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EXPERT
REVIEWSVaccine-preventable diseases
in Europe: where do we
stand?*Expert Rev. Vaccines* Early online, 1–9 (2014)**Sabine Wicker*¹ and
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During the second half of the 20th century, vaccinations led to the control or even eradication of several vaccine-preventable diseases (VPDs) in Europe. However, outbreaks of VPDs continue to occur even in countries with well-established vaccination programs. Reasons include the existence of under-vaccinated populations, the increasing anti-vaccination movement and the increasing movement of populations across borders. Ensuring adequate levels of herd immunity is the only reliable method for preventing epidemics and a re-emergence of VPDs. In order to achieve this, more flexible vaccine delivery platforms are needed targeting the less-privileged people, especially in the context of the current economic crisis. Healthcare personnel and healthcare systems should be prepared to address these challenges in the following years.

KEYWORDS: control • eradication • Europe • immunization • outbreaks • re-emergence • vaccination
• vaccine-preventable diseases

During the second half of the 20th century, vaccinations led to dramatic decline in the incidence or even eradication of many vaccine-preventable diseases (VPDs) [1]. Worldwide, in the first decade of the 21st century, approximately 2.5 million deaths were prevented each year among children aged <5 years through the use of measles, polio and diphtheria–tetanus–pertussis (DTP) vaccines [2]. In 2013, van Panhuis *et al.* estimated that 103 million of childhood diseases in the US have been prevented by the use of vaccines since 1924, which in the past decade alone numbered 26 million cases [1]. A comparison of the period before and after national vaccination recommendation in the US showed greater than 99% decline in the number of cases of diphtheria (100%), measles (99.9%), paralytic poliomyelitis (100%) and rubella (99.9%). A greater than 92% decline in cases and a 99% or greater decline in deaths was shown for mumps, pertussis and tetanus [3].

However, the re-emergence of some VPDs (e.g., measles, mumps and pertussis) has occurred despite longstanding vaccination programs [1,4,5] (TABLES 1 & 2). Beyond that, VPDs are still a major cause of under-five mortality in low- and lower-middle-income countries [6].

In addition to the morbidity and mortality of VPDs, these diseases impose societal and economic costs [3]. Furthermore, VPDs are often under-consulted, under-recognized, misdiagnosed and underreported, which leads to inadequate surveillance data compared to disease incidence [7].

The primary reason for the increased transmission and outbreaks of VPDs is failure to vaccinate susceptible populations [8]. Another important issue is vaccine failure. Regarding vaccine failure, there has been significant progress in recent years. However, the failure to vaccinate still persists [9,10].

The low perceived risk of disease at the individual level can result in lower participation in vaccination programs, with negative consequences for the entire community. Numerous outbreaks have been attributed at least in part to intentional under-vaccination [1].

Achieving timely, high vaccination coverage is crucial to prevent outbreaks of VPDs. An under-vaccinated and susceptible population leads to gaps in herd immunity, resulting in outbreaks [11]. Routine healthcare visits (e.g., general practitioner or occupational physician contacts) or hospitalizations can provide valuable opportunities to recommend and

Table 1. Number of reported cases of vaccine-preventable diseases in the European region according to WHO vaccine-preventable disease monitoring system, 2013 global summary.

	1980	2000	2011	2012
Diphtheria	618	1585	33	32
Measles	8,51,849	37,421	37,073	26,982
Mumps	No data	2,43,344	27,448	38,141
Pertussis	90,546	53,675	34,432	56,941
Polio	549	0	0	0
Rubella	No data	6,21,039	9672	30,509
Rubella (CRS)	No data	48	7	60
Tetanus	1715	412	197	194

CRS: Congenital rubella syndrome.
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vaccinate under-vaccinated patients. Nearly every healthcare provider contact can be used to check the vaccination status of the patients.

Data about VPD outbreaks and vaccination coverage should provide robust evidence to prevent and control VPDs [5]. Unfortunately, national vaccination programs and policies vary among EU and European Economic Area (EEA) countries. Vaccination delivery services, health service infrastructures, systems to monitor vaccination coverage and adverse events are quite different among states, making any comparison of national available data difficult [12]. Methods used as well as the frequency of assessment of vaccination coverage are highly variable in EU/EEA countries, which makes the comparison of vaccination rates exceedingly difficult [13]. However, WHO and the United Nations Children's Fund (UNICEF) are collecting vaccination coverage data [14,15] and the European Centre for Disease Prevention and Control (ECDC) started the '*European Vaccination Coverage Collection System – EVACO project*' to improve the quality of vaccine coverage data at the EU level [5,13].

