Measles Resurgence in Europe: Migrants and Travellers are not the Main Drivers

Wei-Yee Leong1*, Annika Beate Wilder-Smith2

1Lee Kong Chian School of Medicine, Nanyang Technological University, Singapore
2University of Edinburgh, Edinburgh Medical School, Scotland, United Kingdom

ABSTRACT

Measles is a highly transmissible viral infection that may lead to serious illness, lifelong complications, and death. As there is no animal reservoir for measles, measles resurgence is due to human movement of viremic persons. Therefore, some have blamed the enormous migration into Europe in the past 5 years for the measles resurgence in this region. We set out to determine the main driver for measles resurgence in Europe by assessing vaccine coverage rates and economic status in European countries, number of migrants, and travel volumes. Data on measles vaccine coverage rates with two vaccine doses of measles, mumps and rubella (MMR) [Measles Containing Vaccine (MCV)] and total number of measles cases in 2017 for Europe, including Eastern European countries, were obtained, in addition to Gross Domestic Product (GDP), and number of migrants and tourist arrivals. The outcome measured, incidence of measles per 100,000, was log transformed and subsequently analyzed using multiple linear regression, along with predictor variables: number of international migrants, GDP per capita, tourist arrivals, and vaccine coverage. The final model was interpreted by exponentiating the regression coefficients. Incidence of measles was highest in Romania (46.1/100,000), followed by Ukraine (10.8/100,000) and Greece (8.7/100,000). MCV2 coverage in these countries is less than 84%, with lowest coverage rate (75%) reported in Romania. Only vaccine coverage appears to be the significant predictor in the model (p < 0.001) for incidence of measles even after adjusting for international migrants, international tourist arrivals, and GDP per capita. With one unit increase in vaccination coverage, the incidence of measles decreased by 18% [95% confidence interval (CI): 10–25]. Our results showed that number of migrants and international tourist arrivals into any of the European countries were not the drivers for increased measles cases. Countries with high vaccine coverage rates regardless of economic status did not experience a resurgence of measles, even if the number of migrants or incoming travellers was high. The statistically significant sole driver was vaccine coverage rates. These analyses reemphasize the importance of strategies to improve national measles vaccination to achieve coverage greater than 95%.

ARTICLE INFO

Article History
Received 18 July 2019
Accepted 24 September 2019

Keywords
Measles
migration
travel
resurgence
vaccine hesitancy
global vaccine action plan
vaccine coverage

1. INTRODUCTION

Measles is one of the most transmissible viral infections that, although mild in most cases, can cause serious illness, lifelong complications, and death [1]. Before vaccine introduction, measles affected more than 90% of children globally by the age of 15 [2]. Effectiveness of the measles vaccine after one dose administered at the age of 12 months or later is 93% and after two doses is 97% [3]. Therefore, with such a highly efficacious vaccine, measles eradication is theoretically feasible. Hence, in 2010, the World Health Assembly ( WHA) set three milestones for measles prevention to be achieved by 2015: first, aiming for a routine coverage of Measles Containing Vaccine (MCV1) (first dose of MCV) to ≥90% at the national level and ≥80% at the district level; second, to reduce annual measles incidence globally to less than five cases per million population; and third, to reduce global mortality due to measles by 95% [2]. In 2012, the WHA endorsed the GVAP with the objective of eliminating measles in four of the six WHO regions by 2015 and in five regions by 2020 [4]. Indeed, between 2000 and 2017, the estimated MCV1 coverage has increased globally from 72% to 85%, while annual reported measles incidence decreased by 83% and the annual estimated mortality declined by 80% (from 545,174 to 109,638) [2].

The United States was the first WHO region to be declared having achieved measles elimination in 1999; a historic milestone that proved that measles elimination could be achieved through high routine coverage, engagement of regular immunization activities, and a robust and accurate case-based surveillance [5]. However, in 2018, the United States saw a major resurgence, mainly because of the migration crisis in Venezuela, combined with decreasing vaccine coverage in neighboring countries that increased the vulnerability to importation of measles [6,7]. The extent of the current outbreak has significantly hampered WHO’s global measles and rubella elimination goals and efforts. If this persists for longer than 12 months, it will result in affected countries losing their elimination status.

