

Who Gets Measles in Europe?

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Background. Measles outbreaks continue to occur in Europe as a result of suboptimum vaccination coverage. This article aims to describe individuals susceptible to measles, and provide an overview of affected groups and the public settings in which measles transmission occurred in Europe in 2005–2009.

Methods. Individuals susceptible to measles were described and categorized on the basis of factors leading to nonvaccination and vaccine failure. A literature search was conducted to identify affected groups and public settings in which measles transmission occurred.

Results. Most individuals susceptible to measles are previously uninfected and unvaccinated. The reasons for nonvaccination in individuals eligible for vaccination ranged from lack of information to poor access to health care. Several outbreaks have emerged in Roma and Sinti, Traveller, anthroposophic, and ultra-orthodox Jewish communities, and immigrants identifying them as being particularly at risk. Public settings for transmission included mostly educational and health care facilities.

Conclusions. Improved efforts are needed to strengthen immunization programs, identify barriers for measles-containing vaccine uptake, and explore methods to target vulnerable populations that are not being reached with routine immunization delivery services. Specific measures are needed to prevent and control measles in educational and health care facilities. Failure to identify who gets measles and implement the elimination strategies raises concerns for the successful and sustainable elimination of measles in Europe.

Measles outbreaks continue to occur in Europe, underscoring some of the challenges still to be addressed in relation to the goal of eliminating measles from the region [1]. During 2005–2009, several countries reported outbreaks affecting the general population; other outbreaks predominantly involved particular groups. The World Health Organization's strategy for measles elimination in the European region stipulates that vaccination programs should achieve and sustain a minimum of 95% coverage with 2 doses of a measles-containing vaccine (MCV) [1]. Suboptimum vaccination coverage in many countries resulted in unvaccinated individuals comprising the majority of

measles cases in Europe [2]. Therefore, it is fundamental to identify and target susceptible individuals for vaccination. Moreover, increased awareness of settings where measles outbreaks occur will help envisage potential future outbreaks and, therefore, allow prompt and more effective implementation of preventative and control measures. This article aims to describe individuals susceptible to measles and to provide an overview of affected groups and the public settings in which measles transmission occurred in Europe during 2005–2009.

METHODS

With the use of examples from situations in European countries, individuals susceptible to measles were described and categorized on the basis of factors leading to nonvaccination and vaccine failure. To describe particular groups affected by outbreaks and public settings in which measles transmission occurred, a literature search was conducted using the PubMed database. An outbreak was defined as at least 2 epidemiologically linked measles cases. Europe was defined as the current 27 European Union member states (Austria, Belgium, Bulgaria, Cyprus,

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Czech Republic, Denmark, Estonia, France, Finland, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Portugal, Poland, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom), 15 immediate geographically- and culturally-related nearby countries or territories, namely Albania, Belarus, Bosnia and Herzegovina, Croatia, Gibraltar, Iceland, Macedonia (FYRM), Monaco, Moldova, Norway, Russia, Serbia, Switzerland, Turkey and Ukraine, and Israel. The titles of journal articles in English published from 1 January 2005 through 1 May 2010, including the terms “measles” in combination with “Europe” and “European” and the names of the individual countries in Europe and “measles outbreak” and “measles outbreaks” were searched. The search term used for the United Kingdom also included the names of its constituent countries, namely England, Wales, Scotland, and Northern Ireland. The search yielded 190 articles. These were screened to identify particular groups affected by measles outbreaks and the public settings where measles transmission occurred in the 5-year period from 2005 through 2009. Settings outside the household environment were identified. When >1 publication described the same outbreak, the more recent publication was used. A total of 39 articles were selected. The identified affected groups and settings were categorized accordingly, and results were tabulated. The literature on the particular groups affected by measles was also searched to provide the reader with background knowledge on these groups and facts relevant to the subject discussed.

RESULTS

Susceptible Individuals

Immunity is believed to be lifelong after natural infection with measles virus or following a dose of live measles vaccine that is properly administered to an appropriate host and that results in seroconversion [3, 4]. Therefore, individuals who have not been affected by measles and are unvaccinated are susceptible to the disease. In 2007, 3,104 (87%) measles cases in Europe were unvaccinated [2]. Depending on their eligibility to be vaccinated unvaccinated individuals broadly fall into 1 of 2 groups. Of the ineligible group, most are of an inappropriate age for vaccination, according to national immunization programs. A small fraction would, however, be ineligible because they have contraindications to the vaccine. The second group consists of individuals who are eligible for vaccination but are not vaccinated. On the other hand, some individuals are still susceptible, because although having been vaccinated, the vaccine fails to produce an immune response.