This review will provide an overview of the current status of VPDs in Europe, progress to date, as well as challenges and efforts to reach higher vaccination uptake levels. The review focuses on measles, mumps, rubella, diphtheria, pertussis and poliomyelitis.

Search strategy & selection criteria

Data for this review were identified by searches conducted of the PubMed database and open-access websites of WHO, ECDC, US CDC and Robert Koch-Institute.

We searched PubMed to identify the articles published in English through April 2014 using combination of the words 'vaccine preventable diseases', 'measles', 'mumps', 'rubella', 'pertussis', 'poliomyelitis' AND 're-emergence' OR 'outbreak (s)', AND 'epidemiology' OR 'surveillance'.

After a review of the titles, the abstracts of the articles identified through the first PubMed search were screened by both

authors independently. The full text of every relevant article was reviewed. Additional appropriate citations from these articles were also retrieved. We searched open-access websites for relevant content in March 2014. The review focused on the last 5 years to reflect the recent status of VPDs.

A selective literature review concerning reasons for low vaccination rates and measures to improve vaccination rates was conducted as well. A total of 76 articles were selected for this review based on their relevance to the topic.

Measles

The only natural host for the measles virus is humans. The Edmonston measles vaccine was licensed in 1963, and the incidence rates for measles infection declined rapidly afterwards in countries with established two-dose vaccination programs. Due to improved coverage, a further reduction could have been demonstrated after the introduction of the combined measles–mumps–rubella (MMR) vaccine. An estimated 35 million measles cases have been prevented by vaccination in the US since 1963 [1]. Nevertheless, in 2011, still 32,124 measles cases were reported in the EU/EEA, which corresponds to a notification rate of 63.3 cases per million population [16]. In 2012, there were 29,150 and in the first 9 months of 2013, there were 26,321 measles cases in the European Region [17].

A measles incidence rate of less than one confirmed case of measles per million population per year is the indicator for elimination of measles. The target year for measles elimination in Europe is 2015. However, the increase in measles cases in some European countries poses a serious challenge to achieving the regional measles elimination goal. For instance, the UK has declared measles endemic once again [18,19]. Owing to the incorrect assertion that the measles vaccine plays a role in the development of autism, there is skepticism among parents about vaccines, for example, in the UK. This idea, promoted by Andrew Wakefield, led to a decrease of public confidence in the safety of the MMR vaccine and subsequently falling vaccination coverage levels followed by outbreaks of disease. In February 2010, the *Lancet* officially retrieved the Wakefield paper because the study was built on manipulated information. Several studies published afterward proved no relationship between the vaccine and autism [20,21].

In 2012, 2030 laboratory-confirmed cases of measles were reported in England and Wales. From January to October 2013, overall 1883 measles cases were reported in the UK [22]. Since 2000, there have been 12 measles deaths in the UK [18]. In Germany, in 2013, overall 1771 measles cases had been reported, 10-times as much as in 2012 (165 cases) [23].

The primary causes of continued measles cases in the European Region are suboptimal vaccination coverage rates among children and immunity gaps in the population. The reasons why people do not get the measles vaccine in Europe range from lack of information (people do not know that they are eligible for measles vaccination), poor personal knowledge (measles is not regarded as a serious disease), fear of side effects (the measles vaccine may not considered safe by some parents)

to poor access to health care and barriers to vaccination (e.g., either in minority ethnic groups and immigrants including Roma or in religious and anthroposophic communities, and persons whose parents refused to vaccinate in the past) [24,25].

Thus, measles infections in Europe are still causing illness and vaccine-preventable deaths and have implications regarding the global elimination goal. The increase in susceptible persons among older children and young adults because of low coverage in the past and administration of only one measles vaccination in the past, and the decline in natural exposure to measles virus have resulted in an increase in the median age of measles patients in Europe [8]. Over a third of measles patients in the European Region are nowadays older than 20 years, so that adults have emerged as a susceptible group for measles. Adults are primarily susceptible because they were too old to be vaccinated when the two-dose measles vaccination schedules were introduced during the 1980s or they simply missed the opportunity for vaccination and have never been affected by measles [24]. For this reason, susceptible individuals and population groups need to be identified and catch-up vaccination programs are needed to close immunity gaps [17].