Unlike the United States, Europe has reasonably high measles vaccination coverage. In 1998, the WHO European Region set a
target to eliminate measles by 2010 [8], which was not achieved. In 2018, Europe saw a major resurgence of measles; the total number of measles cases in 2018 was the highest in this decade, reaching three times the total cases in 2017 [9]. In 2018, Europe reported more than 21,000 cases of measles, including 35 deaths [10]. Early reports in 2019 show a further 300% increase [11]. As there is no animal reservoir for measles, measles resurgence is due to human movement of viremic persons [10]. With the increasing number of migrants to Europe from countries where measles virus is potentially circulating [12], there is concern that such migration could contribute to the measles resurgence in this region. Indeed, measles seroprotection in migrants is often suboptimal [13–15]. Measles outbreaks in migrant populations have been reported [16]. In addition to migrants, international travellers can also be a major source of measles importation [5,17,18]. Travel-associated measles transmission to household members and other contacts has been described [19,20]. Multiple measles cases can also occur as a result of exposure during air travel [21,22]. The second largest measles outbreak in the United States occurred in 2011 due to measles importation via a traveler [23]. Given the increasing travel volumes globally, including to countries with measles [24], the likelihood of importing measles into Europe is increasing.

We set out to determine the main driver for measles resurgence in Europe by assessing vaccine coverage rates and economic status in European countries, number of migrants, and tourist arrivals.

2. MATERIALS AND METHODS

For this analysis, European countries as listed by WHO Europe were selected (http://www.euro.who.int/en/countries). For these countries, we obtained the most recent data from WHO sources on measles vaccine coverage rates with two vaccine doses of Measles, Mumps, and Rubella (MMR) (MCV2) [25]; the most recent published data are from 2017. We then obtained the number of all measles cases for the year 2017 for each of these European countries [26]. To calculate the population incidence rate, we obtained population size data from Eurostat database [27], and missing population size data for Monaco were substituted by the data from the World Bank. Number of international migrants (2017) for each country was obtained from Eurostat database; migrant and migration population statistics database [27]. A migrant is defined as any person who is moving or has moved across an international border or within a state away from his/her habitual place of residence, regardless of the person’s legal status, whether the movement is voluntary or involuntary, what the causes for the movement are, or what the length of the stay is, according to the world migration report [28,29]. Missing data were substituted with the latest available data from the same Eurostat database or the Migration Data Portal [30], whichever provided the most current data.

Gross Domestic Product (GDP) per capita for the year 2017 by European country was obtained from the World Bank Database [31], and data for international tourist arrival (by country) was retrieved from the United Nations World Trade Organization Tourism Highlights 2018 Report [32]. The term “international tourist arrivals” encompasses tourists and those crossing international borders for purposes other than tourism, such as business and studies.

Since the outcome variable (incidence of measles per 100,000) is highly skewed, it was log transformed using log [(total measles cases + 1)/total population] × 100,000 and then subsequently analyzed using the multiple linear regression model with the exposure variables being measles vaccine coverage, international migrants, international arrivals, and GDP per capita. The interpretation of the final model was by exponentiating the regression coefficients. Statistical analysis was performed using STATA version 14 (STATA Corp., TX, USA).

3. RESULTS

Table 1 summarizes the vaccine coverage rate, GDP per capita, international migrant numbers, international tourist arrivals, and calculated incidence of measles in European countries in 2017. Romania (n = 9076), Ukraine (n = 4782), and Italy (n = 4042) had the highest reported number of measles cases, while incidence of measles was highest in Romania (46.1/100,000), followed by Ukraine (10.8/100,000) and Greece (8.7/100,000). Vaccine coverage (MCV2) in these countries is <84%, with lowest coverage rate (75%) reported in Romania. In the same year, we observed an average of 13,475,163 tourist arrivals compared to 118,974 migrants coming into the selected European countries.

Table 2 shows the exponentiated coefficients of the multiple linear regression model. Only vaccine coverage is the significant predictor in the model (p < 0.001) for measles incidence after adjusting for international migrants, international tourist arrivals, and GDP per capita. With one unit increase in vaccination coverage, the incidence of measles decreases by 18% [95% confidence interval (CI): 10–25].

