed that trust in healthcare systems and more frequent health care visits were associated with higher odds of COVID-19 vaccination, even after accounting for demographic and health factors (20). However, whether these associations hold across different vaccine and healthcare contexts, particularly in the post-pandemic era, remains less clear.

To address this evidence gap, our study compares the demographic, health, and health system factors influencing vaccine confidence and uptake of four vaccines: COVID-19, influenza, human papillomavirus (HPV), and measles, mumps, and rubella (MMR).

2. Methods

2.1. Data source and sampling

Our analysis uses data from the People’s Voice Survey (PVS), a population-representative phone survey on people’s perspectives on and utilization of their health system. The PVS, developed by the QuEST network (based in the US with members in 14 countries), has been validated in several countries (24). The PVS collects detailed demographic information and data on people’s health status, health care utilization patterns, user experience, and overall confidence and trust in the health system. (24)To date, the PVS has been implemented in 18 low-, middle-, and high-income countries. In four countries (Italy, Mexico, the US and the UK), the PVS included a vaccine module used in the present study. These countries were selected due to their diverse health system structures, varying levels of healthcare funding and vaccination coverage, and the significant impacts experienced during the COVID-19 pandemic, evidenced by some of the highest mortality rates globally (**supplemental materials**). Additionally, all four are federal states or countries with decentralized health systems with considerable sub-national variation in poverty rates and socioeconomic status. In Italy and Mexico, survey respondents were sampled using random digit dialing. In the UK and the US, respondents were selected from existing panels. Surveys were conducted between December 2022 and April 2023 among adults (aged 18 and older). The final samples were weighted based on demographic characteristics to represent each country’s adult population. Surveyed adults who had at least one child between the ages of 1 to 18 were asked to report on their children’s vaccination status. In all four countries, sampling was stratified by state or region group created based on median household income in the state or region to ensure sufficient sample size at sub-national levels (**supplemental materials**).

3. Measures

3.1. Vaccine confidence and uptake

Outcomes of interest included uptake of adult vaccinations (for the

respondents themselves), child vaccinations (for the respondents' children) and vaccine confidence. Adult vaccinations included influenza vaccination in the last year (yes/no) and COVID-19 vaccination (number of doses received at the time of the survey ranging from zero to four or more doses). Respondents with children between the ages of 1 and 18 years were also asked to report the vaccination status of any children in defined age ranges: MMR vaccination for the youngest child aged 2 to 6, at least one dose of a COVID-19 vaccine for the youngest child aged 1 to 18, and HPV vaccination for the youngest child aged 13 to 18. In Mexico, the HPV vaccine was only assessed among girls reflecting national vaccine guidelines (25). These age groups were chosen to allow for consistency across countries given differences in national vaccination schedules and to ensure more accurate recall by the parents depending on their children's age. In all four countries, the first dose of MMR vaccine is recommended around one year of age and the second at age 6 (26–29). The first dose of the HPV vaccine is recommended for all children from the age of 11 in Italy, 11 or 12 in the USA, 12–13 in the UK, and for girls aged 11 in Mexico (26–29). Country-specific recommendations for COVID vaccination for children varied and were somewhat unclear at the time of the survey but were generally recommended for all children starting at the age of 6 months (30).

We included two measures of vaccine confidence. The first was derived from the vaccine confidence index proposed by Larson and colleagues (5). Respondents were categorized as “vaccine confident” if they strongly or somewhat agreed with each of the following three statements about vaccines in general: “vaccines are important for my health”, “vaccines are safe”, and “vaccines are effective”. Those who somewhat or strongly agreed with each of the three above statements were categorized as “vaccine confident”. Finally, we included an indicator for COVID-19 vaccine intention based on whether respondents

reported that they were planning to receive all recommended doses of a COVID-19 vaccine in the future once they were available to them (yes/no). These two survey questions were asked to all respondents.

3.2. Health system engagement and health security

We hypothesized that more frequent and better-quality health care could improve vaccine uptake and confidence. We included three measures of health system engagement: health care use in the last year (no visit, 1–2 visits, 3 or more visits), whether the respondent had a regular provider or usual source of care, and whether they had received at least three other preventive health care services in the last year (blood pressure, cholesterol, or blood glucose checks, and dental, or eye exam). Given the evidence that greater confidence and trust in the health system could reduce vaccine hesitancy, we included a measure of health security defined as the respondent's level of confidence in their ability to get and afford quality care if they became very sick. Those who reported being “very” or “somewhat” confident in their ability to get and afford quality care were categorized as confident (compared to “not too” or “not at all” confident) (31). The potential mechanisms linking these constructs to better vaccine uptake and confidence are illustrated in Fig. 1.

3.3. Demographic and health-related characteristics

Our analyses included a series of demographic and health-related characteristics that may influence vaccine uptake and confidence. These were: the respondent's age, education, income, gender, whether they had a chronic illness or longstanding health problem, and whether they had a history of COVID-19 illness. We included an indicator for