Without vaccination, there are higher risks of complications among older people (instead of children and adolescents) and regarding vaccination, there might be more difficulties in creating a widespread well-accepted vaccination campaign among adults compared to children.

To interrupt the circulation of the measles virus, vaccination coverage of not less than 95% with two doses of measles vaccine must be achieved [16].

In 2012, the global measles vaccination coverage of children by their second birthday with one dose of measles-containing vaccine was 84%. Overall, 75% of countries implemented a second dose of measles vaccine in routine vaccination schedule [15,26]. The European Region of WHO has adopted a routine two-dose vaccination schedule within childhood vaccination programs. In particular, in Europe, the overall coverage with at least one dose of measles vaccine in routine vaccination schedule was 92–94% during 2004–2010, however, with fluctuations between countries and within countries as well [8]. The suboptimal vaccination rates in several WHO European Region countries (e.g., Georgia, Turkey, Ukraine, UK, Germany and Italy) as well as in developing countries constitute a challenge for countries already defined as measles-free (e.g., the USA), given the increased movement of people across borders nowadays [27].

As Muscat et al. have pointed out, 'A business as usual approach is not sufficient to reach the elimination target and innovative ways to boost demand for vaccines and provide equitable access through both traditional and new activities need to be considered. [...] without sustained political commitment, determination, appropriate legislation, increased investment, and

Table 2. Reported measles and rubella cases for the 12-month period January 2013–December 2013 (data as of 10 February 2014), a monthly summary of the epidemiological data on selected vaccine-preventable diseases in the European region.

	Total cases	Incidence per 1 million population	Laboratory confirmed	Completeness of reporting (%)
Measles	31,617	34.97	18,078	88.8
Rubella	39,139	43.3	221	76.7

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accelerated action by Member States and partners, the elimination of measles and rubella in the WHO European Region is at stake [17].

Mumps

The only natural host for the mumps virus is humans. In 1945, Enders and Lewis were the first to report production of a live attenuated mumps vaccine. All mumps vaccines in recent use are live vaccines [28]. Mumps vaccine was introduced in 120 countries by the end of 2012 [15]. Mumps outbreaks occur frequently, although the disease is included in the primary vaccination schedule of all EU/EEA Member States. Overall, 57% of mumps cases in the EU/EEA Member States had received at least one dose of mumps-containing vaccine. Mumps outbreaks are reported in almost all EU/EEA Member States, even in populations with high two-dose vaccination coverage [29] or in inadequately or unimmunized populations [30,31]. Mumps infection occurred in all age groups; however, persons between 15 and 24 years of age, followed by 5–14 year olds and 0–4 year olds were the most affected. Based on the available data of the ECDC, the trend in notifications decreased between 2007 and 2011 from 6.9 to 3.5 cases per 100,000 population. However, enhanced surveillance continues to demonstrate a high number of persons with breakthrough infections after one or more doses of mumps-containing vaccine [22,32]. For instance, from June 2009 through June 2010, a large mumps outbreak occurred in the US among highly vaccinated orthodox Jewish persons with intense exposures in religious schools with longstanding face-to-face contacts. Here, 89% of cases had previously received two doses of a mumps-containing vaccine and 8% had received one dose. High rates of two-dose coverage reduced the severity of the disease and the transmission to persons in low-intense exposure settings. The authors concluded thus: 'The risk of infection with mumps may be higher when the exposure dose of virus is large or intensely transmitted. This phenomenon can also explain why the efficacy of the mumps vaccine tends to be lower among household contacts than among school or community contacts' [33]. Maintaining a high vaccination coverage with two doses of MMR vaccine is, therefore, of utmost importance [16,22].

Finland was the first country documented to be mumps-free in 2000 after a successful national two-dose MMR vaccination

program for children [34–36]. Thus, elimination of mumps might be possible.

Rubella

The only natural host for the rubella virus is humans. In 1969 and 1970, rubella vaccine was introduced for commercial use in Europe and North America. The development and use of a live attenuated vaccine has controlled rubella infection during the last decades. Nevertheless, congenital rubella syndrome (CRS) continues to be a severe problem in countries not using rubella vaccine [37]. Rubella vaccine was introduced in 132 countries by the end of 2012 [15,38]. In 2011, Romania and Poland experienced large rubella outbreaks. Overall, 8411 rubella cases were reported in the EU/EEA countries; however, only 817 cases were laboratory confirmed. During November 2012 through October 2013, 39,122 cases of rubella were reported. Poland accounted for 99% of all reported rubella cases. Overall, 61% of the cases were unvaccinated and 10% were vaccinated with one dose. However, less than 1% of the cases were reported as laboratory confirmed [16,22].