4. DISCUSSION

Our findings show a statistically significant inverse relationship between MCV2 coverage rates and notified measles cases in European countries. With one unit increase in vaccination coverage, the incidence of measles is estimated to decrease by 18%. The linear regression model showed that number of migrants and international tourist arrivals into any of the European countries were not the main drivers for increased measles cases, instead suboptimal vaccine coverage was. Countries with high vaccine coverage rates regardless of economic status as measured by GDP did not experience a resurgence of measles, even if the number of migrants or travel arrivals was high.

Although Europe has seen a huge influx of migrants from low- to middle-income countries [12] and such migrants usually have a lower seroprotection for all vaccine preventable diseases including measles [13,14], our findings underpin that migrants are not the main drivers for measles resurgence in Europe. The number of migrants is possibly too low to account for such resurgence and is far surpassed by the number of international tourist arrivals. There were around 120,000 migrants versus 13 million tourist arrivals; in other words, migrants only present <1% of all persons crossing international borders to enter Europe. Tourist travellers would hence be much more likely to contribute to measles spread via population movements, even if their vaccine coverage rates are higher. This was shown in the United States where the majority of imported measles was due to travellers with inadequate
Table 1  Number of international migrants, international tourist arrival, vaccination coverage, measles cases, calculated incidence of measles, population size, GDP per capita for the year 2017, by country in Europe

| Country                  | International migrants (2017) | GDP per capita (2017) | International arrivals (×1000) (2017) | MCV1 (%) | MCV2 (%) | Population (2017) | Measles cases (2017) | 2017 Incidence of measles (per 100,000) |
|--------------------------|-------------------------------|-----------------------|--------------------------------------|-----------|-----------|------------------|----------------------|--------------------------------------|
| Albania                  | 12,943.4                      | 4,643,000             | 96 98                                 | 2,930,000 | 12        | 0.44             |                      |                                      |
| Andorra                  | 49,900.0                      | 3,003,000             | 99 94                                 | 77,000     | 0         | 1.30             |                      |                                      |
| Armenia                  | 966.0                         | 1,495,000             | 96 97                                 | 2,930,000 | 1         | 0.07             |                      |                                      |
| Austria                  | 53,879.3                      | 29,460,000            | 96 84                                 | 8,735,000  | 95        | 1.10             |                      |                                      |
| Azerbaijan               | 17,449.9                      | 2,454,000             | 98 97                                 | 9,828,000  | 0         | 0.01             |                      |                                      |
| Belgium                  | 49,366.7                      | 8,358,000             | 96 85                                 | 11,429,000 | 367       | 3.22             |                      |                                      |
| Bulgaria                 | 20,948.1                      | 8,883,000             | 94 92                                 | 7,085,000  | 165       | 2.34             |                      |                                      |
| Bosnia and Herzegovina   | 13,107.7                      | 92,000                | 92 89                                 | 3,507,000  | 18        | 0.54             |                      |                                      |
| Belarus                  | 18,895.6                      | 2,000,000             | 97 98                                 | 9,468,000  | 1         | 0.02             |                      |                                      |
| Croatia                  | 26,295.5                      | 15,593,000            | 89 95                                 | 4,189,000  | 7         | 0.19             |                      |                                      |
| Cyprus                   | 36,012.4                      | 3,652,000             | 90 88                                 | 1,180,000  | 3         | 0.34             |                      |                                      |
| Czech Republic (Czechia) | 38,019.6                      | 12,808,000            | 97 90                                 | 10,618,000 | 142       | 1.35             |                      |                                      |
| Denmark                  | 54,356.4                      | 10,781,000            | 97 88                                 | 5,734,000  | 4         | 0.09             |                      |                                      |
| Estonia                  | 33,447.8                      | 3,245,000             | 93 91                                 | 1,310,000  | 3         | 0.15             |                      |                                      |
| Finland                  | 46,343.5                      | 3,181,000             | 94 92                                 | 5,523,000  | 11        | 0.22             |                      |                                      |
| France                   | 44,032.9                      | 86,918,000            | 90 80                                 | 64,980,000 | 519       | 0.80             |                      |                                      |
| Georgia                  | 10,674.5                      | 3,479,000             | 95 90                                 | 3,912,000  | 94        | 2.43             |                      |                                      |
| Germany                  | 52,555.9                      | 37,452,000            | 97 93                                 | 82,114,000 | 929       | 1.13             |                      |                                      |
| Greece                   | 28,582.8                      | 27,194,000            | 97 83                                 | 11,160,000 | 968       | 8.68             |                      |                                      |
| Hungary                  | 28,798.6                      | 15,785,000            | 99 99                                 | 9,722,000  | 36        | 0.38             |                      |                                      |
| Iceland                  | 55,322.1                      | 2,224,000             | 92 95                                 | 335,000    | 3         | 1.19             |                      |                                      |
| Ireland                  | 76,744.7                      | 10,388,000            | 92 92                                 | 4,762,000  | 25        | 0.55             |                      |                                      |
| Israel                   | 38,867.8                      | 3,613,000             | 98 96                                 | 8,322,000  | 42        | 0.52             |                      |                                      |
| Italy                    | 40,923.7                      | 58,253,000            | 92 86                                 | 59,360,000 | 4042     | 6.81             |                      |                                      |
| Kyrgyzstan               | 3735.4                       | 2,930,000             | 95 96                                 | 6,045,000  | 5         | 0.10             |                      |                                      |
| Lithuania                | 33,252.7                      | 2,523,000             | 94 92                                 | 2,890,000  | 2         | 0.10             |                      |                                      |
| Luxembourg               | 107,640.6                     | 1,046,000             | 99 86                                 | 583,000    | 4         | 0.86             |                      |                                      |
| Latvia                   | 28,362.0                      | 1,950,000             | 96 89                                 | 1,950,000  | 0         | 0.05             |                      |                                      |
| Monaco                   | 115,700.0                     | 355,000               | 87 79                                 | 39,000    | 1         | 5.13             |                      |                                      |
| Republic of Moldova      | 5710.8                       | 145,000               | 93 92                                 | 4,051,000  | 0         | 0.02             |                      |                                      |
| The former Yugoslav Republic of Macedonia | 15,290.3 | 631,000 | 83 83 | 2,083,000 | 19 | 0.96 |                      |                                      |

