

e-ISSN: 2345-0592 Online issue Indexed in <i>Index Copernicus</i>	Medical Sciences Official website: www.medicisciences.com	
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Change in measles vaccination coverage and connections with outbreaks in Lithuania, Europe and worldwide

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Abstract

Background. Measles is a dangerous viral disease. The number of outbreaks is increasing worldwide. Inadequate vaccination is cited as the main reason for this.

Aim. To identify if there is a correlation between measles cases in Europe and globally in comparison with vaccination coverage.

Materials and methods. A systematic analysis of the literature was carried out in May-June using the search system Google Scholar, the scientific bases and journals, WHO's official website and its database, for Lithuania and its cases - National Center for Public Health and its database.

Results. In this study we found out there is a link between new measles cases, outbreaks, and vaccination rates. As overall immunization rates fall below 95% or remain stagnant, the incidence of new outbreaks rises. While Africa and the Eastern Mediterranean have the lowest vaccination rates and highest new cases from 2018 to 2021, Europe and the Western Pacific are also seeing rising case trends. In Europe, cases have increased annually since the COVID-19 pandemic, and overall vaccination rates remain inadequate. Lithuania is also experiencing challenges with measles, with new cases reported in 2019, 2020, 2023, and 2024.

Conclusions. The top priority is to raise overall immunization coverage above 95%, alongside developing effective healthcare systems and maintaining basic prevention measures. Additionally, innovative solutions like UV-C lamps can help eliminate airborne pathogens like measles.

Keywords: measles, outbreaks of measles, vaccination, immunization

1. Introduction

Measles is a highly contagious viral disease caused by the measles paramyxovirus, a pathogen that affects humans and has no environmental or animal reservoirs. The main complications of measles include middle ear infection, pneumonia and acute encephalitis. Immunity acquired from infection or vaccination provides long-term protection against severe disease and prevents further transmission. Before the introduction of the measles vaccine, over 90% of children under 15 years were infected, and the disease claimed millions of lives annually. The implementation of widespread vaccination has significantly reduced the endemicity of measles. Globally, immunization has led to a marked decrease in the number of measles cases [1]. However, outbreaks of measles indicate that measles remains a threat even in those countries where herd immunity has made the disease appear eradicated.

2. Materials and methods

When preparing a literature review, we searched for articles in both English and Lithuanian. The key words were: measles, vaccination, outbreak of measles. We searched for English articles in specialised search system *Google Scholar*, also in the scientific bases like *Science Direct*, *NCBI*, scientific journals like *The Journal of Infectious Diseases*, *International Journal of Public Health*, *Emerging Infectious Diseases*. There was also a lot of data from WHO's official website and its database. In Lithuanian, we mostly checked the official website of the National Center for Public Health and its database. 29 articles were in English and 4 were in Lithuanian. The articles release date was from 2020 to 2024. The review of scientific literature

was carried out in May-June. The number of measles cases in Lithuania, various world continents and the world as a whole was searched, as well as the percentage of vaccinations and the number of outbreaks.

3. Results

3.1. What is measles?

Measles is one of the most contagious viral diseases globally, typically presenting with a maculopapular rash. It is estimated that one person can infect 12-18 healthy individuals, compared to 1-2 people for influenza and an average of 5-6 people for COVID-19 [2,3,4]. The disease usually begins with non-specific symptoms resembling a cold: fever, cough, runny nose, sore throat, or red eyes. The incubation period is about 7-14 days [5]. Measles spreads through airborne droplets from an infected person's breathing, coughing or sneezing. Initially affecting the respiratory tract, the disease later spreads to multiple organ systems. Major complications include difficulty breathing, blindness, encephalitis, severe diarrhea and associated dehydration, and ear infections. Subacute sclerosing panencephalitis is a slowly progressing fatal complication [2]. The most common cause of measles-related death is pneumonia, accounting for 60% of deaths [6]. Risk groups include pregnant women, unvaccinated individuals and people with immunodeficiency. The disease most frequently affects children under 5 and adults over 30 years old [7].