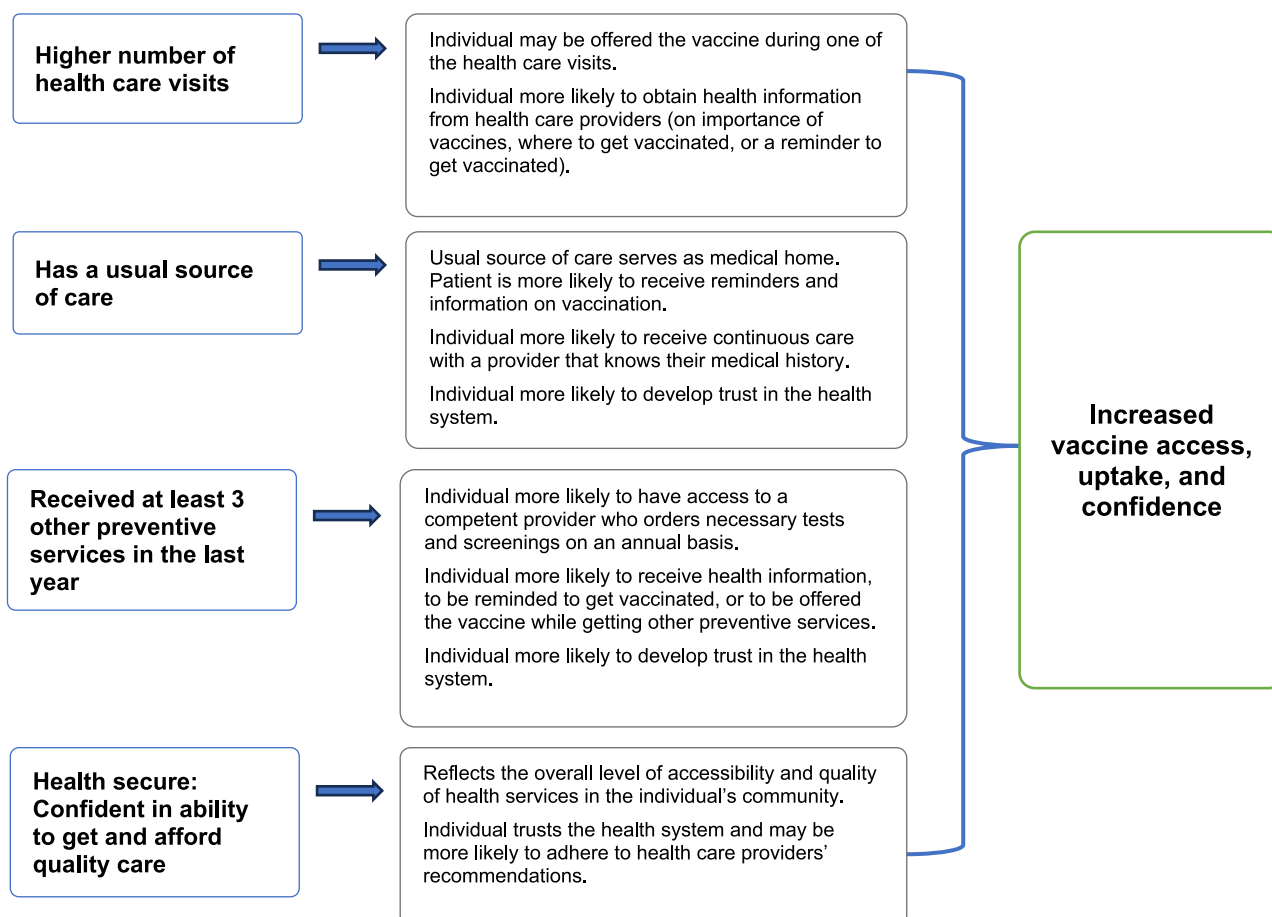


Fig. 1. Potential mechanisms linking health system engagement and health security to vaccine uptake and confidence.

subnational region, which was based on the respondent's region or state of residence and obtained by rankings states and regions within countries by median household income and dividing them into country-specific tertiles (**supplemental materials**). In Mexico, the US, and the UK, we also asked whether the respondent belonged to a minority ethnic, racial, or linguistic group (**supplemental materials**). In the UK and the US, we also included the respondent's political affiliation (**supplemental materials**). Finally, we included an indicator of trust in science and another for trust in the national public health agency (Ministero della Salute in Italy, Secretaria de Salud in Mexico, the UK Health Security Agency (UKHSA) (formerly Public Health England (PHE) in England; Public Health Scotland (PHS) in Scotland; Public Health Wales in Wales; or Public Health Agency (PHA) in Northern Ireland, and the Centers for Disease Control (CDC) in the United States). Income was based on self-reported annual or monthly household or individual income and divided into within-country tertiles (**supplemental materials**).

3.4. Statistical analyses

Descriptive analyses included sampling weights. We used country-specific logistic regression models to assess associations with flu vaccination, vaccine confidence and COVID-19 vaccination intent. For the total number of COVID-19 vaccine doses received, we used country-specific linear regression models. These models included the four measures of health system engagement and health security, and the demographic and health-related characteristics described above.

Given smaller sample sizes for the childhood vaccine analyses (as few respondents had children in the specific age ranges), data from the four countries were combined for the MMR, HPV, and child COVID-19 vaccination regression models. We used vaccine-specific logistic regression models with country fixed effects. Models included the four measures of health system engagement and health security, the child's age, and the following characteristics of caregivers: gender, education, income, state/region group (based on median household income) and trust in science and in the national public health agency. The HPV and COVID-19 vaccination models also included the respondent age in two categories (18–49 and 50+). Respondent age was excluded from the MMR model as parents of children aged 2 to 6 were all aged below 50. For the child COVID-19 vaccination model, we also included whether the caregiver had a chronic illness or a history of COVID-19 illness. All regression models included robust standard errors. Coefficients were reported as average marginal effects on the risk difference and risk ratio scales obtained using the *margins command* in STATA version 18. We conducted a complete case analysis. In the UK, Mexico, and Italy, between 7.3 % and 10 % of respondents refused to answer the question on their income. Political affiliation was also missing for 8.6 % of respondents in the UK. Regression analyses were repeated excluding these covariates.

4. Results

Our analysis included a total of 5180 adult respondents across four countries. Mean age ranged from 42 in Mexico to 52 in Italy. Between 23 % of respondents in Mexico and 51 % in the UK had a chronic illness. Nearly a third of respondents had at least one child between the ages of 1 and 18 (Table 1). Between 30 % in Mexico and 70 % in the UK had experienced COVID-19 illness. Trust in the national public health agency was 16.6 % in Italy, 27.7 % in the USA, 28.7 % in Mexico, and 30.5 % in the UK.