Suboptimal vaccination coverage can lead to pockets of susceptible individuals and an increased number of rubella infections, including CRS [16]. The European WHO regional office has set the elimination goal for rubella at less than one case per million population. The primary ambition of rubella vaccination is prevention of CRS. In the past, many countries only vaccinated adolescent girls and left cohorts of males unvaccinated. However, in order to keep herd immunity, sufficient high vaccination coverage in all age groups and both genders is of utmost importance [16].

Measles and rubella vaccinations are routinely delivered as trivalent MMR vaccine in Europe, and the first of the two recommended doses is normally given during the second year of life [16,22].

Diphtheria

The exotoxin produced by *Corynebacterium diphtheriae* is the most important pathogenetic factor associated with the onset of disease, and humans are the only natural host for *C. diphtheriae*.

Diphtheria vaccination started with the use of toxin-antitoxin circa 1914, and the heat-inactivated diphtheria toxoid vaccine was introduced in 1923. It has been estimated that in the US, about 40 million diphtheria cases have been prevented by vaccination since 1924 [1]. Substantial progress has been made in controlling diphtheria across Europe as well, but diphtheria might be still a serious public health threat [39]. Nowadays, due to childhood vaccination and regular adult booster doses, diphtheria has become a minor problem in Europe. In 2011, 29 EU/EEA countries provided diphtheria surveillance data. Overall, only 20 cases of diphtheria were reported in 2011. However, it is of vital importance to maintain high vaccination coverage across all age groups. Diphtheria is still endemic in Asia, Africa, and South America, and imported infections might occur when vaccination rates would fall [22].

This becomes apparent by a re-emergence of diphtheria in the Russian Federation in the early 1990s which demonstrated the continuous threat of the disease [40]. A highly susceptible childhood population, partly as a result of using low-potency DTP vaccine, and an unprotected adult population due to waning of vaccine-derived immunity and large-scale population movements led to re-emergence of diphtheria in the Russian Federation [41]. More than 115,000 cases and 3000 deaths were reported from 1990 to 1997. The diphtheria epidemic peaked in 1994 when 39,582 cases and 1104 deaths were reported. Most of the cases and deaths occurred among adults as a consequence of an accumulation of a large number of susceptible adults who lacked immunity [42].

In seven Western Europe countries, sero-epidemiology studies have demonstrated that many adults have immunity levels below the protective threshold due to waning immunity (e.g., 70–75% of 50–60 year olds in the UK were seronegative) [39,41].

A study from the US showed that only 19% of individuals in the general population and about 39% of healthcare personnel (HCP) reported having ever heard of the DTP vaccine [43,44]. Normally, the intent to receive vaccination is linked with the knowledge that a vaccination exists.

In 2012, global coverage of infants with three doses of DTP vaccine was 83% [15]. The result of a serological survey in six European countries (Czech Republic, Hungary, Ireland, Latvia, Luxembourg and Slovakia) and Israel showed that increasing age was associated with an increase of seronegative subjects in the absence of repeated booster doses [22,45]. In every industrialized nation, the number of elderly people is exponentially growing, hence vaccination programs that decrease morbidity and mortality in the elderly need to be given a high priority [46].

Pertussis

The causative agent of pertussis is *Bordetella pertussis*. Two other organisms in the genus *Bordetella* are *Bordetella parapertussis* and *Bordetella bronchiseptica*. The only natural host for *B. pertussis* is humans, while sheep can also be the host for *B. parapertussis*. Recent studies on respiratory *B. pertussis* infections of mice and pigs have provided explanations on the mechanisms of natural and vaccine-induced immunity and in the design of improved pertussis vaccines based on a formulation that includes a Toll-like receptor agonist as an adjuvant [47].

Pertussis vaccines have been available since 1920s, but the worst pertussis epidemic in the US since 1959 occurred in 2012, with more than 38,000 cases. Pertussis is the only VPD which has been consistently on the rise in the US [1,48,49]. Studies from Europe have also highlighted the growing burden of pertussis infection in adolescents and adults [7]. The notification rate of pertussis infections in the EU/EEA Member States increased for the first time since 2008. In 2011, 5.57 cases per 100,000 population has been demonstrated.