Note: There are no available data from 2017. Data are substituted with the latest available data from either Eurostat database or Migration Data Portal (whichever is more current). Data from 2016. Data from 2010. [https://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=tps00176&plugin=1]. [https://migrationdataportal.org/?isStockAbs_btt=2017&cm=49:795]. [https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD]. [https://www.e-unwto.org/doi/pdf/10.18111/9789284419876]. [http://apps.who.int/gho/data/node.main.MCV2n?lang=en]. [http://apps.who.int/gho/data/node.main.MCV2n?lang=en]. [http://apps.who.int/gho/data/node.main.A826?lang=en]. [http://apps.who.int/gho/data/node.main.MCV2n?lang=en]. [https://population.un.org/wpp/DataQuery/]. [http://apps.who.int/gho/data/view.main.1540_62?lang=en].
Table 2  Exponentiated coefficient of multiple linear regression model for incidence of measles

| Incidence of measles (2017) | Coefficient | 95% CI (coefficient) | Exponentiated (coefficient) | Exponentiated (95% CI coefficient) |
|-----------------------------|-------------|----------------------|-----------------------------|-----------------------------------|
| Vaccine coverage            | −0.19       | −0.28, −0.10         | 0.82 (p < 0.0001)           | 0.75, 0.90                        |
| International migrants      | 1.72e−7     | −2.04e−7, 5.48e−7    | 1.00 (p = 0.359)            | 1.00, 1.00                        |
| GDP per capita              | −3.68e−7    | −2.73e−7, 2.66e−5    | 1.00 (p = 0.978)            | 1.00, 1.00                        |
| International tourist arrival| 5.69e−4     | −2.979e−4, 4.11e−4   | 1.00 (p = 0.749)            | 1.00, 1.00                        |