Regarding health system engagement, between 51 % and 69 % of respondents had at least three health care visits in the last year and between 74.7 % in Italy and 87.6 % in the UK reported having a usual source of care or regular provider. Across the four countries, 51.2 % on average had received at least three preventative care services (blood pressure, glucose, cholesterol checks or dental and eye exam); ranging

Table 1
Characteristics of respondents.

	Italy	Mexico	UK	USA
	(N = 1001) N (%)	(N = 1002) N (%)	(N = 1677) N (%)	(N = 1500) N (%)
Health system engagement and health security				
Number of health care visits in past year				
No visit	19.8 %	20.6 %	10.7 %	6.9 %
1–2 visits	29.0 %	28.1 %	25.8 %	24.2 %
3+ visits	51.2 %	51.3 %	63.5 %	69.0 %
Has a usual source of care or regular provider	74.7 %	81.9 %	87.6 %	83.0 %
Received at least 3 other preventive care services in past year ^a	49.3 %	42.4 %	43.3 %	67.3 %
Health secure: confident in ability to get and afford quality care	63.9 %	65.8 %	48.8 %	57.7 %
Demographics and health				
Age, mean (SD)	51.71 (17.51)	42.27 (16.32)	48.83 (18.28)	47.62 (17.72)
Gender				
Male	48.0 %	47.5 %	48.4 %	49.1 %
Female	52.0 %	52.5 %	51.6 %	50.9 %
Has children between the age of 1–18	23.1 %	42.6 %	30.9 %	32.9 %
Has a chronic or longstanding illness	32.2 %	23.4 %	50.9 %	40.7 %
Had COVID-19 at least once	53.7 %	30.0 %	69.7 %	54.8 %
Education				
None or primary only	18.3 %	29.5 %	0.8 %	4.9 %
Secondary	66.2 %	53.0 %	23.6 %	33.4 %
Post-secondary	15.5 %	17.5 %	75.5 %	61.6 %
Individual or household income ^b				
Poorest	45.6 %	58.2 %	32.1 %	33.5 %
Middle	29.4 %	20.8 %	30.4 %	25.3 %
Richest	24.9 %	21.0 %	37.6 %	41.1 %
Minority group ^b		7.2 %	10.1 %	37.7 %
Trusts scientists	34.8 %	32.4 %	47.3 %	32.6 %
Trusts national public health agency ^c	16.6 %	28.7 %	30.5 %	27.1 %
Political affiliation ^d				
UK: Labour			24.5 %	
UK: Conservatives			32.5 %	
UK: Other			16.5 %	
UK: Did not vote			26.4 %	
US: Democrat, independent or other				59.8 %
US: Republican				40.2 %
Stage or region group ^e				
Poorest	30.9 %	31.0 %	19.6 %	30.4 %
Middle	29.2 %	34.8 %	35.5 %	32.6 %
Richest	39.9 %	34.2 %	44.9 %	37.0 %

a. Received at least three of the following in the last year: blood pressure check, blood cholesterol check, blood sugar checks, dental exam, eye exam.

b. Country-specific income and minority group categories are shown in supplemental materials.

c. Proportion of respondents who reported trusting scientists and their national public health agency “a lot” (compared to “some”, “not much” or “not at all”. Public health agencies were Ministero della Salute in Italy, Secretaria de Salud in Mexico, the UK Health Security Agency (UKHSA) (formerly Public Health England (PHE) in England; Public Health Scotland (PHS) in Scotland; Public Health Wales in Wales; Public Health Agency (PHA) in Northern Ireland, and the Centers for Disease Control (CDC) in the United States.

d. Respondents reported the political party for which they had voted for in the last election.

e. State of region groups are based on median household income in the region or state where the respondent lives and are described in supplemental materials.

from 42.4 % in Mexico to 67.3 % in the US. Health security was highest in Mexico (65.8 %) and lowest in the UK (48.8 %). The characteristics of respondents who had children between the ages of 1 and 18 are shown in **supplemental materials**. Respondents with young children were younger on average and were less likely to be vaccinated themselves

(against influenza or with three doses of a COVID vaccine) compared to respondents without young children.

On average across the four countries, 46.5 % had received a flu vaccine in the last year and 64.0 % had received at least three doses of a COVID-19 vaccine. Flu vaccination was lowest in Italy (28.0 %) and highest in the UK (54.6 %). COVID-19 vaccination with at least three doses was lowest in the USA (45.0 %) and highest in the UK (78.9 %). Across the four countries, 43.0 % of children aged 1–18 had at least one dose of a COVID-19 vaccine, 57.9 % of those aged 13–18 had received the HPV vaccine, and 88.0 % of those aged 2–6 had the MMR vaccine. The USA had the lowest rates of all three children's vaccines (Fig. 2). Vaccine confidence was 76.6 % overall and ranged from 66.3 % in the USA to 86.9 % in Mexico (Fig. 3). COVID-19 vaccination intent ranged from only 44.2 % in the USA to 85.9 % in Mexico. Some respondents with multiple doses answered negatively to the intent question reflecting their hesitancy towards additional COVID vaccinations.

Associations between health system engagement and health security and vaccine uptake are shown in Fig. 4. Overall, adjusted associations were stronger for flu than for the COVID-19 vaccine (Fig. 4A, B, and supplemental materials). Having received at least three other preventive health services in the last year was associated with both COVID-19 and flu vaccination in all four countries. Similarly, having three or more health care visits in the last year was associated with greater uptake of both COVID-19 and flu vaccines in all countries except Italy.

Health security (being confident in your ability to get and afford quality care) improved adult vaccination uptake but only in Italy and the USA. Having a usual source of care was not strongly associated with COVID-19 vaccination but had strong associations with flu vaccination particularly in Mexico and the USA. For children's vaccines, health security had a statistically significant association with COVID-19 vaccination and having a usual source of care was associated with HPV vaccine uptake (Fig. 4C).