The increased incidence of pertussis infections maybe due to the increased awareness of the disease as well as improvements in laboratory diagnostic and surveillance and changes in

pertussis strains [22]. Furthermore, neither natural infection nor vaccination provides lifelong immunity against pertussis; numerous studies have confirmed that immunity wanes rapidly after vaccination with the acellular vaccine [50]. It seems that *B. pertussis* is still circulating because the vaccination strategy (to vaccinate almost exclusively children) is no longer appropriate. On this account, booster doses for adolescents and adults are warranted [7,51,52]. On the other hand, the acellular vaccine may work less efficiently and offers protection for shorter duration, compared to the cellular pertussis vaccine, so a new pertussis vaccine with at least a longer duration of protection is needed [47,50,53].

In spite of the existence of routine childhood vaccination programs, *B. pertussis* still circulates in all developed countries and the disease incidence has been increasing in adolescents and adults in recent years. In adolescents and adults, the disease usually manifests atypically in the form of prolonged cough, and thus, it is not considered early in the course. For this reason, these age-groups constitute the main sources for transmission of infection to young infants who cannot be fully protected unless they receive the three primary doses. The belief that pertussis infection is mostly a childhood disease is a common misconception. Untreated, pertussis infection is highly contagious during the first weeks, and one primary case can lead to 11–17 secondary cases in an immune-naïve population [7].

Most severe cases, hospitalizations and deaths occur in infants, especially under 6 months, too young to be vaccinated. In infants younger than 12 months who get pertussis, approximately 50% are hospitalized. Of those infants who are hospitalized with pertussis, about 67% will have apnea, 23% will get pneumonia and 1.6% will die. For this reason, the Advisory Committee on Immunization Practices recommended in 2012 that pregnant women get a dose of Tdap during each pregnancy [54].

In 2008, 195,000 children under the age of 5 years were estimated to have died from pertussis worldwide [55]. In 2011, 89,000 pertussis deaths have been reported (under 5 year deaths: 84,000) [6,38].

In 2012, global coverage of infants with three doses of DTP vaccine was 83% [15].

Poliomyelitis

The only natural host for the poliomyelitis virus is humans. The inactivated Salk polio vaccine was introduced in 1955 and the incidence rates for polio infections decreased substantially in the years that followed. A further reduction could be shown after the introduction of the Sabin live attenuated oral polio vaccine (OPV) in 1961. Nowadays, inactivated polio vaccines are used in all EU/EEA countries, except Poland, where OPV is still used for the fourth dose. However, OPV is used in a majority of countries worldwide. In rare cases, OPV can cause vaccine-associated paralytic polio and with low coverage, OPV can evolve to become circulating vaccine-derived polioviruses that cause outbreaks [56–58].

Eradication in the US was shown in 1979. The European Regional Commission for the Certification of the Eradication of Poliomyelitis certified the European Region to be poliomyelitis-free in June 2002.

Since 1988, global polio incidence has declined more than 99% [10]. In 2012, an estimated 84% of infants worldwide were vaccinated with three doses of polio vaccine [15]. In January 2014, India was declared as poliomyelitis-free after 3 years without any case of polio. In 2014, worldwide, only three countries remain endemic for indigenous transmission of wild poliovirus: Nigeria, Pakistan and Afghanistan.

According to global polio surveillance data from 6 May 2014, 74 polio cases have been reported in 2014 from Afghanistan, Cameroon, Equatorial Guinea, Ethiopia, Iraq, Nigeria, Pakistan and Syria. In contrast, in 2013, a total of 416 polio cases were reported [59].

Prior to the recent outbreak, Syria's last confirmed polio case (due to an imported wild poliovirus) was in 1999. The total number of confirmed polio cases was 23 for 2013. After a rapid and effective response plan from WHO and UNICEF, Syria remained polio-free till October 2013. Before the current crisis, the vaccination program in Syria was one of the best programs in the region. The coverage rate of the OPV 3rd dose was above 90% until the year 2010 and then declined sharply to 68% in 2012 due to the civil war and the disruption of the vaccination program [59,60].

