

THREAT ASSESSMENT BRIEF

Measles on the rise in the EU/EEA: considerations for public health response

16 February 2024

Summary

In 2023, significant increases in the number of measles cases and outbreaks were observed globally, including in 40 of the 53 countries of the European region, and in at least ten EU/EEA countries. Measles cases are expected to continue increasing in the EU/EEA in the coming months due to sub-optimal vaccination coverage for measles containing vaccines (MCV) in a number of EU/EEA countries, the high probability of importation from areas experiencing high circulation and the fact that the coming months represent the seasonal peak of the virus.

The risk from measles was assessed for four different population groups by the probability of infection and its impact. The overall risk is assessed as moderate for infants <12 months of age for whom vaccination is not indicated in most countries, and for children ≥ 1 -5 years of age who are known to be at risk of higher morbidity and mortality due to measles complications. In addition, the overall risk is assessed as moderate for immunocompromised persons. Older unvaccinated children (>5 years of age) and unvaccinated adults are estimated to have low to moderate risk from measles, as they do not usually present with severe disease or complications. Finally, for the population that is immune to measles, the risk is low due to the high protection conferred by the two-dose vaccination scheme or the lifelong protection from natural disease.

ECDC encourages EU/EEA public health authorities to focus on the following activities in view of the expected rise of measles cases:

- **Close immunity gaps and achieve and maintain high vaccination coverage for MCV (>95% with the second dose).** Identify and reach, including with immunisation information systems, unvaccinated or partially vaccinated populations and provide opportunities for vaccination, including during key healthcare encounters.
- **Strive towards high quality surveillance, and adequate public health capacity, especially for early detection, diagnosis, response and control** of outbreaks at local, regional, and national level. Prompt diagnosis facilitates reporting. Early detection mechanisms prevent further transmission and facilitate control of new clusters. Strengthening of laboratory diagnostic capacity will facilitate tracking virus genotypes and transmission chains.
- **Increase clinical awareness of health professionals** for the prompt diagnosis of measles, e.g. through training on the **current measles epidemiology**, clinical presentation, and on non-typical affected population groups such as older children and adults.
- **Promote vaccine acceptance and uptake.** Identify drivers of sub-optimal vaccine uptake **to ensure tailored interventions.** Initiatives should include risk communication, awareness raising and training for healthcare providers to support them in their conversations around vaccination, and community-based interventions that address barriers in under-served population groups. Several resources and examples of national activities are provided in the Technical Annex of this assessment.

Suggested citation: European Centre for Disease Prevention and Control. Measles on the rise in the EU/EEA: considerations for public health response. 16 February 2024. Stockholm: ECDC; 2024.

Stockholm, February 2024

ISBN 978-92-9498-693-1

doi: 10.2900/064162

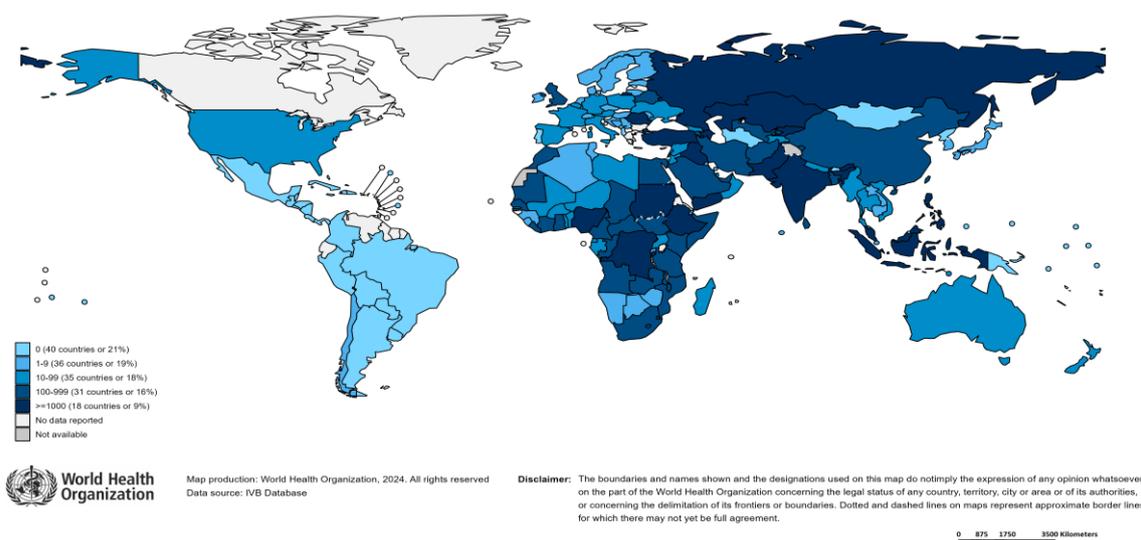
Catalogue number TQ-02-24-220-EN-N

Epidemiological situation

Global situation

Compared to the period 2020-2022, there was an increase in the number of reported measles cases and outbreaks globally in 2023, with most cases reported in Yemen, India and Ethiopia [1]. In January 2024, the WHO Region of the Americas issued an epidemiological alert for measles, urging countries in the region 'to continue with activities to increase and maintain adequate vaccination coverage against measles, rubella, and mumps'. WHO also reiterated that vaccination, epidemiological surveillance, and preparation of rapid response measures to measles and rubella outbreaks constitute the three major strategies to annually monitor and reverify the interruption of endemic transmission of these viruses [2]. The WHO European region also experienced a rise in measles cases in 2023 with over 30 000 cases reported by 40 of the 53 countries, including 21 000 hospitalisations. The rise of cases escalated towards the end of 2023 and continues into 2024. Measles has affected all age groups with significant differences in age distribution between countries. Two out of five measles cases reported are in children less than five years of age [3]. Austria and Romania are among the ten most affected countries listed by the WHO Regional Office for Europe (WHO/Europe), although Kazakhstan, Kyrgyzstan and Armenia are the ones with the highest numbers of cases [4]. The increase of measles is largely attributed to decrease of vaccination coverage during the COVID-19 pandemic from 2020 to 2022, that contributed to an increase of un- or under vaccinated individuals in the European region and globally [3].