3.2. Relevance of the topic

Given that measles is a dangerous disease for all age groups and its incidence has been rising globally since 2022 with no specific treatment available, vaccination remains the most effective

preventive measure [7]. Two doses of the measles-containing vaccine (MCV) are 97% effective in preventing measles, making it one of the most effective vaccines ever developed. Mild adverse reactions occur in less than 20% of patients and severe reactions are very rare. Before the creation of the vaccine, measles infected the majority of children under 15 years old and caused 135 million new cases and over 6 million deaths annually worldwide. The first single-dose measles vaccine was licensed in 1963 for a public use and African countries began national vaccination programs. By 1967, Gambia became the first country to halt virus transmission. In 1971, the combined MMR (measles, mumps, and rubella) vaccine was created, requiring a second dose, and in 2005, the MMRV (measles, mumps, rubella and varicella) vaccine was developed [8]. With the start of massive measles immunization in the 1980s globally, morbidity and mortality decreased significantly. From 2000-2018, global annual measles incidence per million people dropped by 66%, from 145 to 49 cases, annual reported cases decreased by 59%, from 853,479 to 353,236 cases, and estimated annual deaths from measles fell by 73%, from 535,600 to 142,300 cases. Routine measles vaccination with mass immunization campaigns are crucial. Achieving herd immunity requires maintaining high ($\geq 95\%$) two-dose vaccination coverage, essential for controlling the spread and aiming to eliminate measles. Despite the ongoing global WHO immunization campaign and the 2018-2019 measles outbreak, vaccination response and coverage remain inadequate [2]. The growing problem is the increasing number of measles cases and outbreaks, especially among unvaccinated individuals - primarily school-aged children and young adults [9]. Therefore, it

is crucial to identify the correlation between measles cases in Europe and globally in comparison with vaccination coverage, in order to educate the public about the insufficient scale of herd immunity and the resulting rise in new cases and outbreaks, so it is the aim of our research.

3.3. Situation of the measles

3.3.1. Situation in the world

Regarding the global measles situation over the past six years, interesting trends can be observed, with an uneven distribution of measles cases and outbreaks across different world regions. There is a fluctuating course of new measles cases. In 2018, 360 296 cases were recorded globally (twice as many as the previous year). In 2019, there was more than a twofold increase in new cases from 2018, with 873 022 cases. In 2020, a decrease in measles was observed, with 159 073 cases, and in 2021, there were 123 171 cases. However, from 2022, the number of cases began to rise again, with 205 173 cases, followed by 321 582 cases in 2023. According to WHO (Geneva) data from April 2024, there have been 94 438 cases so far. The reasons for such an interesting dynamic could be numerous, including COVID-19 protection measures, widespread quarantine, however the aspect of vaccination remains significant [10]. Global MCV vaccine coverage has stagnated since 2010, standing at 84-86% of the population. In 2019, there was the highest number of measles-related deaths in nearly two decades, and endemic spread resurged in several countries that had previously achieved measles infection control goals. As highlighted in the Democratic Republic of the Congo, the most severe outbreaks occur in resource-poor environments, leading to serious consequences. Reduced

measles vaccination during the 2018-2020 Ebola outbreak contributed to a measles outbreak, resulting in approximately 7000 measles-related deaths compared to 2243 Ebola deaths. The COVID-19 pandemic further worsened the long-term coverage of children's vaccinations. WHO estimated that in 2020, 22.7 million children missed their routine vaccination, which is 19.5% more than in 2019. UNICEF reported that from 2019 to 2021, 67 million children were under-vaccinated or entirely unvaccinated, and the number of children receiving the first dose of MCV (MCV1) decreased by 5%. In 2022, Cardoso Pinto et al. published a systematic review demonstrating that routine childhood vaccinations decreased by an average of 10.8% during the early COVID-19 pandemic [11].

Breaking cases down by region, in 2024, there have been 11 145 measles cases in Africa, 120 cases in North and South America, 29 405 in the Eastern Mediterranean region, 10 040 in the South-East Asia region, and 961 cases in the Western Pacific region, with Europe maintaining the highest number of cases at 42 767. According to data from 2018-2022, the African region had the most cases, with the Eastern Mediterranean region coming in second in 2021-2022 [12]. This can be explained by low vaccination coverage: in 2022, the African region had the lowest immunization rates of all WHO regions, with 69% for the first dose and 45% for the second dose, while the Eastern Mediterranean region had 83% and 78%, respectively. Reasons for the lower vaccination percentages in the African and Eastern Mediterranean regions include a lower number of literate and educated people, misinformation, limited healthcare systems, inaccessible services for those in need, staff shortages, poor infrastructure, vaccine unavailability, hard-to-reach living areas,

military conflicts and poorly functioning vaccination campaigns [13,14].