Associations with vaccine confidence and COVID-19 vaccine intent are shown in Fig. 5. Health security was associated with the two vaccine confidence measures in all countries except Mexico. Having a usual source of care was also associated with improved vaccine confidence and COVID-19 vaccine intent in Italy and Mexico.

Several other demographic and health related factors were associated with vaccine uptake (supplemental materials). Being aged 65 and above was positively associated with COVID-19 vaccination in all countries and with flu vaccination in all countries except Mexico. Trust in scientists was a strong determinant of COVID-19 vaccination for adults in all countries and for child COVID-19 vaccination. For example, in the USA, trust in scientists increased the probability of COVID-19 vaccination by 69 percentage points (95 % CI 53, 84, supplemental materials). Higher individual or household income generally improved vaccine uptake and confidence. Wealthier subnational states and regions had lower flu vaccine uptake in Italy and the UK but higher COVID-19

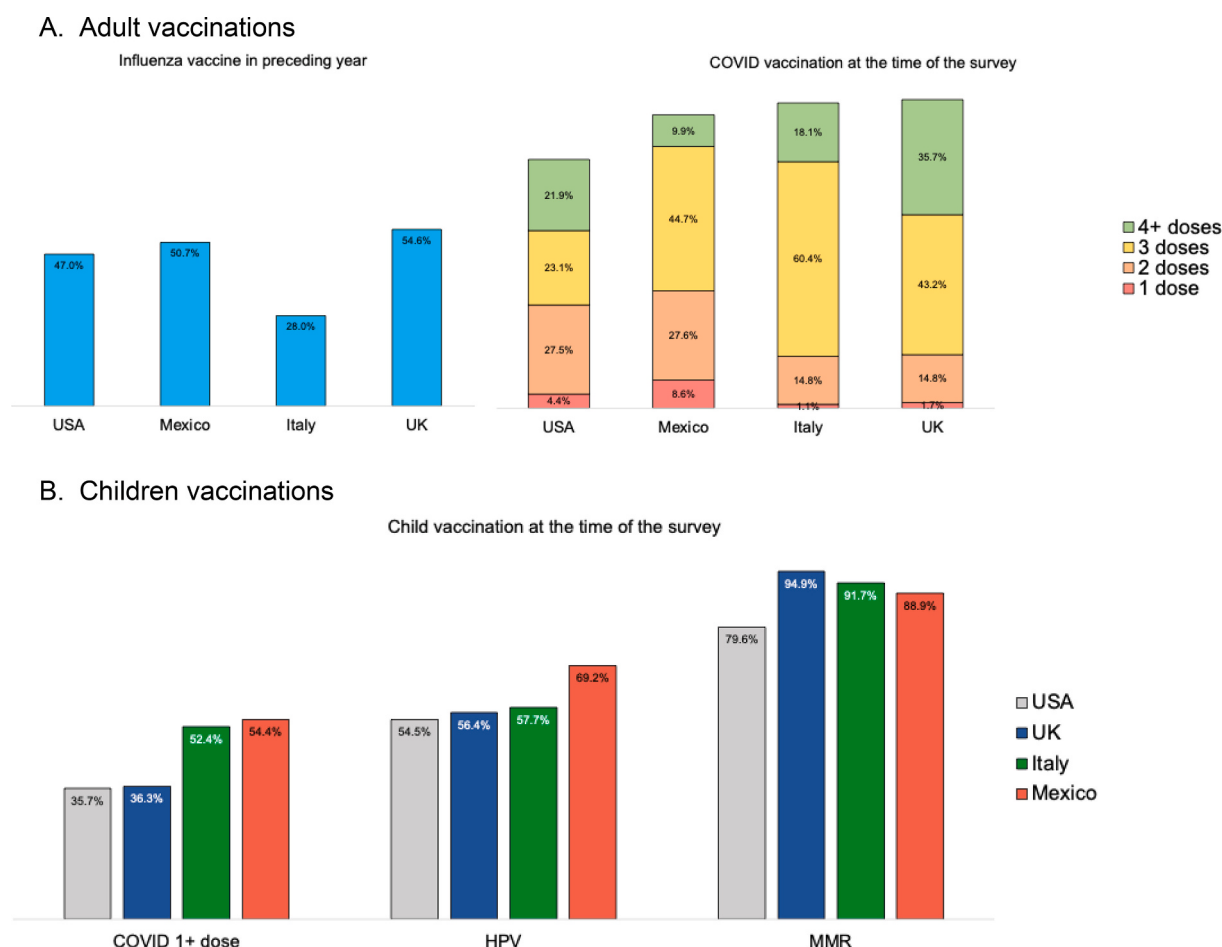


Fig. 2. Reported vaccination uptake in four countries.

Child COVID-19 vaccine is at least one dose among the respondent's youngest child aged 1 to 18. Child COVID-19 vaccination was assessed among 474 respondents in the USA, 382 in Mexico, 212 in Italy, and 512 in the UK. Human papillomavirus (HPV) vaccination is among the youngest child aged 13–18 (and only girls in Mexico). HPV vaccination was assessed among 203 respondents in the US, 90 in Mexico, 102 in Italy, and 201 in the UK. Measles, mumps and rubella (MMR) vaccination is among the youngest child aged 2–6 years old. MMR vaccination was assessed among 207 respondents in the US, 142 in Mexico, 51 in Italy, and 194 in the UK.