or absent immunization coverage against measles, rather than migrants [33]. Another study compared the potential risk of measles importation from migrants versus travellers into the United States using a cross-sectional, ecological design [34]. The study showed that there are 10 times more annual U.S. visitors to high measles incidence countries than there are U.S. immigrants from high measles incidence countries. In The Netherlands, travellers introduced measles resulting in a cluster of measles in unvaccinated persons, but due to the high vaccine coverage rate in this country it did not spread further [35]. GeoSentinel is a global sentinel surveillance of infectious diseases in returning travelers [36]. Measles remains a risk for travellers, with 94 measles diagnoses reported to the GeoSentinel network from 2000 to 2014, two-thirds since 2010 [37], with Asia being the most common exposure region, followed by Africa and Europe. The years 2018 and 2019, however, saw a further increase of measles in travellers seen at GeoSentinel sites [38]. Efforts to reduce travel-associated measles should target all travellers, with a particular focus on catch-up vaccination initiatives of susceptible adults [5]. To minimize the risk of introducing measles, physicians should advise persons who are planning international travel to have received at least two doses of measles vaccination before travel [1]. Persons born before 1957 are considered to be immune to measles [2]. However, the key message is that introduction of measles into areas or countries in Europe should not result in autochthonous transmission if vaccine coverage rates were to be high. Our analyses reemphasize the importance of strategies to improve national measles vaccination to achieve coverage far greater than 95%. Measles vaccination is integrated in all European national immunization programs; therefore, the reasons for the continuing suboptimal MCV2 vaccine coverage in some countries need to be determined in order to implement policies to improve coverage and thereby eliminate measles in the European region.

While reported childhood immunization coverage rates demonstrate high two-dose MMR coverage of >95% in many European countries, such coverage rates only provide data on the current program; hence, such data are limited to younger age groups and are often not available for adolescents or adults. For example, in Australia, young adults have been shown to be an important group at risk of under-immunization, as a result of lower vaccine coverage during childhood in an era of decline disease rates and single-vaccine dose recommendations [39]. Another concern is that measles-specific IgG antibodies may decline with time since vaccination; however, the implications of declining measles-specific IgG antibody levels for maintaining measles elimination are unclear. The plaque reduction neutralization measurement of functional measles-specific antibodies does not assess cellular immunity that may be associated with durable protective immunity after vaccination [40]. Despite of declining antibody levels, there is currently no evidence that booster doses would be considered in any country at higher age. There is a need to determine correlates of protection against measles transmission and disease in the post-elimination era [39].

Although the vast majority of measles cases in Europe occur in countries with weak health systems, vaccine refusal is emerging as a risk factor in countries with strong health systems: vaccine hesitancy was nominated as one of the top 10 global health threats in 2019 [41]. Vaccine hesitancy encompasses the broad spectrum from total refusal to delayed acceptance, despite the availability of vaccination services [42]. With the increasing role of social media in spreading inaccurate information regarding vaccine-associated risks, clinicians need to scale up their efforts in managing parental concerns about vaccination and responding to questions from the public regarding the rationale for, and safety of, measles vaccines [1,43].

In summary, our study confirmed that vaccine coverage rates are the main drivers of measles resurgence in Europe. Countries with MCV2 >95% in Europe do not see a high measles incidence, even if the number of migrants and travellers are high. This notion is also consistent with observations for polio: polio importation will not result in secondary transmission if the vaccine coverage is high [44]. Nevertheless, pockets of unvaccinated persons even in high coverage countries can trigger small outbreaks [35]. In addition to maintaining and increasing high vaccine coverage rates of new birth cohorts in Europe, prevention of measles outbreaks requires the identification and vaccination of high-risk persons such as school-attending children, college students, international travellers, migrants, and health care workers, or those persons from communities with certain religious or other worldviews that are associated with vaccine hesitancy. Clinicians should consider measles among patients presenting with febrile rash illness and history of recent travel, and clinicians should promptly report suspected illnesses. Early identification of infectious patients, rapid public health investigation, and maintenance of high vaccine coverage are critical for the prevention and control of measles outbreaks. Because adults and adolescents are usually missed in national vaccination programs, travel medicine consultations should fill the gap [45]. Homogeneous consistent coverage >95% needs to be achieved.

CONFLICTS OF INTEREST

The authors declare they have no conflicts of interest.