Figure 1. Number of reported measles cases from July to December 2023, WHO [1]



Current situation in the EU/EEA

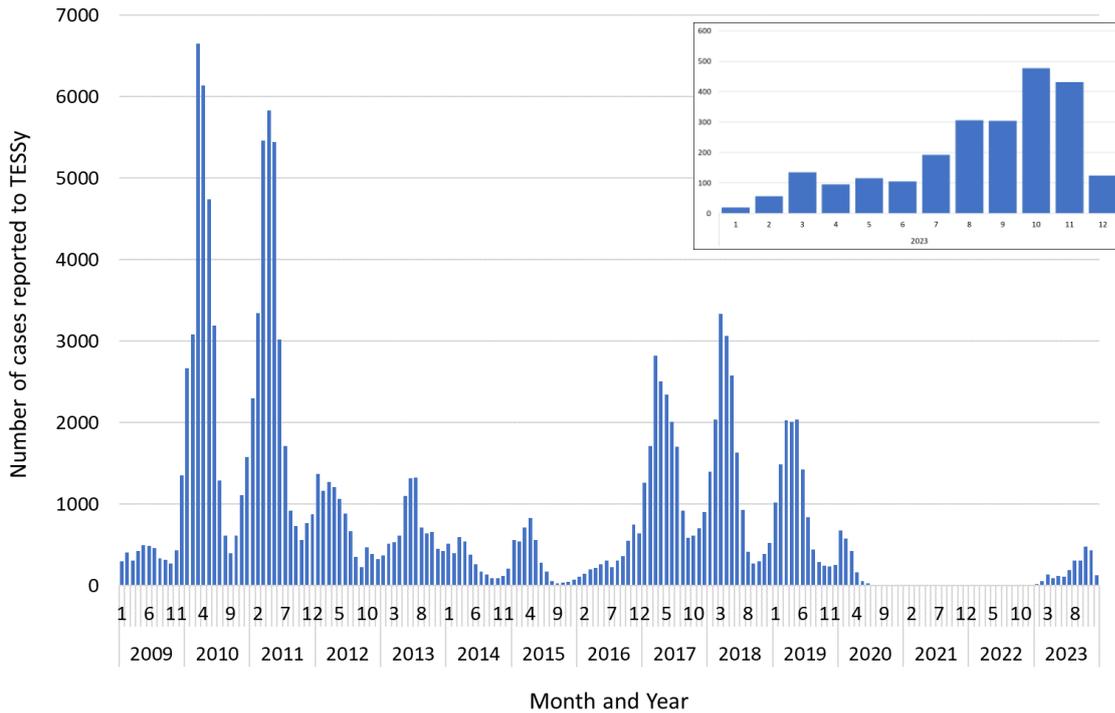
In the EU/EEA, measles activity began to increase in 2023 after a period of unusually low activity in 2020–2022, which coincided with the COVID-19 pandemic (Figure 2). During 2023, while many EU/EEA countries continued to report no or very low (sporadic) cases, measles outbreaks were reported by several other countries (Romania, Austria, and France).

The outbreak in Romania has been ongoing since mid-February 2023, and on 5 December 2023, the Ministry of Health declared a national measles epidemic [5]. In 2023, there were 2 361 measles cases reported to ECDC by EU/EEA countries, of which 1 755 (74.3%) were reported by Romania. More recent figures from the Romanian Institute of Public Health show that Romania has detected 4 679 confirmed cases between 1 January 2023 and 6 February 2024 [6].

During January and February 2024, ECDC observed an increasing number of EU/EEA countries reporting measles cases, with six fatal cases reported in Romania and one in Ireland [6-8].

Of the 2 361 cases reported by EU/EEA countries between 1 January to 31 December 2023, 5.4% (128) were recorded as having been imported and a further 0.9% (22) were recorded as import-related cases, meaning the source of infection (exposure) was outside the reporting country. Although there is variation in the proportion of imported cases by country, the overall majority of people have acquired the disease within the reported country through community/local transmission.

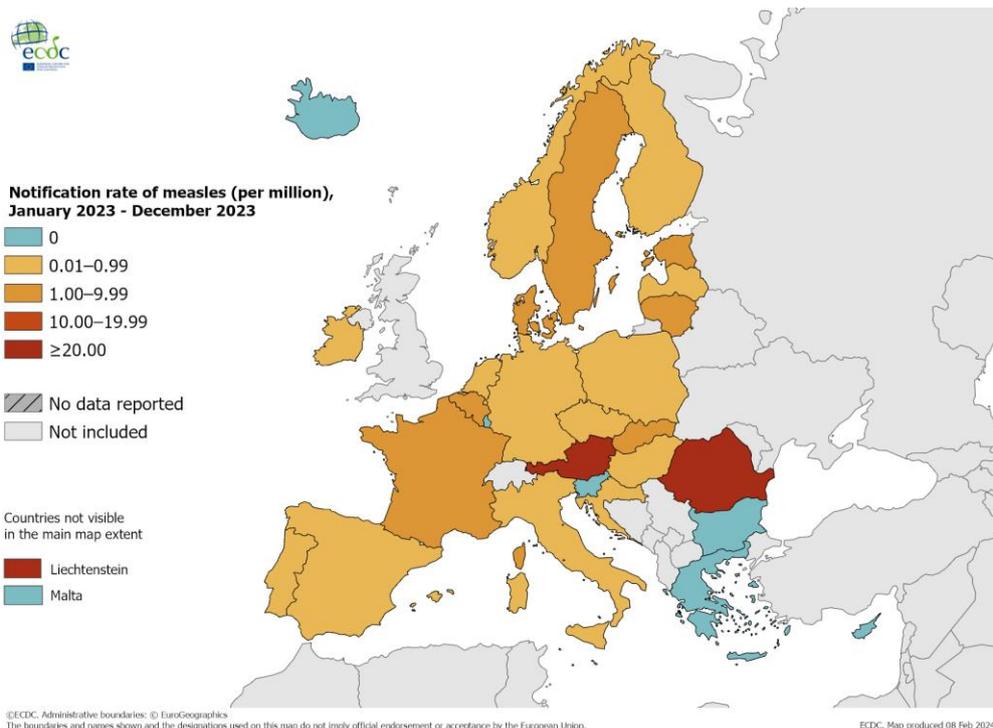
Figure 2. Number of measles cases reported to TESSy by month and year, EU/EEA countries*, 1 January 2009 to 31 December 2023



* Despite UK historically being an EU/EEA country, data reported by UK have been excluded for all years to allow comparison

During the period 1 January to 31 December 2023, the notification rate per 1 million population was highest in Romania (92.16), Liechtenstein (76.32), Austria (20.72), Belgium (5.94) and Estonia (3.0) (Figure 3). There were five countries with a notification rate between 1.0 and 2.0 per 1 million population (France: 1.74, Denmark: 1.53, Slovakia: 1.10, Lithuania: 1.07; Sweden: 1.05) and another 13 with a notification rate <1.0 per 1 million population (Germany: 0.99, Poland: 0.98, Ireland: 0.79, Croatia: 0.78, Italy: 0.75, Latvia: 0.53, the Netherlands: 0.40, Norway: 0.37, Spain: 0.27, Finland: 0.18, Hungary: 0.10, Portugal: 0.10, Czechia: 0.10). Seven countries reported no cases in 2023 (Bulgaria, Cyprus, Greece, Iceland, Luxembourg, Malta, Slovenia).