According to an assessment of the ECDC, '*The increase of the number of polio cases and countries reporting poliovirus transmission puts EU/EEA Member States at risk for introduction and transmission of the virus*' [58]. ECDC estimated that 12 million residents in the EU younger than 30 years are not vaccinated against polio [61]. Due to these pockets of unvaccinated persons and the fact that poliovirus is still circulating, an importation of cases into polio-free areas like the EU remains a potential threat. Several EU countries have detected vaccine-derived poliovirus strains in their sewage water, either from newly vaccinated visitors, migrants or chronic carriers in countries that have shifted to inactivated polio vaccines [58]. In WHO European region, wild poliovirus type 1 was detected in spring and summer 2013 in environmental samples and stool samples from 42 asymptomatic carriers in Israel [58]. However, due to high vaccination coverage in Israel, there has been no evidence of transmission of poliovirus infection, thus highlighting once more the importance of keeping high vaccination coverage in all groups in Europe.

Reasons for low vaccination rates

Well-established vaccination programs with timely conducted vaccinations offer the opportunity to completely control or even eliminate serious infectious diseases.

This is the case of MMR, given the characteristics of its three components in terms of humans being the only natural host. However, '*Vaccines are victims of their own success*' because in the absence of VPDs, many people might fear vaccines more than the diseases with which they have had no personal

experience [62–65]. Lack of knowledge of seriousness of the disease will lead to reduced vaccine acceptance. Recent studies demonstrate that there is an inverse relationship between the incidence of VPDs and safety concerns of vaccines. When VPDs rates decrease, the perception of risk of infection might decrease and the risks of side effects due to vaccination might be rated higher [3]. Several studies have shown that vaccine acceptance is generally driven by self-perceived risk of infection. If people perceive a low level of risk, they are unlikely to accept vaccination [66].

Current studies describe a so-called ‘*vaccine hesitancy*’: individuals ‘*who are delaying vaccination, accepting only some vaccines, or who are yet undecided, but reluctant and predicted that pressure to vaccinate might be counter-productive*’ [63].

Skepticism about the benefits of vaccinations and concerns about vaccine safety as well as fear of adverse effects from being vaccinated are the major obstacles of the public to accept vaccinations [67]. Due to religious or philosophical objections to vaccination, opposition to vaccination programs has occurred, for example, in Germany, Nigeria, Pakistan and Afghanistan [68,69]. A recent review identified numerous VPD outbreaks (e.g., measles, mumps, pertussis and poliomyelitis) which occurred within religious communities or spread from them to broader communities [70].

A minor problem in Europe but a major problem in low-income countries poses limited healthcare access in areas of conflict and war zones and poor acceptance of preventative measures in some hard-to-reach populations that make vaccine refusal more likely [71].

An important issue poses anti-vaccinationists who spread mistruths and ignore scientific data. Their actions have had disruptive and costly effects, which resulted in numerous outbreaks of VPDs [72].

How to improve the situation?

Different approaches to continually improve the vaccination rates and prevent the re-emergence of VPDs need to be considered. First, surveillance for timely identification and monitoring of cases and outbreaks need to be amended. Case definitions of VPDs for surveillance need to be developed or have to be applied to improve the specificity and enhance the comparability of country-specific surveillance systems. In the EU, different methods are used for assessing vaccination coverage. A standardized method for assessing vaccination coverage would improve comparability across the EU and might increase the quality of surveillance systems [73].

Second, communication campaigns should be developed and refined. Social mobilization and strong media attention with advocacy for vaccination are needed to draw the public attention to the burden of VPDs. Innovative strategies and tools to effectively communicate the seriousness of VPDs and the benefits of vaccination to the general population and to HCP are warranted [8,63,64].

Third, a public commitment and a local engagement to vaccination schedules and policies are required. The surveillance of

vaccination rates needs to be monitored close-mesh. Unless vaccination coverage is adequately sustained, further outbreaks due to pockets of under-vaccination will occur [8,71,74].

Fourth, supplementary vaccination activities (e.g., offering free vaccination to persons not covered by routine vaccination programs, and recall systems handled by general practitioner, occupational physicians and pediatrician practices) should be implemented. The aim is to reach and maintain high vaccine coverage from infancy throughout childhood, and the adult and elderly population. Achieving high vaccine uptake among the adult and the elderly population will require a greater understanding among this part of the population concerning the burden of disease of VPDs and the benefits of vaccination. Vaccination should be an essential part of an adult preventive health care [3,8,46].

Fifth, there is a need to establish or expand already existing vaccine delivery platforms for people with limited access to vaccinations throughout Europe, especially within the context of the current economic crisis. This includes marginalized people, homeless, Roma, unemployed and immigrants.