AUTHOR CONTRIBUTIONS

W.Y.L. did the statistical analyses, W.Y.L. and A.B.W-S. obtained the data from various public sources and both wrote the final manuscript.
REFERENCES

[1] Strebel PM, Orenstein WA. Measles. N Engl J Med 2019;381; 349–57.

[2] World Health Organization. Measles vaccines: WHO position paper – April 2017. Wkly Epidemiol Rec 2017;92:205–27.

[3] McLean HQ, Fiebelkorn AP, Temte JL, Wallace GS. Centers for Disease Control and Prevention. Prevention of measles, rubella, congenital rubella syndrome, and mumps, 2013: summary recommendations of the Advisory Committee on Immunization Practices (ACIP). MMWR Recomm Rep 2013;62;1–34.

[4] World Health Organization. Global Vaccine Action Plan 2011–2020. Available from: https://www.who.int/immunization/global_vaccine_action_plan/GVAP_doc_2011_2020/en/.

[5] Heywood AE. Measles: a re-emerging problem in migrants and travellers. J Travel Med 2018;25.

[6] Fujita DM, Salvador FS, Nali LHDS, Luna EJA. Decreasing vaccine coverage rates led to increased vulnerability to the importation of vaccine-preventable diseases in Brazil. J Travel Med 2018;25.

[7] Tuite AR, Thomas-Bachi A, Acosta H, Bhatia D, Huber C, Petrasek K, et al. Infectious disease implications of large-scale migration of Venezuelan nationals. J Travel Med 2018;25.

[8] World Health Organization. Eliminating measles and rubella. Framework for the verification process in the WHO European Region. Available from: http://www.euro.who.int/__data/assets/pdf_file/0009/247356/Eliminating-measles-and-rubella-Framework-for-the-verification-process-in-the-WHO-European-Region.pdf.

[9] Leong WY. Measles cases hit record high in Europe in 2018. J Travel Med 2018;25.

[10] Massad E. Measles and human movement in Europe. J Travel Med 2018;25.

[11] Mahase E. Measles cases rise 300% globally in first few months of 2019. BMJ 2019;365;l1810.

[12] Pavli A, Maltezou H. Health problems of newly arrived migrants and refugees in Europe. J Travel Med 2017:24.

[13] Cecarelli G, Vita S, Riva E, Cella E, Lopalco M, Antonelli F, et al. Susceptibility to measles in migrant population: implication for policy makers. J Travel Med 2018;25.

[14] Staeherlin C, Chernet A, Sydov W, Piso R, Suter-Riniker F, Funex S, et al. Seroprotection rates of vaccine-preventable diseases among newly arrived Eritrean asylum seekers in Switzerland: a cross-sectional study. J Travel Med 2019;26.

[15] Hu X, Xiao S, Chen B, Sa Z. Gaps in the 2010 measles SIA coverage among migrant children in Beijing: evidence from a parental survey. Vaccine 2012;30;5721–5.

[16] Ratho RK, Mishra B, Singh T, Rao P, Kumar R. Measles outbreak in a migrant population. Indian J Pediatr 2005;72;893–4.

[17] Lee AD, Clemons NS, Patel M, Gastañaduy PA. International importations of measles virus into the United States during the postelimination era, 2001–2016. J Infect Dis 2019;219;1616–23.

[18] Jost M, Luzi D, Metzler S, Miran B, Mutsch M. Measles associated with international travel in the region of the Americas, Australia and Europe, 2001–2013: a systematic review. Travel Med Infect Dis 2015;13;10–18.

[19] Slade TA, Klekamp B, Rico E, Mejia-Echeverry A. Measles outbreak in an unvaccinated family and a possibly associated international traveler - Orange County, Florida, December 2012-January 2013. MMWR Morb Mortal Wkly Rep 2014; 63;781–4.

[20] Centers for Disease Control and Prevention (CDC). Notes from the field: measles outbreak associated with a traveler returning from India - North Carolina, April-May 2013. MMWR Morb Mortal Wkly Rep 2013;62;753.

[21] Centers for Disease Control and Prevention (CDC). Notes from the field: multiple cases of measles after exposure during air travel—Australia and New Zealand, January 2011. MMWR Morb Mortal Wkly Rep 2011;60;851.