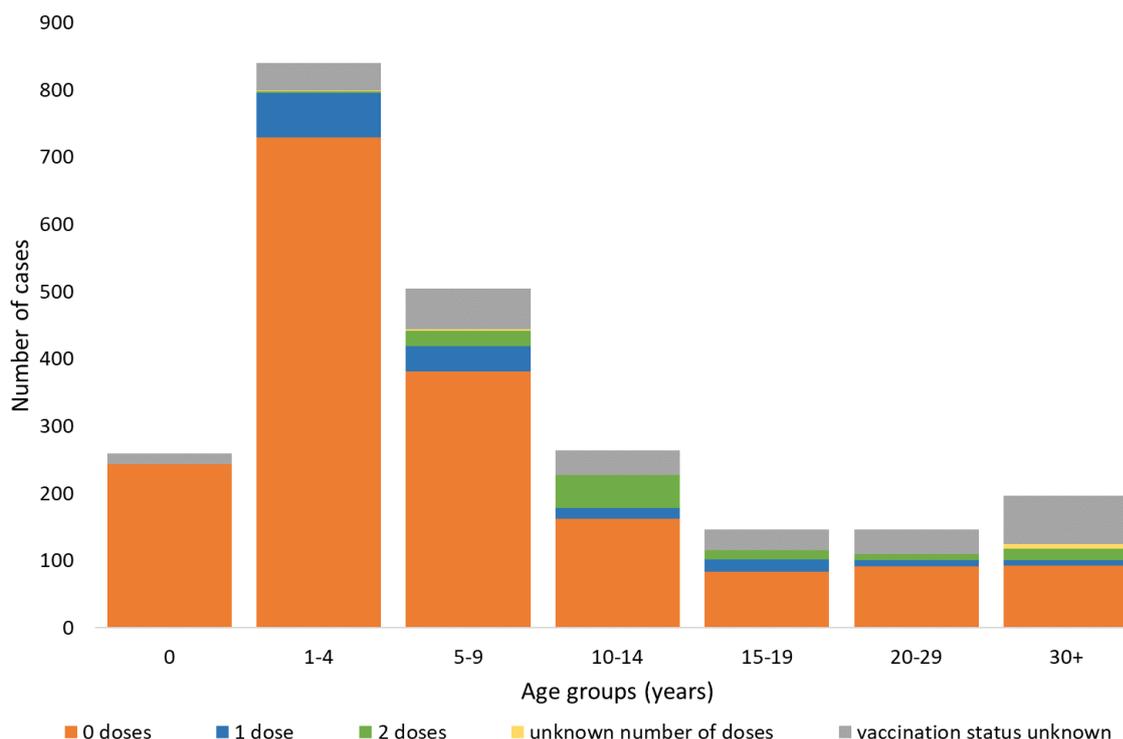
Figure 3. Incidence of measles cases (per million population) reported to TESSy by country, EU/EEA countries, 1 January 2023 to 31 December 2023



Note: The high notification rate reported for Liechtenstein is the result of only three imported measles cases reported in 2023

According to data reported to The European Surveillance System (TESSy), measles cases in EU/EEA countries were reported across all age groups between 1 January and 31 December 2023, with the highest number of cases among children aged 1–4 years, followed by children aged 5–9 years (Figure 4). This overall trend is largely driven by the situation in Romania, and a few other countries follow the same trend. However, other EU/EEA countries have reported the highest proportion of cases in other age groups, such as children aged 10–14 years (e.g. France), or adults aged 30 years and older (e.g. Germany, Italy, the Netherlands). This highlights that measles can affect all age groups. Overall, 75.7% of cases reported in 2023 (1 786 of 2 361) were unvaccinated. The proportion of unvaccinated cases varied by age group: it was highest among children aged less than 1 year (94.2%), who in the majority of countries are too young to be vaccinated [9], and was lowest among adults aged 30 years and over (where 46.7% were unvaccinated and 36.2% had unknown vaccination status). The trends in age groups and proportion of unvaccinated individuals is similar to previous years (data available in previously published Annual Epidemiological Reports [10]).

Figure 4. Number of measles cases reported to TESSy by age group and vaccination status, EU/EEA countries, 1 January 2023 to 31 December 2023



Measles-containing vaccine coverage

The attenuated live measles vaccine is highly effective. However, due to the high transmissibility of the measles virus, very high vaccination coverage ($\geq 95\%$) with two doses of measles-containing vaccine (MCV) is necessary to interrupt measles transmission. The latest national vaccination coverage estimates up to 2022 for MCV dose 1 and dose 2 are available from the WHO Global Health Observatory[11].