Susceptibility Due to Nonvaccination

Ineligible individuals

Inappropriate age. In most European countries' national vaccination programs, the measles vaccine is given in combination with mumps and rubella vaccine (MMR) and is administered as

a 2-dose schedule. As the first dose is usually recommended at 12–15 months of age [5], persons younger than this age are ineligible for vaccination. Infants are usually protected by maternally-derived antibodies only during their first months of life [3] after which they become susceptible to measles. Indeed, during 2006 and 2007, the highest age-specific measles incidence was observed in infants <1 year of age [2]. This also reflected the intensity of the transmission of measles. Individuals younger than the recommended age for the second MCV dose are ineligible for complete vaccination and, having received only 1 dose, could still be susceptible to measles. Most countries recommend the second dose by 6 years of age [5]. In 2007, 137 (17%) persons with measles who were aged 1–4 years had been vaccinated with a single dose. However, an undetermined proportion of these would not have been eligible, because they were too young to be vaccinated.

Some adults are also susceptible because they have not been affected by measles and were too old to be vaccinated when the 2-dose measles immunization schedules were introduced during the 1980s. In 2007, 724 (19%) persons with measles in Europe were aged ≥ 20 years [2]. However, this proportion would also include individuals, particularly those in their early twenties who would have been targeted at the start of the vaccination campaigns but missed the opportunity for vaccination. *Contraindications for MCV vaccination.* Individuals with a serious allergy to any of the ingredients or constituents of vaccines containing a measles component would be ineligible for vaccination. In addition, because the measles component is live-attenuated, MCVs are contraindicated in acute severe illness and severe immunodeficiency [3] resulting from conditions, such as malignancy and its treatment, AIDS, prolonged high-dose steroid treatment, and certain rare inherited primary immunodeficiency disorders. Patients with such conditions resulting in deficiencies of cell-mediated immunity and with measles have a severe and often fatal course [6]. Two measles-related deaths reported in Europe during 2006–2007 occurred among immunocompromised patients; one had a genetic immunodeficiency disorder, and the other was receiving immunosuppressive therapy for an underlying lung condition [7, 8].

Eligible individuals

In 2007, of those persons with measles in Europe who were aged 15–19 years, 358 (85%) were unvaccinated and 42 (10%) had received a single dose [2]. According to national immunization programs, they should have received 2 MCV doses. The risk factors for nonvaccination or delayed vaccination are complex and diverse and range from personal knowledge of vaccines to access to health care.

Lack of information, misinformation, and beliefs. Individuals may be unvaccinated because their parents were not adequately informed about measles vaccination and its benefits or were concerned about its safety [9, 10]. In the United Kingdom, many

parents and some health care professionals were uncertain about whether to have children vaccinated after considerable media coverage of a research article published in 1998 that suggested a link between the MMR vaccine and the development of gastrointestinal disease and autism. The research was discredited, and the article was eventually retracted from published record 12 years later [11]. However, this controversy resulted in the proportion of children in the United Kingdom who received their first vaccine dose by 2 years of age decreasing from a high of 92.5% during April–June 1995 [12] to a low of 78.9% during the same period in 2003 [13]. During 2006 and 2007, the level of reported measles cases placed the United Kingdom in the high incidence category (>1 case per 100,000 inhabitants) for measles [2]. In Germany, parents objected to vaccination because they thought that the child benefited from the illness itself [14], and family doctors were reported to withhold advice or even advise against measles vaccination [15]. During 2006 and 2007, Germany was in the moderate to high incidence category for measles (0.1–1 and >1 case per 100,000 inhabitants, respectively) [2]. The outbreak in Belgium during 2007–2008 among members of the ultra-orthodox Jewish community mostly involved individuals eligible for vaccination who were unvaccinated patients of the same general practitioner known to oppose vaccination [16]. Other persons in this outbreak, however, were not vaccinated because of fear of adverse effects, allergy, or frequent disease during childhood. None of the families mentioned religious beliefs as a reason for nonvaccination.

Parental perception of the diseases that are preventable by vaccines can also influence their decision to have their children vaccinated or not. Apart from the MMR vaccine being least likely to be considered safe, measles was often not regarded as a serious disease [10, 17]. Such poor personal knowledge results in doubt, skepticism, and opposition toward vaccination and empowers anti-vaccination activists. Anti-vaccination groups have been known to exist for >200 years, disrupting the use of many vaccines in various countries [18]. Vaccine opponents usually have their attitudes rooted in health concerns and philosophical, and religious beliefs and often are part of communities whose members share the same attitudes toward vaccines.

Incorrect information on the contraindications to MCV also has negative consequences. In the Ukraine outbreak during 2005–2006, the older age profile of the cases suggested a lack of previous vaccination because of the extensive number of contraindications accepted in the former Soviet Union [19]. In Italy, a country that has repeatedly experienced large outbreaks [7, 20], both parents and pediatricians were reported to give disproportionate importance to mild intercurrent diseases as a reason to defer vaccination [21].