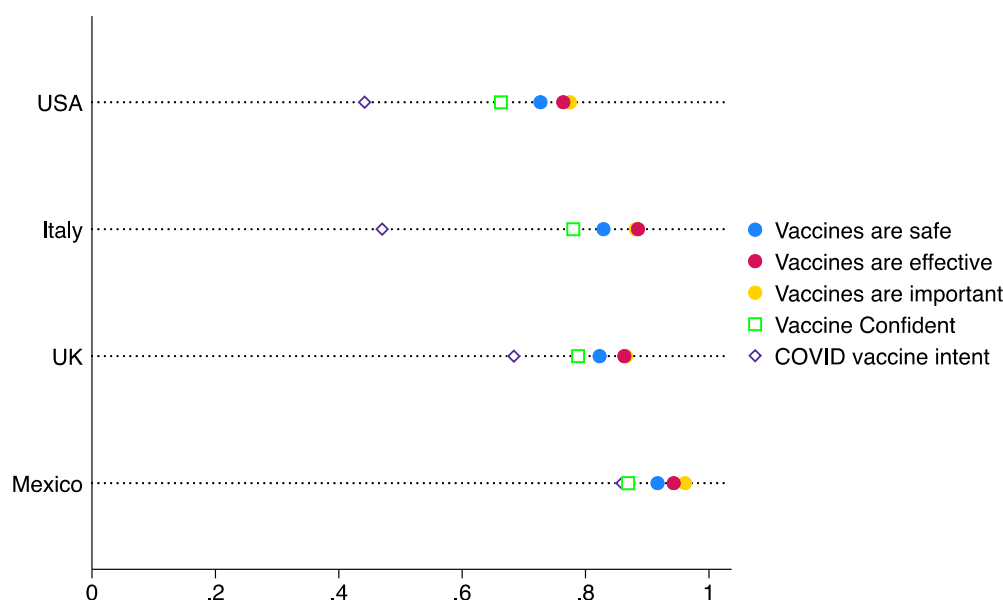


Fig. 3. Vaccine confidence in four countries.

Vaccine confident respondents are those who somewhat or strongly agree with each of the following three statements: “vaccines are important for my health”, “vaccines are safe”, and “vaccines are effective”.

COVID-19 vaccine intent is the proportion of respondent who plan to receive all required doses of a COVID-19 vaccine in the future once they are available to them.

vaccination rates in Mexico and the US. The probability of MMR vaccination was 16 percentage points higher (95 % CI 2, 30) among children of respondents who reported trusting their national public health agency. Trusting the national public health agency also positively influenced flu and COVID-19 vaccination in the US and the UK. Respondents in the US, Mexico and Italy had a higher probability of vaccinating their children against COVID-19 compared to those in the UK. US respondents were less likely to vaccinate their children against MMR compared to those in the UK (**supplemental materials**). Trust in scientists and the national public health agency were among the strongest determinants of vaccine confidence, though with varying effect sizes across the four countries.

Finally, political affiliation (which was only measured in the UK and the US) influenced vaccine uptake, confidence and intent. In the UK, those who did not vote in the 2019 elections were less likely to take vaccines and less confident in vaccines compared to those who voted for the Labour party. In the US, those leaning Republican were less likely to be vaccinated against the flu (Risk difference (RD) -0.10, 95 % CI -0.15, -0.04) and COVID-19 (RD -0.62, 95 % CI -0.76, -0.47), they were less confident in vaccines, and they were less likely to vaccinate their own children against COVID-19 and MMR (results not shown). Minority group status was only associated with COVID-19 vaccine intent in the US, whereby those belonging to a minority ethnic or racial group were more likely to plan to take all COVID-19 vaccine doses in the future. Regression analyses were repeated excluding household or individual income and political affiliation in the UK due to a high level of missingness for these covariates. We found no meaningful changes in coefficient estimates and interpretations (results not shown).

5. Discussion

Using nationally representative surveys of adults in four countries, our study compared the demographic, health and health system determinants of vaccine confidence, intent, and uptake of four different vaccines. We found that better health system engagement and health security was positively associated with vaccine uptake, confidence, and intent, although the strength of these associations varied across countries. Additionally, sociopolitical and demographic factors such as trust in science and in the national public health agency, age, education,

income level, and political affiliation were also associated with vaccine uptake and confidence.

We found that receiving at least three other preventive health services in the past year was associated with higher probabilities of flu and COVID-19 vaccination in all four countries. Having three or more health care visits was associated with higher probabilities of flu and COVID-19 vaccination in all countries except Italy. Having a regular provider was associated with higher probability of flu vaccination in Mexico and the US only. These associations tended to be stronger in the US and Mexico compared to the UK and Italy. This may partly reflect differences in health system structure and funding: the UK and Italy provide universal health coverage through the National Health Service (NHS) and the Servizio Sanitario Nazionale, respectively. Therefore individual-level variation in health system engagement may have less influence on vaccine outcomes in countries with universal health coverage as opposed to countries like the United States and Mexico that rely on a multi-payer system, large private sectors, fragmented health care delivery, and important inequalities in access and quality. In addition, the health system engagement measures may have different meanings across countries. In Italy and the UK, having three or more health care visits may truly reflect a person's pattern of health care utilization or reliance on services. In countries without universal health care this may also capture disparities in healthcare access between insured and uninsured people. These findings align from those of a recent systematic review on vaccine hesitancy, that revealed that individuals with limited healthcare interactions, such as fewer visits or hospitalizations, were less likely to be vaccinated, while the absence of a regular source of care was particularly detrimental to vaccination rates among high-risk groups, including pregnant women and individuals with chronic conditions (32). Additionally, continuity of care and access to high-quality healthcare have been linked to greater uptake of preventive services, such as chronic disease screenings and vaccinations (33–36). Recommendations by health professionals have consistently emerged as a critical factor in vaccine uptake in multiple studies examining vaccines against COVID-19, flu, rotavirus, and tetanus, diphtheria, and pertussis (Tdap) (37–39). For instance, a meta-analysis of 49 studies reported that pregnant women who received a provider recommendation were 10 to 12 times more likely to receive a Tdap or flu vaccine (40).