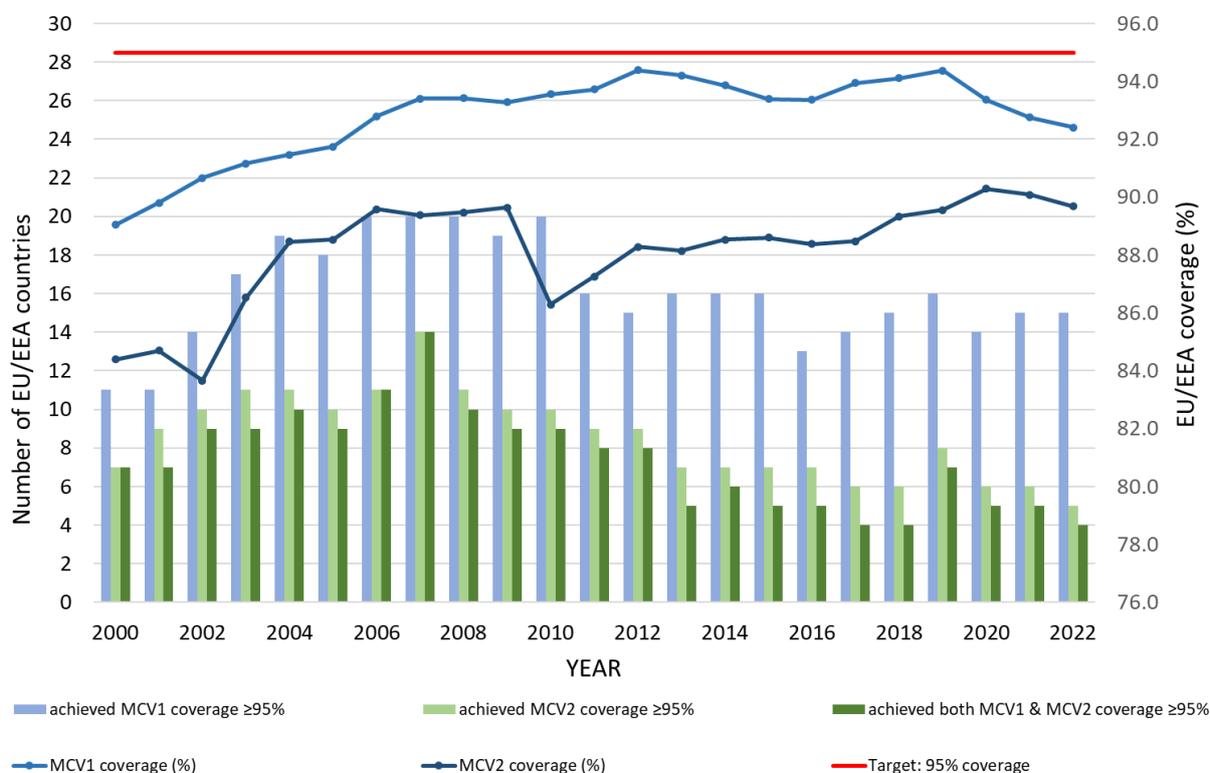
In 2022, the EU/EEA experienced a slight decline in average vaccination coverage compared to 2018. The mean vaccination coverage for the first dose of measles-containing vaccine (MCV1) decreased from 95% in 2018 to 92% in 2022. Within the EU/EEA, 16 Member States observed a decrease in MCV1 coverage, ranging from a 1% to 24% decrease, while five Member States observed an increase ranging from 1% to 3%. Similarly, the mean coverage for the second dose (MCV2) decreased from 91% in 2018 to 89% in 2022, with 13 Member States reporting a decrease (1% to 23%) and seven Member States reporting an increase (1% to 12%).

Based on the 2022 data, only 50% of EU/EEA countries reported a coverage of $\geq 95\%$ for the first dose [12] and only 17% achieved this threshold for the second dose [13]. Only four countries had an estimated coverage of $\geq 95\%$ for both MCV1 and MCV2 in 2022 (Figure 5).

At the global level, vaccination programmes were heavily affected by the COVID-19 pandemic. There was a sharp decline of MCV coverage observed during this period, leaving 24.7 million children unvaccinated. The global estimates for MCV1 coverage dropped from 86% in 2018 to 83% in 2022, accounting for 14.7 million deprived of MCV [11,14-16]. In the EU/EEA, vaccination programmes appeared to be more resilient, with many countries able to maintain vaccination coverage in 2020-2022 at similar levels to previous years (2018-2019).

However, even in the pre-pandemic period, less than half of EU/EEA countries achieved $\geq 95\%$ vaccination coverage for MCV1, and very few achieved $\geq 95\%$ coverage for MCV2 (Figure 5). The observed vaccine coverage estimates (Figure 5) indicate that in many countries, routine childhood vaccination against measles is below the level recommended to achieve and sustain measles elimination [17].

Figure 5. Number of countries who achieved $\geq 95\%$ coverage for MCV1, MCV2, and both doses by year (left axis), and EU/EEA coverage estimates for MCV1 and MCV2 by year (right axis), EU/EEA countries*, 2000 to 2022



* Despite UK historically being an EU/EEA country, data reported by UK have been excluded for all years to allow comparison
 Source: WHO Global Health Observatory: [Immunization coverage estimates \(who.int\)](https://www.who.int/data/stories/immunization-coverage-estimates)

ECDC risk assessment for the EU/EEA

This risk assessment has been developed based on the currently available data at the time of publication and follows the ECDC rapid risk assessment methodology, where the overall risk is determined by a combination of the probability of infection and its impact [18].

What is the public health risk associated with the potential increase of measles in the coming months?

An overview of the ECDC assessment can be found in the table below.

Table 1. Assessment of the risk associated with measles infection in the EU/EEA, by population group

	Infants < 12 months	Unvaccinated children 1 to 5 years	Unvaccinated children > 5 years and unvaccinated adults	Immuno-compromised persons*	Population immune to measles**
Probability	Low to moderate	Low to moderate	Low to moderate	Low to moderate	Low
Impact	High	Moderate	Low to moderate	Moderate	Very low
Overall risk	Moderate	Moderate	Low to Moderate	Moderate	Very low

*Immunocompromised persons; e.g. persons living with HIV, cancer, etc.

**Immune population: population either vaccinated with two doses of a measles containing vaccine or immune due to natural immunity; this population might vary in size in the different Member States.

The probability of measles exposure and potential subsequent infection depends on the vaccination status of the person and the vaccination status of close contacts, as well as the circulation of measles virus in the particular community or setting. Herd immunity can protect unvaccinated infants, pregnant women or immunocompromised people.

The probability of exposure to measles in the EU/EEA is expected to rise due to the increasing number of cases in the European Region and globally. In addition, measles has typical seasonal patterns with cases increasing during late winter and spring. Therefore, an increase of cases would be expected in the coming months. Furthermore, due to the continuous movement of people within and outside the EU/EEA, there is a high probability of importation of measles between Member States, as well as exportation outside the region. In areas and settings with high MCV uptake, the probability of exposure remains low, as is the probability of clusters and outbreaks of measles. In areas with higher rates of unvaccinated population pockets, the circulation of measles is more likely. Therefore, the probability of exposure to it can be moderate or even high. In the context of clusters or outbreaks, measles is extremely contagious with secondary attack rates reaching 90% among unvaccinated exposed persons.