Poor access to health care. Outbreaks have often occurred in minority ethnic groups and immigrants. A variety of factors can

act as barriers for members of such groups to avail themselves for vaccination. These factors include: cultural, language, ethnicity, racial discrimination, and socioeconomic. Collectively, individuals sharing such risk factors have been identified as being part of vulnerable populations with low vaccination coverage. These are described in more detail below.

Susceptibility Due to Vaccine Failure

Two percent to 5% of vaccinated children who receive only 1 dose of age-appropriate MCV fail to develop immunity to measles (primary vaccine failure) [3, 22]. Nevertheless, non-response to the first dose is generally overcome by the administration of a second dose [23], inducing the same high rate of immune response that follows initial vaccination [3]. Failure to induce immune response may also be the result of administering MCV at too young an age [24], because of the presence of maternally-derived antibodies that may neutralize the vaccine virus. Other potential causes of primary vaccine failure include poor quality vaccines and their improper storage. Possible reasons contributing to the outbreak in the Ukraine during 2005–2006 included poor quality control during vaccine production and a break in the cold chain [19]. Waning of vaccine-induced immunity does not appear to play a major role in reducing overall population immunity to measles [25], and case reports of measles occurrence in individuals with a previously documented seroconversion after MCV vaccination (secondary vaccine failure) are rare [26, 27].

Affected Groups and Settings for Transmission

During the period 2005–2009, several measles outbreaks in Europe were documented among Roma and Sinti communities, Traveller communities, anthroposophic groups, ultra-orthodox Jewish communities, and immigrants identifying them as being particularly at risk (Table 1). Most cases were unvaccinated or vaccinated with only 1 MCV dose. Background information on the particular groups affected by measles in Europe is given in the appendix.

Unvaccinated international travelers to countries where measles is still endemic or where outbreaks are ongoing have also been identified as a risk group. The importance of recognizing this heterogeneous group lies in its increased risk of acquiring measles as much as in its ability to spread the disease across borders. In 2007, 84 (4%) cases with a known importation status in Europe were considered as imported [2]. Measles virus importation has resulted in several outbreaks among the general population [7, 28, 29], and particular groups [16, 30–37], in schools [36, 38], and in health care settings [39–43].

Many outbreaks consisted of a series of transmission chains in families and household contacts [7, 44–47]. However, several others had their foci in school settings. Schools and daycare centers embracing philosophies and religious beliefs that oppose vaccination were particularly affected. These included anthroposophic schools, also known as Steiner or Waldorf schools,

Table 1. Measles Outbreaks Among Particular Groups

Period	Country	Groups affected ^a	Comments	References
2004–2007	Romania	Roma	The outbreak that involved >8,000 cases, started among unvaccinated members of Roma and Sinti communities and spread to the general population.	[67]
2005	Portugal	Romanian community	An imported measles case from Romania resulted in an outbreak affecting 6 children in two Romanian communities living in Portugal.	[32]
2005–2006	Greece	Roma and immigrants	Out of 171 reported cases, 94 (55%) belonged to Roma families, mostly unvaccinated preschool age children. The outbreak also involved 25 (15%) immigrants who were unvaccinated and incompletely vaccinated.	[68]
2006	Italy	Roma and Sinti	An outbreak of 17 cases in the Autonomous Province of Bolzano-South Tyrol involved 13 Roma/Sinti. Another outbreak of nine cases among Roma/Sinti occurred on the island of Sardinia and included 4 children who had returned from Rome after attending a funeral there. None of the Roma/Sinti had been vaccinated against measles.	[69]
2006	Italy	Roma and Sinti	An outbreak involving 98 cases was reported in the Roma/Sinti community in 19 settlements in Rome. At the same time a total of 204 cases were reported in the general population.	[70]
2006	Spain	Travellers and Roma	The first 2 cases belonged to a Traveller community living mainly in the UK. In addition, the outbreak involved Roma (9 cases) and the general population.	[34]
2007	Serbia	Roma	Out of 78 confirmed cases, 77 were in Roma.	[71]
2007	Belgium	Ultra-orthodox Jewish community	The outbreak involved at least 137 cases of whom 129 cases (94%) were members of the ultra-orthodox Jewish community living in Antwerp, Belgium. The first two cases were children of the same community who had returned from a summer camp in the UK.	[16]
2007	UK	Irish Traveller community	The outbreak involved 173 cases of which 156 were in Travellers. Early in the course of the outbreak, 21 confirmed cases were reported among Travellers who attended a funeral in London, England.	[72]
2007	Norway	Irish Travellers	Fifteen cases were reported in Travellers from England at a camping site in Norway. The index case was reported to have been in contact with a measles case in England.	[33]
2007–2008	Italy	Roma/Sinti	The outbreak that started in the region of Piemonte spread to other regions. Transmission occurred in the general population, in families, schools, hospitals, anti-vaccination groups and in Roma/Sinti. Importation from the UK was reported.	[7]
2007	Israel	Ultra-orthodox Jewish community	The outbreak involved 491 cases almost exclusively in the same ultra-orthodox Jewish community in Jerusalem. The outbreak was linked to members of the same community living in London, England. Infants had the highest age-specific incidence.	[35]
2008	Austria	Anthroposophic community	Of the 394 outbreak cases, 123 were in students attending anthroposophic educational facilities in Salzburg. The outbreak spread to other members of the anthroposophic community and the general population.	[36]
2008	Netherlands	Anthroposophic community	The outbreak primarily involved students in two anthroposophic schools. It extended to involve the family members of the students.	[73]
2008	Croatia	Roma	The outbreak involved a Roma community and the general population. Importation from Italy was reported.	[37]
2009	Bulgaria	Roma	The outbreak emerged after seven years without indigenous transmission. The index case was reported to be imported from Germany. By the end of week 48 of 2009, 957 measles cases had been recorded, of which at least 90% were in Roma.	[30]
2009	Austria	Anthroposophic community	An outbreak involving 37 cases spread from the general population (12 cases) to an anthroposophic community (25 cases).	[74]
2009	Poland	Roma	Among 41 cases reported in an outbreak in Pulawy, 35 in Roma. Importation from England was described.	[31]
2009–2010	Ireland	Traveller and Roma communities	The outbreak involved Travellers, Roma and the general population.	[75]