Our findings align with existing literature, highlighting a stronger

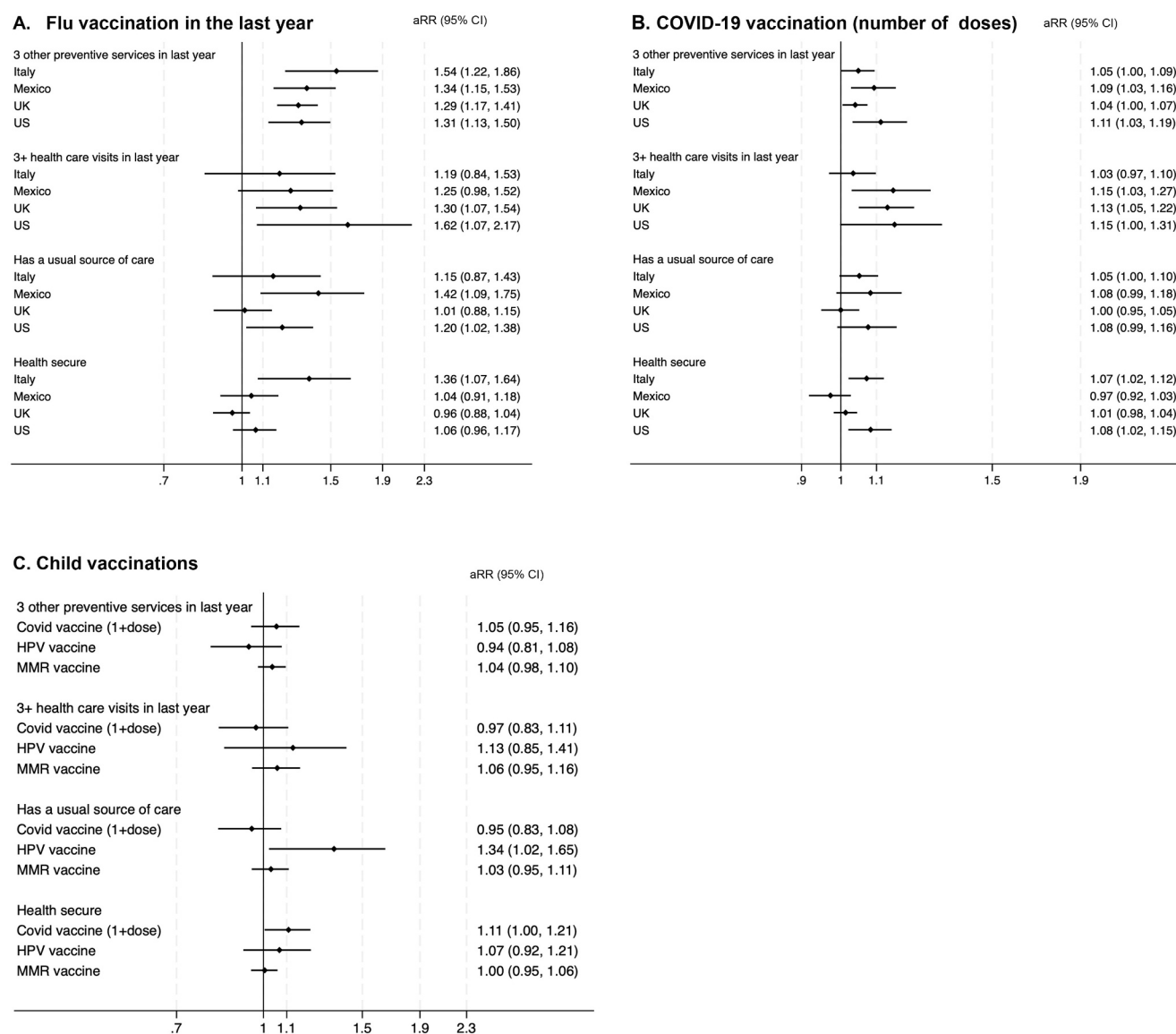


Fig. 4. Associations between health system engagement and health security and vaccine uptake.

aRR are adjusted risk ratios. Forest plot A shows results from country-specific logistic regression models for the probability of having received a flu vaccine in the year preceding the survey. Forest plot B shows results from country-specific linear regression models for the number of COVID-19 vaccine doses received. Regression models in A and B were adjusted for age, gender, postsecondary education, household or individual income, chronic illness, COVID-19 illness, state or region group, trust in scientists. Trust in national public health agency, minority group (Mexico, UK, US), and political affiliation (UK, US). Forest plot C shows results from vaccine-specific logistic regression models that combine all four countries. Models in C were adjusted for child age and respondent's age (HPV and COVID-19 only), gender, postsecondary education, income, state or region group, trust in scientists, trust in national public health agency. The model for child COVID-19 vaccination was also adjusted for whether the respondent had a chronic illness and experienced COVID. Full regression results are in supplemental materials. Risk ratios were obtained using postestimation (margins) commands in STATA version 18.

correlation between health system engagement and influenza vaccination than COVID-19 vaccination. (41–44) This phenomenon may be attributed to socio-political factors unique to the COVID-19 pandemic that confound the association between health systems and COVID-19 vaccine uptake such as trust in science, trust in public health agencies, political affiliation, wealth, and education level (43,45–47). In particular, our analysis revealed that COVID-19 vaccine uptake was more heavily influenced by socio-economic and political factors than flu vaccine uptake. This may reflect the extent to which, in all four countries to some degree but especially in the US, socioeconomic characteristics influence where one obtains information, with some outlets amplifying vaccine disinformation.

Our findings underscore the essential role of health security, defined as confidence in one's ability to access and afford quality healthcare, in

influencing vaccine uptake, confidence, and intent. Notably, the association between health security and vaccine intent and confidence varied and was strongest in Italy. This variation once again points to differences that may arise related to systems of healthcare financing and delivery. For instance, Italy's publicly funded and decentralized healthcare system impact access and quality and affordability differently than the United States' multi-payer system (48).