Vaccination coverage is disproportionately lower in low-income countries. The 2021 global vaccination report estimated that out of 18.2 million unvaccinated children, 12.8 million (70%) lived in middle-income countries, and 5 million (27%) lived in low-income countries [15]. The highest vaccination percentages in 2022 were achieved by the European and Western Pacific regions: the European region had 93% immunization for the first dose and 91% for the second dose, and the Western Pacific region had 92% and 91%, respectively [16]. This correlates with fewer disease outbreaks in these regions from 2018-2022 compared to other world regions. Despite this, even these regions faced the threat of measles outbreaks. A sharp increase in cases was observed in the European region in 2022, 2023, and 2024. In 2023, Kazakhstan was identified as the country with the most cases globally, with 65% of cases among children under five and 70% among unvaccinated individuals. This contributed to the overall and sudden increase in cases in the European region in 2023-2024, because Kazakhstan is part of the WHO European region [17]. However, a concerning trend is also observed in the Western Pacific region, where measles cases increased by 255% from 2022 to 2023. This surge is attributed to discrepancies in vaccination coverage, gaps in disease surveillance and travel by individuals from outbreak-affected countries. The decline in vaccination coverage in several Western Pacific countries during the COVID-19 pandemic, ongoing measles outbreaks in the Philippines and persistent endemic measles spread in Malaysia threaten a resurgence of measles in the region in 2024-2025 [18]. Therefore, the most

problematic regions for immunization remain Africa and the Eastern Mediterranean, which recorded the highest number of cases from 2018-2022. However, there is also a significant threat to the European and Western Pacific regions, where case numbers are rapidly increasing due to insufficient overall immunization rates.

3.3.2. Situation in Europe According to WHO, the European region is experiencing a dramatic increase in measles cases. As of April 10, 2024, there were 42 767 laboratory-confirmed cases in the region, exceeding the total number reported in 2023 [19]. In 2023, 40 out of 53 countries in the region and at least 10 EU/EEA countries reported an increase in measles cases. In 2023, more than 42 200 cases were confirmed in 41 member countries, compared to 941 cases in 2022, representing a 44-fold increase [20]. As of November 2023, there were about 21 000 hospitalizations and 5 measles-related deaths [21]. In 2023, cases were distributed relatively evenly across EU/EEA countries, except for Romania, Austria and France. Romania declared a measles epidemic in 2023, with 4679 cases from January 1 to February 6, including 6 deaths. In 2023, cases in EU/EEA countries were reported in all age groups, with the highest numbers among children aged 1-4 and 5-9 years old [22]. Data from the past six years suggests uneven growth in cases in the region: 89 148 in 2018, 106 130 in 2019, 10 945 in 2020, 99 in 2021, and 941 in 2022 [10]. This uneven trend and the tenfold decrease in 2020 compared to 2019 and 2021 compared to 2020, similarly to the situation in Lithuania, may be due to not increased vaccination rates, however COVID-19 pandemic-related health measures such as protective measures against COVID-19, which also prevented measles and contact restrictions,

when schools were closed in all countries and remote learning was introduced in at least 18 countries. It is difficult to discuss whether remote doctor consultations during the pandemic affected accurate measles diagnosis, especially since it was much harder to assess measles without seeing the patients' rash in person [23]. The biggest link to increased incidence in specific age groups is inadequate vaccination. In 2023, 75.7% of reported measles cases in the European region were unvaccinated patients. The largest proportion of unvaccinated children was among those under 1 year old (94.2%), while among individuals aged 30 and older, 46.7% were unvaccinated, and 36.2% had unknown vaccination status. In 2022, infants under 1 year old were the most affected age group (3.2 cases per 1 000 000 people), along with children aged from 1 to 4 years old. Such low vaccination rates among infected children and the highest increase in new cases in 2023 among 1-4 and 5-9-year-olds raise significant concerns about the increased risk of mortality from measles complications [22]. Regarding vaccination rates in the European region in 2023, WHO has not released data. In 2018, there was 95% one-dose vaccine coverage, in 2019 - 96%, 2020-2021 - 94%, 2022 - 93%, so a decreasing trend is observed. When it comes to the second dose of the vaccine, only since 2018 a vaccination rate higher than 90% has been observed: 91% in 2018, 92% in 2019, 91% in 2020, 92% in 2021 and 91% in 2022. However, this is still insufficient. The sudden outbreak of cases in 2022 (941 cases compared to 99 cases in 2021) and the rapidly increasing number of new cases in 2023 (42 200) are associated with the continuously decreasing first-dose vaccination rate and the fluctuating second-dose rate [24]. The national coverage for measles vaccines