Sixth, it is of particular importance that an ongoing high-level political commitment to vaccination should be guaranteed. Awareness among politicians regarding VPDs should afford a financially supported vaccination program [8]. More public awareness and engagement around vaccination issues is needed to sustain sufficient vaccination rates.

Last but not the least, vaccination policies for HCP need to be improved. Due to close contact with patients, HCP are at increased risk of acquiring VPDs. Vaccinating HCP against VPDs protects the individual HCP and reduces the risk of transmission to patients and to other HCP, as well as family and friends [75]. Furthermore, HCP with lower attitudes toward vaccinations might recommend fewer vaccinations to their patients. HCP are expected to be a role model for their patients regarding sufficient vaccination rates [27,76].

Expert commentary

More than half a century after the wide implementation of vaccination programs against several VPDs in Europe, VPDs still occur and pose a threat both at the individual level as well as at the level of community. This is attributed to the fact that despite the overall high vaccination coverage against several VPDs, there are subgroups and communities with suboptimal vaccination coverage serving as pouches of susceptible people within countries. Importation of VPDs into these under-vaccinated populations poses a risk for VPD outbreaks in association with significant morbidity and mortality. Reasons for failing to get vaccinated or to complete the recommended vaccination scheme include safety concerns and informed parental refusal of their children getting vaccinated, religious and philosophical opposition, and difficulties in healthcare access. Social media play a prominent role in the dissemination of anti-vaccination ideas. Irrespective of the cause, outbreaks of VPDs still occur in Europe. This emphasizes the need to maintain high vaccination rates in all age groups and the importance to

implement booster strategies if necessary. Given the current economic crisis, the emergence of several VPDs elsewhere (e.g., poliomyelitis in Syria in 2013) and the increasing movement of people across borders, there is a need to intensify vaccinations during childhood and adulthood and reach the less-privileged people in the community through flexible vaccination delivery platforms. Education of the general population as well as HCP about the safety and efficacy of vaccines is of outmost importance. Overall, surveillance of VPDs should be enhanced globally and vaccination coverage rates should be estimated systematically. This emphasizes the need to maintain high vaccination rates in all age groups and the importance to implement booster strategies if necessary. Research is essential to identify additional tools and strategies to ensure sufficient vaccination rates and to avoid gaps in herd immunity.

Five-year view

- It appears highly unlikely to reach measles elimination in Europe by 2015. Measles elimination in Europe will take longer than expected.
- The current economic crisis will challenge healthcare systems in terms of delivering vaccinations to less-privileged people across Europe: more flexible vaccine delivery platforms are needed.
- Achieving and sustaining high and timely routine vaccination coverage in all age groups is of outmost importance in order to protect the whole population.

- It is likely that standardized surveillance systems for the estimation of vaccination coverage rates in the general population will be established within the EU.
- The anti-vaccination movement will continue to rise and question the input of vaccines in human morbidity and mortality, despite their recorded enormous efficacy in real life.
- Social media will play a more prominent role through dissemination of anti-vaccination ideas.
- HCP and healthcare systems should be better prepared in order to confront these challenges.

Financial & competing interests disclosure

The views in this article are the personal views of the authors and do not necessarily represent the views of the professional organizations or institutions of which we are members. S Wicker is a member of the German Standing Committee on Vaccination (STIKO) and vice-chairperson of the German Verification Committee for Measles and Rubella Elimination. She has received honoraria for non-product-related talks on influenza vaccination from GlaxoSmithKline, Sanofi Pasteur, AstraZeneca and Novartis and has participated in workshops about healthcare personnel and vaccination sponsored by Abbott. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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Key issues

- Despite the availability of many safe and effective vaccines and the establishment of vaccination programs for more than half a century, outbreaks due to vaccine-preventable diseases (VPDs) continue to occur in developed countries including those in Europe.
- Achieving and sustaining high and timely routine vaccination coverage in all age groups are of outmost importance in order to prevent outbreaks and re-emergence of VPDs.
- There is a need to establish more flexible vaccination delivery platforms in Europe, in order to access the less-privileged people within the context of the current economic crisis.
- The anti-vaccination movement will increase further in the following years.
- Education of the general population and healthcare personnel (HCP) about vaccines should be promoted.

References

Papers of special note have been highlighted as:

• of interest

•• of considerable interest

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