The overall risk **for unvaccinated infants under the age of 12 months**, who are too young to be vaccinated, is assessed as **moderate**, with low to moderate probability of exposure, depending on the factors outlined above (community vaccination coverage for MCV, vaccination status of their close contacts and prevalence of measles in their community). We assess a high impact of the disease if contracted, due to high morbidity following measles (secondary bacterial infections and complications, even death) in this population. Three out of the six reported deaths in the ongoing outbreak in Romania were in infants <12 months of age [6].

For **unvaccinated children one to five years of age**, the overall risk is assessed as **moderate**. Their likelihood of exposure again depends on the MCV vaccine uptake in their community, the immunity status of their contacts and the circulation of measles, and can vary from low to moderate. The impact of measles in this age group is assessed as moderate, as measles can have several complications in this age group. Complications with secondary bacterial infections are frequent, and severe outcomes are known, including acute encephalitis (one out of every 1 000 measles cases), which often results in permanent brain damage, while one to three out of every 1 000 children who becomes infected with measles may die from respiratory and neurologic complications. Of note, no antivirals are authorised for the treatment of severe measles disease, only vitamin A and supportive care [19]. These complications and/or deaths are only preventable through vaccination.

The **overall risk for unvaccinated children over five years of age and unvaccinated adults is assessed as low to moderate**, with low to moderate probability of exposure and low to moderate impact of the disease. Children over five years of age may exhibit relatively mild symptoms and fewer complications unless there are underlying conditions. Adults infected with measles generally exhibit moderate to severe symptoms with frequent secondary pneumonias and bacterial infections [20]

Unvaccinated population groups (children and adults) may comprise hard-to-reach populations which have low vaccine uptake for a variety of reasons. These may include certain ethnic minorities, recently arrived or undocumented migrants and all populations with poor access to health services, as well as children of families with low vaccine confidence due to religious or personal beliefs [21-23].

Children older than one year of age and adults (particularly of younger ages) may be already partially vaccinated with one dose of measles containing vaccine, and would therefore be partially protected, as one dose of MCV is approximately 93% effective at preventing measles. However, this group might experience mild to moderate symptoms, which are sometimes atypical, and are also able to transmit the disease. Adults exhibiting measles symptoms may initially be overlooked since initial symptoms are quite common (fever, coryza, conjunctivitis) and GPs and other health practitioners may not be familiar with the disease. Health professionals should also be vigilant that it may be difficult to recognise the characteristic rash, which will result in the further spread of the disease.

More severe disease and increased mortality has been described in **immunocompromised children and adults** (e.g. living with HIV, cancer etc) and pregnant women [19]. Therefore, their overall risk in these population groups is assessed as **moderate**. Nosocomial outbreaks have been described involving healthcare workers exposed to measles in the hospital environment (usually through the emergency department), which may increase the risk of exposure of immunocompromised persons [24-26].

For fully **vaccinated (children or adults) or people who have previously contracted the disease, the risk is assessed as very low**. This is due to the fact that two MCV doses are approximately 97% effective in preventing measles and measles infection confers lifelong immunity [27].

ECDC recommendations

Reported vaccination coverage levels for measles are sub-optimal in a number of EU/EEA and neighbouring countries. As the number of cases are expected to rise in the near future, ECDC encourages EU/EEA public health authorities focus on the following areas:

- Close immunity gaps and achieve and maintain high vaccination coverage for MCV (>95% with the second dose).
- Strive towards high quality surveillance, and adequate public health capacity, especially for early detection, diagnosis, response and control of outbreaks.
- Increase the clinical awareness of health professionals.
- Promote vaccine acceptance and uptake by employing specific risk communication strategies, addressing barriers to vaccination and engaging with under-served populations.

More specifically:

- Countries should work towards **closing immunity gaps and achieving and maintaining high vaccination coverage for MCV (>95% for the second dose)**. More specific key actions related to vaccination programmes include the following:
 - Implement robust systems, including vaccination information systems, to identify and reach the unvaccinated or partially-vaccinated population.
 - Integrate vaccination into healthcare services by requesting doctors to check the vaccination status of their patients during any visit, and either administer vaccination to those that are unvaccinated or partially-vaccinated or guide them to the easiest way to get vaccinated. This also applies to adult populations, who might have missed the full course of MCV vaccination. Ensure there is sufficient vaccine availability.
 - Assess the profile of individuals who are susceptible to measles, in order to inform work to close immunity gaps and achieve and sustain high vaccination coverage (regional, national levels).
 - Ensure equity in access to vaccination, especially for vulnerable populations like migrants who may enter the EU/EEA insufficiently immunised, and those who live in crowded settings e.g. refugee camps, Roma settlements etc.
 - Catch-up vaccination campaigns should be implemented following existing WHO recommendations [28].
- Countries should also **strive towards high quality surveillance and strengthen their capacity for early detection and control** of outbreaks at local, regional, and national level.
 - Countries should continue investing in, and supporting, high quality measles surveillance system(s) and the establishment of early detection and reporting mechanisms to identify and respond promptly to cases [29].
 - Capacity for case investigation, contact tracing, implementation of swift isolation and control measures including vaccination are needed to prevent further transmission upon the detection of new cases. Exchange of information on cross-border cases via established EU and international channels is important to avoid re-establishment of measles in receiving countries.
 - Adequate sample collection (including supply of appropriate swabs and trained personnel) and transport capacity as well as laboratory capacity with robust diagnostics are needed. Monitoring of measles viral genotypes can facilitate tracking transmission chains.
- Public health authorities should **increase awareness about measles among healthcare providers**.
 - Healthcare workers need to be updated on the local epidemiological situation as well as the clinical presentation of measles (e.g. age shift to young adults), to ensure that all cases are diagnosed.
 - Protocols for the management of cases of fever with rash in hospitals and GP practices should be reviewed and implemented (e.g. for the encounters in emergency departments), in order to avoid nosocomial transmission of measles.
 - Checking and updating vaccination against measles should be a routine practice during travel medicine consultations and general health checks prior to travelling, including those travelling within the EU/EEA. Measles should also be considered in the diagnostic process for patients post-travel, irrespective of their age and travel destination, when they present with symptoms like fever and rash.
 - Healthcare professionals should be fully vaccinated.
- There is need to employ **risk communication and strategies to promote vaccine acceptance and uptake**.
 - The identification of drivers of sub-optimal MMR vaccine acceptance and uptake is a key step to ensure that tailored interventions are implemented in response. Information on frameworks and the use of behavioural models are provided in the Technical Annex.
 - Trends in vaccine confidence need to be monitored [30] to inform tailored actions, for example when a decline in confidence is observed in specific population groups, such as younger adults, healthcare professionals, etc.