decreased from 95% in 2019 to 92% in 2022. The coverage for the first dose decreased most sharply in Romania and Poland, and six countries, including Cyprus, Estonia, Lithuania, the Netherlands, Poland and Romania, reported that the first-dose coverage was less than 90% in 2022 [25]. Romania's case can illustrate the consequences of reduced vaccination coverage - in 2023, there was a measles outbreak in Romania, and in 2022 the first-dose vaccination rate was only 83%, and the second-dose rate was 71% [23]. Only five EU/EEA countries achieved more than 95% vaccination coverage with the second dose in 2022 - Hungary, Norway, Poland, Portugal and Slovakia. The connection with vaccination is clear - Hungary, Portugal and Slovakia did not record any measles cases in 2022 [11]. Thus, as vaccination coverage decreases or remains unstable in the European region, the number of sporadic outbreaks in countries, especially those with lower vaccination rates, increases. To eliminate measles, countries must achieve and maintain more than 95% coverage using two doses of the measles vaccine. Therefore, achieving high routine vaccination coverage must remain a top priority for all countries [21].

3.3.3. Situation in Lithuania

In Lithuania, children are vaccinated twice according to the national immunization schedule: at 15 months and 6-7 years old. The combined MMR (measles, mumps and rubella) vaccine is used. The MMR vaccine was introduced in 1946, and since 1988, two doses have been administered [26]. In 2017, WHO's European Regional Verification Commission for Measles and Rubella Elimination (RVC) declared Lithuania as one of 33 countries in the European region to have eliminated measles

[27,28]. However, there was a measles outbreak in Lithuania in 2019 resulting in 834 cases, mostly in major cities: 425 in Kaunas and 314 in Vilnius. In 2020, only 2 cases were reported in the Kaunas district, indicating a significant decrease. There were no cases in 2021 and 2022. As of April 12, 2024, 19 cases have been observed in 2024, showing an increase compared to previous years (in 2023, there were 3 cases in the Klaipėda district). Among adults, 68.4% of those infected were unvaccinated, 10.5% had an incomplete vaccination course, and 21.1% were fully vaccinated [26]. It is believed that fewer cases were observed during the COVID-19 pandemic due to reduced hospital and doctor accessibility, milder disease forms or possibly fewer cases due to COVID-19 control measures like masks, respirators and quarantine, which also had an impact on other airborne diseases including measles. In Lithuania, the overall vaccination rate is declining: from 94% in 2019 to 87% in 2022 [29]. In 2022, the MMR vaccination rate among 2-year-olds was 86.46%, and among 7-year-olds, 86.53%. In 2023, 87.08% of children under 2 years old and 85.72% of children under 7 years old were vaccinated [30]. In 2021, fewer children were vaccinated with the MMR vaccine in almost all Lithuanian municipalities, with sufficient coverage remaining only in Alytus County and only in the 7-year-old age group. In Klaipėda, MMR vaccination coverage for 2-year-olds decreased to 80.70% in 2022 [29]. National Center For Public Health (in Lithuanian - NVSC) specialists emphasize that to control measles, 95% of the population must be vaccinated; otherwise, there is a real threat of outbreaks not only among children but also among adults [29]. Thus, observing the situation in Lithuania, overall vaccination coverage is

insufficient (only a few municipalities ensure adequate levels), increasing the likelihood of new outbreaks.

3.4. Discussion and recommendations

In summary, new measles cases, outbreaks, and vaccination rates are closely related. As the overall immunization percentage decreases or remains below 95%, the number of new outbreaks increases. This problem is encountered worldwide. Although Africa and the Eastern Mediterranean were identified as regions with the lowest vaccination rates and the highest number of new cases an increasing trend in cases has been observed in Europe and the Western Pacific region [12]. The most vulnerable groups are children aged 1-4 and 5-9 years old, with the primary cause of measles being non-vaccination [22]. Lithuania is also facing issues with measles, with new cases observed in 2019, 2020, 2023 and 2024 [26].