[22] Nelson K, Marienau K, Schmehl C, Redd S. Measles transmission during air travel, United States, December 1, 2008–December 31, 2011. Travel Med Infect Dis 2013;11;81–9.

[23] Collier MG, Gierzyniowski A, Duszyński T, Munson C, Wenger M, Beard B, et al. Measles outbreak associated with international travel, Indiana, 2011. J Pediatric Infect Dis Soc 2013;2;110–18.

[24] Glaessner D, Kester J, Paulose H, Alizadeh A, Valentin B. Global travel patterns: an overview. J Travel Med 2017:24.

[25] World Health Organization. Immunization coverage rates. Available from: http://apps.who.int/immunization_monitoring/global_summary/time_series/sscoverage_mcv2.html.

[26] World Health Organization. Surveillance of vaccine preventable diseases. Available from: https://www.who.int/immunization_monitoring/surveillance/burden/vpd/surveillance_type/active/measles_monthlydata/en/.

[27] Eurostat. European Statistics. Available from: https://ec.europa.eu/eurostat/web/population-demography-migration-projections/data/database.

[28] International Organization for Migration (IOM). World Migration Report 2018. Available from: http://publications.iom.int/system/files/pdf/wmr_2018_en.pdf.

[29] Douglas P, Cetron M, Spiegel P. Definitions matter: migrants, immigrants, asylum seekers and refugees. J Travel Med 2019;26.

[30] Migration Data Portal. Available from: https://migrationdataportal.org/?t=2013&i=flows_abs_immig1&cm49=112.

[31] World Bank Database. Available from: https://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD.

[32] United Nations World Tourism Organization. UNWTO Tourism Highlights 2018 Report. Available from: https://www.e-unwto.org/pdf/do/10.18111/9789284419876.

[33] Edelson P, Anderson JA. Reported cases of measles in international air travelers to the United States, August 2005–March 2008. J Travel Med 2011;18;178–82.

[34] Bednarczyk RA, Rebollolo PA, Omer SB. Assessment of the role of international travel and unauthorized immigration on measles importation to the United States. J Travel Med 2016;23.

[35] van Binnendijk RS, Hahné S, Timen A, van Kempen G, Kohl RHG, Boot HJ, et al. Air travel as a risk factor for introduction of measles in a highly vaccinated population. Vaccine 2008;26;5775–7.

[36] Wilder-Smith A, Boggild AK. Sentinel surveillance in travel medicine: 20 years of GeoSentinel Publications (1999–2018). J Travel Med 2018;25.

[37] Sotir MJ, Esposito DH, Barnett ED, Leder K, Kozarsky PE, Lim PL, et al. Measles in the 21st Century, a continuing preventable risk to travelers: data from the GeoSentinel Global Network. Clin Infect Dis 2016;62;210–12.

[38] Angelo KM, Libman M, Gautret P, Barnett E, Grobusch MP, Hagmann SHF, et al. The rise in travel-associated measles infections—GeoSentinel, 2015–2019. J Travel Med 2019;26.

[39] Gidding HF, Quinn HE, Hueston L, Dwyer DE, McIntyre PB. Declining measles antibodies in the era of elimination: Australia’s experience. Vaccine 2018;36;507–13.
Haralambieva IH, Kennedy RB, Ovsyannikova IG, Schaid DJ, Poland GA. Current perspectives in assessing humoral immunity after measles vaccination. Expert Rev Vaccines 2019;18;75–87.

World Health Organization. Ten threats to global health in 2019. Available from: https://www.who.int/emergencies/ten-threats-to-global-health-in-2019.

MacDonald NE, SAGE Working Group on Vaccine Hesitancy. Vaccine hesitancy: definition, scope and determinants. Vaccine 2015;33;4161–4.

Edwards KM, Hackell JM, Committee on infectious diseases, The Committee on Practice and Ambulatory Medicine. Countering vaccine hesitancy. Pediatrics 2016;138:e20162146.

Wilder-Smith A, Leong WY, Lopez LF, Amaku M, Quam M, Khan K, et al. Potential for international spread of wild poliovirus via travelers. BMC Med 2015;13;133.

Bühler S, Lang P, Bally B, Hatz C, Jaeger VK. Stop measles in Switzerland – The importance of travel medicine. Vaccine 2017;35;3760–3.