Our findings highlighting the importance of trust in health systems and providers are aligned with previous studies that have similarly highlighted their impact on vaccine hesitancy and intent (49–51). A literature review on vaccine hesitancy in Europe, conducted by the European Centre for Disease Prevention and Control (ECDC), identified nine studies and reports highlighting the role of mistrust in health systems and services as a significant factor contributing to vaccine

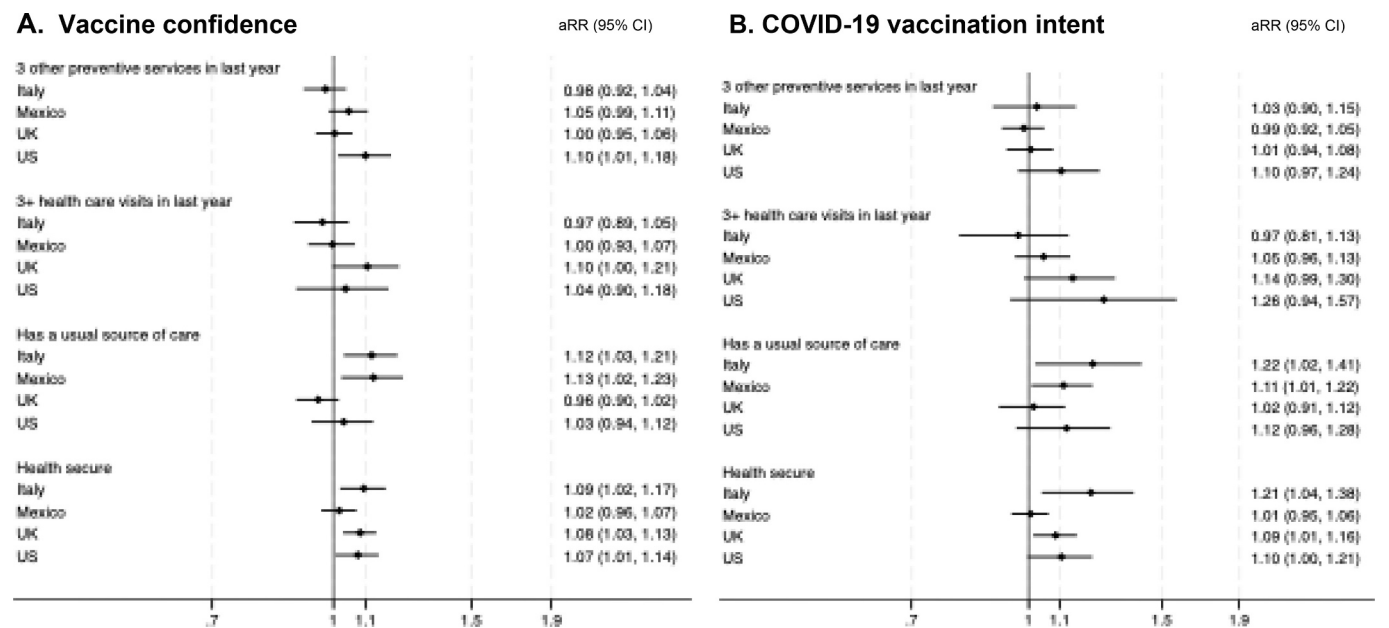


Fig. 5. Associations between health system engagement and health security and vaccine confidence and intent. aRR are adjusted risk ratios. Forest plot A shows results from country-specific logistic regression models for the probability of being vaccine confident defined as strongly or somewhat agreeing with each of the following three statements about vaccines in general: “vaccines are important for my health”, “vaccines are safe”, and “vaccines are effective”. Forest plot B shows results from country-specific logistic regression models for the probability of planning to receive all recommended doses of a COVID-19 vaccine in the future if they are available. Regression models in A and B were adjusted for age, gender, postsecondary education, household or individual income, chronic illness, past COVID-19 illness, state or region group, trust in scientists, trust in national public health agency, minority group (Mexico, UK, US), and political affiliation (UK, US). Full regression results are in supplemental materials. Risk ratios were obtained using postestimation (margins) commands in STATA version 18.

hesitancy (50). Notably, we found that health system engagement and health security had stronger associations with vaccine uptake than vaccine confidence. This may indicate that health systems can play a bigger role in modifying behaviors rather than opinions on vaccines. Health systems may be particularly critical in addressing barriers to vaccine uptake, specifically those associated with ‘complacency’ and ‘convenience’. People who do not take vaccines due to ‘convenience’ may be particularly responsive to health system interventions to improve uptake. However, the strength of these associations should be interpreted with consideration to health system organization and financing variations across countries.

Our analysis of childhood vaccinations found that health system engagement and health security had more limited influence on vaccine uptake – though our pooled analyses may hide country-specific variations. Only the HPV vaccine showed a strong association with a measure of health system engagement, specifically having a regular source of care, while only childhood COVID-19 vaccination was associated with health security. This limited association may reflect how our study measured the health system engagement of parents, which may not fully capture engagement relevant to children (52,53). The MMR vaccine, which is mandatory for school attendance in many settings, was not associated with health system engagement and security.

Our study offers distinct contributions to the literature on vaccine hesitancy and vaccine uptake by examining health system engagement and health security across one middle- and three high-income countries. In 2019, Figueiredo et al. measured vaccine confidence in 149 countries and found that between 46 % and 65 % of respondents in Italy, Mexico, the UK, and the US believed that vaccines were safe and effective (6). Our data, collected in 2022–2023, revealed very similar rates of vaccine confidence in Italy, Mexico, and the UK, but a marked decline in vaccine confidence in the United States: from 61 %–65 % in 2019 to 37 %–39 % only in 2022 (supplemental materials). This is unsurprising given the increased politicization of vaccination in the US during the COVID-19 pandemic. While Figueiredo and colleagues primarily examined

vaccine perceptions, trust, and demographic characteristics, our study also expands on this by exploring how these factors correlate with actual vaccine uptake and with health system engagement and health security. Our study relies on nationally representative samples of adults in four countries and a previously validated survey on health care utilization and health system confidence. We analyzed vaccine uptake, confidence, and intent separately across diverse healthcare contexts, deepening insights into how individual and health system factors contribute to vaccine behaviors.