- Communication strategies should seek to raise public awareness about the risks of the disease and outbreaks, the importance of timely vaccination with two doses of MCV, options for catch-up vaccination where available, as well as the importance of high vaccine coverage to prevent outbreaks and contribute to measles elimination. Tailored information should be offered to specific populations. Examples of information that countries are already providing are available in the Technical Annex.
- Population concerns around the vaccine should be addressed. As identified in studies, the main concerns around the MMR vaccine in Europe revolve around vaccine safety, perceived low severity of disease, lack of information, mistrust in governments and the low risk of getting infected [31]. Also, any circulating mis- and disinformation should be monitored and addressed. ECDC provides communication materials and guides with key messages on measles, vaccination and addressing common concerns [32-34], as well as a guide and e-learning [35,36] on countering online misinformation on vaccines.
- Given the important role of healthcare professionals (HCP) in motivating parents/caregivers to vaccinate their children, strategies need to include awareness raising, as well as education and materials to support them in their conversations around vaccination and understand parental concerns. Examples of educational interventions with HCP in six EU countries and the UK are described in a report from the VAX-TRUST project [37].
- **Addressing barriers and engaging with underserved populations** is crucial.
 - Systemic barriers that impact vaccine uptake in under-served populations need to be monitored and addressed with targeted strategies, to reduce inequalities in vaccine uptake [38].
 - Tailored community-based interventions to address specific factors that affect uptake in disadvantaged, isolated and difficult-to-reach communities can include supporting vaccine literacy among health providers and in the affected communities (including translation services and cultural competence training); enhancing community involvement; strengthening advocacy with community leaders and representatives [39].

Limitations

This threat assessment brief is based on data with the following limitations:

- Latest vaccination coverage estimates for MCV1 and MCV2 doses in the EU/EEA are only available for 2022.
- Surveillance data on measles cases may be incomplete, especially for recent months, and data included here are subject to change.

Source and date of request

ECDC internal decision, 2 February 2024.

References

1. World Health Organization (WHO). Immunization Analysis and Insights - Provisional monthly measles and rubella data. 2024. Available at: <https://www.who.int/teams/immunization-vaccines-and-biologicals/immunization-analysis-and-insights/surveillance/monitoring/provisional-monthly-measles-and-rubella-data>
2. Pan American Health Organization/World Health Organization (PAHO/WHO). Epidemiological Alert: Measles in the Region of the Americas. 29 January 2024. Washington, D.C.: (PAHO/WHO); 2024. Available at: <https://www.paho.org/en/documents/epidemiological-alert-measles-region-americas-29-january-2024>
3. World Health Organization Regional Office for Europe (WHO/EURO). A 30-fold rise of measles cases in 2023 in the WHO European Region warrants urgent action. Geneva: WHO EURO; 2023. Available at: <https://www.who.int/europe/news/item/14-12-2023-a-30-fold-rise-of-measles-cases-in-2023-in-the-who-european-region-warrants-urgent-action>
4. World Health Organization (WHO). Measles and rubella monthly update — WHO European Region. 2023. Available at: https://cdn.who.int/media/docs/librariesprovider2/euro-health-topics/vaccines-and-immunization/eur_mr_monthly_update_en_november-2023.pdf?sfvrsn=ccddae3a_2&download=true
5. Romania Ministry of Health. Ministerul Sănătății a declarat epidemie de rujeolă la nivel național - Ministerul Sănătății (ms.ro) Bukarest: RMOH; 2023. Available at: <https://www.ms.ro/ro/centrul-de-presa/ministerul-s%C4%83n%C4%83t%C4%83%C8%9Bii-a-declarat-epidemie-de-rujeol%C4%83-la-nivel-na%C8%9Bional/>
6. Romania Ministry of Health. Measles epidemiological reports. Bukarest; 2023. Available at: <https://insp.gov.ro/centrul-national-de-supraveghere-si-control-al-bolilor-transmisibile-cnscbt/informari-saptamanale/>
7. European Centre for Disease Prevention and Control (ECDC). Communicable disease threats report, 14-20 January 2024, week 3. Stockholm: ECDC; 2024. Available at: <https://www.ecdc.europa.eu/en/publications-data/communicable-disease-threats-report-14-20-january-2024-week-3>
8. The Health Protection Surveillance Centre Ireland. Death of an adult with confirmed measles in Dublin and Midlands Health Region. Dublin: HPSC; 2024. Available at: <https://www.hpsc.ie/news/title-24083-en.html>
9. European Centre for Disease Prevention and Control (ECDC). Vaccine Scheduler. Stockholm: ECDC; 2024. Available at: <https://vaccine-schedule.ecdc.europa.eu/Scheduler/ByDisease?SelectedDiseaseId=8&SelectedCountryIdByDisease=-1>
10. European Centre for Disease Prevention and Control (ECDC). Annual Epidemiological Reports (AERs). Stockholm: ECDC; 2024. Available at: <https://www.ecdc.europa.eu/en/publications-data/monitoring/all-annual-epidemiological-reports>
11. World Health Organization (WHO). Measles vaccinations coverage. Geneva: WHO. Available at: <https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/immunization-coverage-estimates>
12. European Centre for Disease Prevention and Control (ECDC). Map of Coverage of first dose of measles- and rubella-containing vaccine, 2022. Stockholm: ECDC; 2022. Available at: <https://www.ecdc.europa.eu/en/publications-data/coverage-first-dose-measles-and-rubella-containing-vaccine-2022>
13. European Centre for Disease Prevention and Control (ECDC). Map of Coverage of second dose of measles-containing vaccine, 2022. Stockholm: ECDC; 2022. Available at: <https://www.ecdc.europa.eu/en/publications-data/coverage-second-dose-measles-containing-vaccine-2022>
14. Basu S, Ashok G, Debroy R, Ramaiah S, Livingstone P, Anbarasu A. Impact of the COVID-19 pandemic on routine vaccine landscape: A global perspective. Hum Vaccin Immunother. 2023 Dec 31;19(1):2199656.
15. World Health Organization (WHO). Childhood immunization begins recovery after covid 19 backslide. Geneva: WHO; 2023. Available at: <https://www.who.int/news/item/18-07-2023-childhood-immunization-begins-recovery-after-covid-19-backslide>
16. World Health Organization Vaccine Alliance. The Big Catch-Up: An Essential Immunization Recovery Plan for 2023 and Beyond. New York: WHO; 2023.
17. World Health Organization Regional Office for Europe (WHO/EURO). Eliminating measles and rubella: framework for the verification process in the WHO European Region 2014. Copenhagen: WHO/EURO; 2014. Available at: <https://www.who.int/europe/publications/i/item/9789289060783>