WHO made several recommendations to reduce the number of measles cases. The most important aspect remains increasing the overall immunization coverage to over 95%, which requires the highest priority: investing more funds, providing countries with necessary vaccines, and giving evidence-based information. It is also crucial to help develop more effective healthcare systems in countries experiencing war or famine conditions, to increase education in communities that strictly oppose vaccines, to identify the reasons behind skepticism Another important recommendation is to maintain simple prevention measures such as hand hygiene, limiting contact with symptomatic individuals and using protective measures. The introduction of innovative preventive measures is also beneficial, such as using UV-C light lamps, which target airborne

pathogens and can destroy up to 98% of pathogens in enclosed spaces. Additionally, actively monitoring any increases in measles cases in countries to detect them early is essential [2,5,22,31,32].

4. Conclusions

Even though the rate of universal immunization against measles is declining, the most effective recommendations for reducing the number of new cases remain: increasing the extent of universal immunization to > 95%, developing more efficient health protection systems in poor countries, analysing reasons why such countries refuse national vaccination, not forgetting basic preventive measures (hand hygiene, protective measures) and also by turning to innovative preventive measures, such as UV-C lamps, which effectively destroy the causative agents of measles.

References

1. Xu J, Doyon-Plourde P, Tunis M, Quach C. Effect of early measles vaccination on long-term protection: A systematic review. *Vaccine*. 2021 May;39(22):2929-37. Available from: <https://www.sciencedirect.com/science/article/pii/S0264410X21004473>
2. Gastañaduy PA, Goodson JL, Panagiotakopoulos L, Rota PA, Orenstein WA, Patel M. Measles in the 21st Century: Progress Toward Achieving and Sustaining Elimination. *J Infect Dis*. 2021 Oct 1;224(Suppl 4) – S428. Available from: https://academic.oup.com/jid/article/224/Supplement_4/S420/6378081
3. Cheung J, Tsang TK, Yen H, et al. Determining Existing Human Population Immunity as Part of Assessing Influenza

- Pandemic Risk. *Emerg Infect Dis.* 2022;28(5):977-985. Available from: https://wwwnc.cdc.gov/eid/article/28/5/21-1965_article
4. Ramirez V. What Is R0? Gauging Contagious Infections [Internet]. *Healthline.* 2020. Available from: <https://www.healthline.com/health/r-naught-reproduction-number>
 5. Blakely K, Suttle R, Wood T, Stallworth K, Baker N. Measles — What’s Old Is New Again. *Nurs Womens Health.* 2020;24(1):45-51. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1751485119302314>
 6. World Health Organization. Measles. Available from: <https://www.who.int/news-room/fact-sheets/detail/measles>
 7. European Centre For Disease Prevention and Control. Factsheet about measles. Available from: <https://www.ecdc.europa.eu/en/measles/facts>
 8. World Health Organization. History of measles vaccination. 2023. Available from: <https://www.who.int/news-room/spotlight/history-of-vaccination/history-of-measles-vaccination>
 9. Nacionalinis visuomenės sveikatos centras. Tymų statistiniai duomenys. Available from: <https://nvsc.lrv.lt/lt/uzkrečiamųjų-ligų-valdymas/uzkrečiamosios-ligos/tymai/tymu-statistiniai-duomenys/>
 10. World Health Organization. Measles reported cases and incidence. Available from: <https://immunizationdata.who.int/global/wiise-detail-page/measles-reported-cases-and-incidence?CODE=EUR&YEAR=>
 11. European Centre For Disease Prevention and Control. Annual Epidemiological Report for 2022. Available from: <https://www.ecdc.europa.eu/sites/default/files/documents/Measles%20Annual%20Epidemiological%20Report%202022%20data.pdf>
 12. World Health Organization. Measles vaccination coverage MCV1. Available from: <https://immunizationdata.who.int/global/wiise-detail-page/measles-vaccination-coverage?CODE=EMR+SEAR+AFR+EUR+WPR+AMR&ANTIGEN=MCV1&YEAR=>
 13. Oduoye MO, Zuhair V, Marbell A, Olatunji GD, Khan AA, Farooq A, et al. The recent measles outbreak in South African Region is due to low vaccination coverage. What should we do to mitigate it? *New Microbes New Infect* [Internet]. 2023 Sep 1;54:101164. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10344677/>
 14. Musa N. Progress Toward Measles Elimination — World Health Organization Eastern Mediterranean Region, 2019–2022. *MMWR Morb Mortal Wkly Rep* [Internet]. 2024;73. Available from: <https://www.cdc.gov/mmwr/volumes/73/wr/mm7307a1.htm>
 15. Packham A, Taylor AE, Karangwa M-P, Sherry E, Muvunyi C, Green CA. Measles Vaccine Coverage and Disease Outbreaks: A Systematic Review of the Early Impact of COVID-19 in Low and Lower-Middle Income Countries. *Int J Public Health.* 2024;69:1606997. Available from: <https://www.ssph-journal.org/journals/international-journal-of-public-health/articles/10.3389/ijph.2024.1606997/full>
 16. World Health Organization. Measles vaccination coverage MCV1, MCV2. Available from:

<https://immunizationdata.who.int/global/wiise-detail-page/measles-vaccination-coverage>

17. University of Minnesota. Measles activity expands rapidly in Europe, Kazakhstan worst affected. Center for Infectious Disease Research and Policy. Available from: <https://www.cidrap.umn.edu/measles/measles-activity-expands-rapidly-europe-kazakhstan-worst-affected>

18. World Health Organization. Western Pacific countries at risk of measles outbreaks due to immunization and surveillance gaps. Available from: <https://www.who.int/westernpacific/news/item/01-03-2024-western-pacific-countries-at-risk-of-measles-outbreaks-due-to-immunization-and-surveillance-gaps>

19. World Health Organization. Provisional monthly measles and rubella data. Available from: <https://www.who.int/teams/immunization-vaccines-and-biologicals/immunization-analysis-and-insights/surveillance/monitoring/provisional-monthly-measles-and-rubella-data>

20. United Nations Regional Information Centre. WHO: "Alarming" rise of measles cases in Europe. Available from: <https://unric.org/en/who-alarming-rise-of-measles-cases-in-europe/>

21. World Health Organization. A 30-fold rise of measles cases in 2023 in the WHO European Region warrants urgent action. Available from: <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>

22. European Centre For Disease Prevention and Control. Measles EU Threat

Assessment Brief February 2024. Available from:

<https://www.ecdc.europa.eu/sites/default/files/documents/measles-eu-threat-assessment-brief-february-2024.pdf>

23. Nicolay N, Mirinavičiute G, Mollet T, Celentano LP, Bacci S. Epidemiology of measles during the COVID-19 pandemic, a description of the surveillance data, 29 EU/EEA countries and the United Kingdom, January to May 2020. *Euro Surveill.* 2020 Aug 6;25(31). Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7459270/>

24. World Health Organization. Measles vaccination coverage. Available from: <https://immunizationdata.who.int/global/wiise-detail-page/measles-vaccination-coverage?CODE=EUR&ANTIGEN=MCV2&YEAR=>

25. Al-Tawfiq JA, Jain N, Tanasov A, Schlagenhauf P. Measles Matter: Recent Outbreaks Highlight the Need for Catch-up Vaccination in Europe and Around the Globe. *New Microbes New Infect.* 2024 Apr 1;58:101238–8. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10973198/>

26. Nacionalinis visuomenės sveikatos centras. Tymai. Available from: <https://nvsc.lrv.lt/lt/uzkreciamuju-ligu-valdymas/uzkreciamosios-ligos/ligu-aprasai-pagal-abecele/t/tymai-2/>

27. Swain C. Measles eliminated in 33 countries. Cambridge MedChem Consulting. Available from: https://www.cambridgemedchemconsulting.com/news/index_files/a146522aa2b7f4a12dabc0a38cb9f587-294.html

28. World Health Organization Regional Office for Europe. Measles and rubella elimination country profile: Lithuania. Available from: <https://iris.who.int/handle/10665/346415>
29. Nacionalinis visuomenės sveikatos centras. Lietuvoje – pirmieji tymų atvejai, raginame nepamiršti skiepų. Available from: <https://nvsc.lrv.lt/lt/naujienos/lietuvoje-pirmieji-tymu-atvejai-ragine-nepamirsti-skiepu/>
30. Nacionalinis visuomenės sveikatos centras. Skiepijimo situacija Lietuvoje per metus reikšmingai nepagerėjo – dar reikia pasistengti. Available from: <https://nvsc.lrv.lt/lt/naujienos/skiepijimo-situacija-lietuvoje-per-metus-reiksmingai-nepagerejo-dar-reikia-pasistengti/>
31. Higuera V. Measles: Everything You Need to Know. 2024. Available from: <https://www.healthline.com/health/measles#prevention>
32. Columbia University Irving Medical Center. New Type of Ultraviolet Light Makes Indoor Air as Safe as Outdoors. 2022. Available from: <https://www.cuimc.columbia.edu/news/new-type-ultraviolet-light-makes-indoor-air-safe-outdoors>