Our study builds on recent work by Arsenault and colleagues (2024), which examined associations between health system quality and COVID-19 vaccination across 14 countries using the same survey instrument. While both studies look at the association between health system engagement and COVID-19 vaccine uptake, our analysis advances the literature in several important ways. First, we expand the scope of vaccine outcomes by comparing COVID-19 vaccination with influenza vaccination, offering insight into how COVID-19 vaccines outcomes may change as they become routinized. Second, we incorporate vaccinations for children (MMR, HPV, and COVID-19), which were not included in the earlier study, thereby broadening the understanding of how health system engagement and health security may influence parental vaccine behavior. Third, our study goes beyond vaccine uptake and incorporates measures of vaccine confidence and intent, offering a more comprehensive view of vaccine-related attitudes and behaviors that may mediate uptake. Finally, we differentiate COVID-19 vaccine uptake using the total number of COVID-19 vaccine doses received, rather than relying on fixed thresholds (i.e. 2+ or 3+ doses) allowing for a more granular analysis (20).

Nonetheless, this study has limitations. First, several of the health-system measures we included related to health care received in the last year; however, it is possible that some (or all) of the vaccines reported were received more than a year before the survey. Therefore, for this analysis, we assumed the reported health-care experience in the last year to be representative of health care received in recent years. Second,

self-reported vaccine uptake may be influenced by social desirability bias. Additionally, we measured the health system engagement of parents, which may not fully capture the engagement relevant to children, for example through school-based programs. Although all four vaccines are actively offered in all four countries, vaccine policies and health financing systems differed between countries and may have had an impact on inter-country comparisons. There were also differences in HPV vaccine eligibility and availability; with Mexico being the only country without gender neutral vaccination and small variations in the timeline for HPV vaccine introduction for boys between the other three countries. In two of the four studied countries (USA and Italy), MMR vaccination is mandatory for school attendance, reducing variation and thus the ability to detect the impact of health system factors on vaccine uptake. Variations in health system characteristics, such as between publicly funded systems like in the UK and Italy and multi-payer systems like those in the US and Mexico, may influence how health system engagement measures are interpreted. All four countries are federal or otherwise decentralized, with sub-national differences in policies and context, but our sample size did not permit sub-national disaggregation. Thus, we know there are large regional variations in uptake in Italy and the US, the latter reflecting a range of factors including variation in political affiliations (54,55). While political affiliation is in some settings correlated with exposure to disinformation, this is an indirect (and context-varying) measure. A further complication is that socioeconomic, cultural, and political effects can vary markedly over time (56). Regression analyses for children vaccines combined data from all countries and therefore represent average effects across the four countries. These associations should be interpreted with caution as their meaning differs from country-specific regressions for the adult vaccines. Additionally, given that the same statistical models were repeated across multiple country subsamples and for multiple vaccine outcomes, there is a risk of Type I error from multiple testing. We did not apply formal adjustments as this may have obscured potentially meaningful findings. To address this, we have interpreted associations cautiously, particularly when associations were not observed in all countries. Lastly, we did not capture variables found to be important in other studies, such as religious and cultural beliefs, misinformation, and loss of confidence due to disease resurgence, which were beyond the scope of our study but likely contribute to the complexity of determinants of vaccine uptake (1,50,52,53,57).

Our study highlights the critical role of health system engagement and health security in strengthening vaccine confidence and increasing vaccine uptake. Programs and policies aimed at promoting preventive services and ensuring continuity of care by strengthening public health and primary care and the linkages between them may enhance vaccine uptake (58). The stronger association between health system engagement and Flu vaccination, compared to COVID-19 vaccination, offers insights into the potential trajectory of COVID-19 vaccines if they become routinized. Enhanced integration of COVID-19 and Flu vaccination, particularly in primary care settings, could further boost COVID-19 vaccine uptake in countries where this is not already taking place. However, sociopolitical factors exacerbating vaccine skepticism may dampen the potential effects of vaccine routinization and integration. For childhood vaccines, which were less influenced by health system factors in our study, policy efforts may need to focus on addressing socioeconomic inequities in vaccine access and overcoming social, political, and informational barriers. These will require measures to overcome the many barriers to vaccination faced by disadvantaged groups and measures to combat disinformation and increasing vaccine awareness through schools and healthcare providers (59). Strengthening access to high-quality healthcare and fostering public trust in health systems are essential strategies for improving vaccine uptake across diverse populations and regions. Across all settings, implementing or strengthening universal health coverage (UHC), building public trust in the health system and improving health security is essential to improve health and equity. However, particularly in countries without UHC, our findings

suggest that health systems can play a role in improving vaccine uptake. Public health agencies in these settings should coordinate with health care systems and health providers to implement targeted and strategic health system efforts to improve vaccine uptake. This includes strengthening primary and preventive health care access, reducing financial and logistical barriers to preventive health, and leveraging partnerships with health care providers.

Credit authorship contribution statement

Catherine Arsenault: Writing – original draft, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Sindhu Ravishankar:** Writing – original draft. **Todd Lewis:** Writing – review & editing, Formal analysis, Data curation. **Patricio Armeni:** Writing – review & editing, Conceptualization. **Kevin Croke:** Writing – review & editing. **Svetlana V. Doubova:** Writing – review & editing, Conceptualization. **Martin McKee:** Writing – review & editing. **Rosanna Tarricone:** Writing – review & editing, Conceptualization. **Margaret E. Kruk:** Writing – review & editing, Validation, Resources, Methodology, Funding acquisition, Conceptualization.

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Declaration of competing interest

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

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2025.127134>.

Data availability

Data will be made available on request.

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