18. European Centre for Disease Prevention and Control (ECDC). Operational tool on rapid risk assessment methodology - ECDC 2019. Stockholm: ECDC; 2019. Available at: <https://www.ecdc.europa.eu/en/publications-data/operational-tool-rapid-risk-assessment-methodology-ecdc-2019>
19. Committee on Infectious Diseases AAoP, Kimberlin DW, Barnett ED, Lynfield R, Sawyer MH. Red Book: 2021–2024 Report of the Committee on Infectious Diseases: American Academy of Pediatrics; 2021.
20. Bennett J., Mandell G., Dolin R., Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases. Elsevier – 2019. Available at: <https://shop.elsevier.com/books/mandell-douglas-and-bennetts-principles-and-practice-of-infectious-diseases/bennett/978-0-323-48255-4>
21. Godefroy R, Chaud P, Ninove L, Dina J, Decoppet A, Casha P, et al. Measles outbreak in a French Roma community in the Provence-Alpes-Côte d'Azur region, France, May to July 2017. *Int J Infect Dis.* 2018 Nov;76:97-101.
22. Tombat K, van Dijk JP. Roma Health: An Overview of Communicable Diseases in Eastern and Central Europe. *Int J Environ Res Public Health.* 2020 Oct 20;17(20)
23. Knol MJ, Urbanus AT, Swart EM, Mollema L, Ruijs WL, van Binnendijk RS, et al. Large ongoing measles outbreak in a religious community in the Netherlands since May 2013. *Eurosurveillance.* 2013;18(36):20580. Available at: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES2013.18.36.20580>
24. Pampaka D, López-Perea N, Fernández-García A, Huertas-Zarco I, Castellanos-Martínez M, Villatoro-Bongiorno K, et al. An interregional measles outbreak in Spain with nosocomial transmission, November 2017 to July 2018. *Eurosurveillance.* 2023;28(17):2200634. Available at: <https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2023.28.17.2200634>
25. Haviari S, Bénet T, Saadatian-Elahi M, André P, Loulergue P, Vanhems P. Vaccination of healthcare workers: A review. *Hum Vaccin Immunother.* 2015;11(11):2522-37.
26. Porretta A, Quattrone F, Aquino F, Pieve G, Bruni B, Gemignani G, et al. A nosocomial measles outbreak in Italy, February-April 2017. *Euro Surveill.* 2017 Aug 17;22(33)
27. McLean HQ, Fiebelkorn AP, Temte JL, Wallace GS. Prevention of measles, rubella, congenital rubella syndrome, and mumps, 2013: summary recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep.* 2013 Jun 14;62(Rr-04):1-34.
28. World Health Organization Regional Office for Europe (WHO/EURO). Operational considerations for planning and implementing catch-up vaccination in the WHO European Region. Copenhagen: WHO EURO; 2022. Available at: <https://www.who.int/europe/publications/i/item/WHO-EURO-2022-4751-44514-63005>
29. World Health Organization Regional Office for Europe (WHO/EURO). Eliminating measles and rubella in the WHO European Region: integrated guidance for surveillance, outbreak response and verification of elimination. 2024. Available at: <https://iris.who.int/handle/10665/375923>
30. Vaccine Confidence Project. State of Vaccine Confidence in the European Union. Luxembourg: EC; 2022. Available at: https://health.ec.europa.eu/system/files/2023-02/2022_confidence_rep_en.pdf
31. Karafillakis E, Larson HJ. The benefit of the doubt or doubts over benefits? A systematic literature review of perceived risks of vaccines in European populations. *Vaccine.* 2017 2017/09/05;35(37):4840-50. Available at: <https://www.sciencedirect.com/science/article/pii/S0264410X17309696>
32. European Centre for Disease Prevention and Control (ECDC). Communication toolkit on immunisation: How to increase immunisation uptake. Stockholm: ECDC; 2017. Available at: <https://www.ecdc.europa.eu/en/publications-data/communication-toolkit-immunisation-how-increase-immunisation-uptake>
33. European vaccination information portal. Measles factsheet. Brussels: EU; 2020. Available at: <https://vaccination-info.europa.eu/en/disease-factsheets/measles>
34. European Centre for Disease Prevention and Control (ECDC). Measles and rubella elimination: communicating the importance of vaccination. Stockholm: ECDC; 2014. Available at: <https://www.ecdc.europa.eu/en/publications-data/measles-and-rubella-elimination-communicating-importance-vaccination>
35. European Centre for Disease Prevention and Control (ECDC). Countering online vaccine misinformation in the EU/EEA. . Stockholm: ECDC; 2021. Available at: <https://www.ecdc.europa.eu/en/publications-data/countering-online-vaccine-misinformation-eu-eea>
36. European Centre for Disease Prevention and Control (ECDC). ECDC launches e-learning course on how to address online vaccination misinformation. Stockholm: ECDC; 2022. Available at: <https://www.ecdc.europa.eu/en/news-events/ecdc-launches-e-learning-course-how-address-online-vaccination-misinformation>

37. De Vito E., Esposito M., Sannella A., Ferrara M., Langiano E., R. L. Country Reports on the Intervention Developed and Implemented in Target Regions. VAX-TRUST deliverable 5.32023. Available at: <https://cordis.europa.eu/project/id/965280/results>
38. Essa-Hadad J, Gorelik Y, Vervoort J, Jansen D, Edelstein M. Understanding the health system barriers and enablers to childhood MMR and HPV vaccination among disadvantaged, minority or underserved populations in middle- and high-income countries: a systematic review. *European Journal of Public Health*. 2024 Available at: <https://doi.org/10.1093/eurpub/ckad232>
39. Ekezie W, Awwad S, Krauchenberg A, Karara N, Dembiński Ł, Grossman Z, et al. Access to Vaccination among Disadvantaged, Isolated and Difficult-to-Reach Communities in the WHO European Region: A Systematic Review. *Vaccines*. 2022;10(7):1038. Available at: <https://www.mdpi.com/2076-393X/10/7/1038>
40. Betsch C, Schmid P, Heinemeier D, Korn L, Holtmann C, Böhm R. Beyond confidence: Development of a measure assessing the 5C psychological antecedents of vaccination. *PLoS One*. 2018;13(12):e0208601.
41. European Centre for Disease Prevention and Control (ECDC). Facilitating COVID-19 vaccination acceptance and uptake in the EU/EEA. Stockholm: ECDC; 2021. Available at: <https://www.ecdc.europa.eu/sites/default/files/documents/Facilitating-vaccination-uptake-in-the-EU-EEA.pdf>
42. Habersaat KB, Pistol A, Stanescu A, Hewitt C, Grbic M, Butu C, et al. Measles outbreak in Romania: understanding factors related to suboptimal vaccination uptake. *European Journal of Public Health*. 2020;30(5):986-92. Available at: <https://doi.org/10.1093/eurpub/ckaa079>
43. National Institute for Public Health and the Environment of the Netherlands. Concerns over falling vaccination coverage within National Immunisation Programme. Bilthoven: RIVM; 2023. Available at: <https://www.rivm.nl/en/news/concerns-over-falling-vaccination-coverage-within-national-immunisation-programme>
44. Direção-Geral da Saúde Portugal. Comunicados e Despachos da Diretora-Geral da Saúde. Lisbon2024. Available at: <https://www.dgs.pt/publicacoes/comunicados-e-despachos-do-diretor-geral.aspx>
45. National Public Health Organization Greece. Establishment of a working group to strengthen vaccination coverage and address a possible outbreak of measles cases in Greece - Athens; 2024. Available at: <https://eody.gov.gr/systasi-omadas-ergasias-gia-tin-enischysi-tis-emvoliaistikis-kalypsis-kai-tin-antimetopisi-pithanis-exarsis-kroysmaton-ilaras-stin-ellada/>
46. Ministry of Health Greece. National Immunization Committee Recommendations for Measles Vaccination – Athens 2024. Available at: <https://www.moh.gov.gr/articles/health/dieythynsh-dhmosias-ygieinhs/emboliasmoi/12181-systaseis-ths-ethnikhs-epitrophs-emboliasmwn-gia-ton-emboliasmo-enanti-ths-ilaras>
47. Health Service Executive (HSE) Ireland. HSE urges parents to make sure children and young people are vaccinated against measles. Dublin. Available at: <https://www.hse.ie/eng/services/news/media/pressrel/hse-urges-parents-to-make-sure-children-and-young-people-are-vaccinated-against-measles.html>

Technical Annex

Further information on risk communication and strategies to increase vaccine acceptance and uptake

Diagnostic tools on factors leading to lower vaccine acceptance and uptake

A framework such as the '5Cs' – which looks at Confidence, Constraints, Complacency, Calculation, and Collective responsibility – can be used to understand psychological antecedents of vaccination [40,41]. Behaviour change models can support development of tailored strategies. For example, the WHO Regional Office for Europe worked with Romania on a study of determinants of suboptimal measles vaccination uptake, using the WHO Tailoring Immunisation Programmes approach, building on the COM-B model to identify necessary conditions for behaviour change: Capability, physical and social opportunity, and motivation [42].

Monitoring trends in vaccine confidence to inform actions

The 'State of Vaccine Confidence in the EU' report (from 2022), shows that confidence in the MMR vaccine has remained stable and relatively high over time in relation to previous study periods (2018 and 2020). However, it declined in some countries, and showed differences between age groups –with drops in confidence in younger adults. The study also shows that confidence in the MMR vaccine among healthcare professionals (HCP) is in general high, but with a decrease in some countries in the number of HCP that agreed with statements that the MMR vaccine is both safe and important for children [30].

An example of interventions to address trends in vaccine uptake and confidence comes from the Netherlands. After observing a decline in the generally high uptake of vaccines within the national vaccination programme, an apparent fall in measles vaccination coverage for babies just below 90% for the first time in years, and poll results from 2022 showing that young parents have become less positive about vaccinations, the national public health institute is working with healthcare providers on how coverage can be improved, and launched a research programme (SocioVax) to gain insights into how best to inform people about vaccinations, how to help them make vaccination decisions and how to make vaccination more accessible [43].

Examples of risk communication activities reported by some EU countries

- The Directorate-General for Health in Portugal issued press releases on recent measles cases in the country, actions taken by the authorities, and reminded the population about the importance of vaccination and the schedule [44].
- Greece's National Public Health Organisation is preparing strategies for possible outbreaks, which include: informing the population about timely vaccination with two MCV doses, information for refugee and migrant accommodation centres, information for those about to travel to complete measles vaccination before a trip, especially if going to countries with outbreaks [45]. In addition, the Greek Ministry of Health issued a circular based on the current recommendation of the Hellenic National Immunization Technical Advisory Group for the timely vaccination of children, adolescents and adults with two doses of MMR vaccine [46]. Greece also plans to send a second circular to all healthcare workers with guidelines regarding infection control measures to prevent healthcare associated transmission.
- Ireland's Health Service Executive urges parents to make sure children and young people are vaccinated against measles, in the context of increased cases in Europe and the UK. Actions people should take to protect their families and communities are described [47].

Strategies to address lower vaccination uptake in underserved population groups

A study done as part of the RIVER-EU project identified the following key factors affecting vaccination (for MMR, and also HPV vaccines) in disadvantaged, minority populations in middle-to-high-income countries (including four EU/EEA countries): service delivery (limited time, geographic distance, lack of culturally-appropriate translated materials, difficulties navigating healthcare system), healthcare workforce (language and poor communication skills), financial costs and feelings of discrimination [38]. To address these barriers, the abovementioned study highlights the following strategies related to communication and facilitating access: educational materials and health services provided in the minority population's native language and in a culturally-appropriate manner by health professionals adequately trained in cultural competence; simple and clear guidelines to help new immigrant and minority groups access the healthcare system; automatic reminders and recall systems to facilitate vaccination.

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All experts have submitted declarations of interest, and a review of these declarations did not reveal any conflict of interest.