NOTE. ^a Named as quoted from the references.

Table 2. Settings for Measles Transmission in Europe

Period	Country	City/Region	Comments	Reference
Schools and daycare centres				
2005	Germany	Bavaria	Most cases were related to schools and preschool facilities: 45 attended a primary school in Munich; 52 attended the same Montessori school; 42 attended in four kindergartens and 38 were in four other schools.	[45]
2005–06	Spain	La Rioja	The outbreak involved two daycare centers as part of larger outbreak of 18 confirmed cases.	[76]
2006	Germany	Duisburg	During the outbreak in Duisburg, the largest two clusters occurred at secondary schools and involved 55 and 33 cases.	[77]
2006	Italy	Lazio	A cluster of 6 cases occurred among adolescents and young adults attending a professional school in the outskirts of Rome.	[70]
2006–07	Spain	Catalonia	Preschool and daycare facilities were identified as sources of infection in 68 cases.	[44]
2006–07	Italy	Puglia	Of the 18 cases reported in this outbreak, 8 were in unvaccinated students attending the same school.	[78]
2006–07	Switzerland	Countrywide	The outbreak involved schools, an anthroposophic boarding school and daycare centers.	[47]
2007	Germany	Bavaria	The initial outbreak in Montessori school affecting 26 students spread to other schools and a kindergarten. A total of 90 cases were reported in the districts of Passau and Rottal-Inn in Lower Bavaria.	[79]
2007	Germany	Bavaria	A cluster was reported in a Montessori kindergarten in which 12 children became ill with measles.	[80]
2007–08	Italy	Countrywide	The outbreak started in the region of Piemonte spreading to other regions. Various settings identified including schools.	[7]
2008	Austria	Salzburg	The outbreak involved 123 pupils attending an anthroposophic school (116 cases) and a kindergarten (7 cases). It extended to the neighboring German federal state of Bavaria through cases in German pupils attending the same anthroposophic school in Salzburg.	[36]
2008	France	Burgundy and other regions	A total of 110 cases were identified among elementary and secondary students of 2 private religious schools and their siblings. The outbreak extended to the general community and also involved other private and public schools.	[81]
2008	Germany	Baden-Württemberg	Nineteen measles cases were identified in children, adolescents and young adults attending a school in the county of Lörrach.	[82]
2008	UK	London	Outbreaks were reported in 2 schools with 9 confirmed and 29 probable cases.	[83]
2009	Austria	Styria	The outbreak involved 12 pupils of an anthroposophic school.	[74]
2009	Switzerland	Lausanne	An outbreak was identified mainly affecting students from the Ecole Polytechnique Fédérale and the University of Lausanne following an importation of measles from Mali.	[38]
Hospital and health care facilities				
2005–06	Greece	Unspecified	The outbreak consisted of two hospital clusters with 4 cases each.	[68]
2005–06	Spain	La Rioja	The outbreak involved patient-to-doctor and doctor-to-patient transmission as part of larger outbreak of 18 confirmed cases.	[76]
2006	Italy	Grosseto	Twelve patients including 8 health care workers were reported to have acquired measles through nosocomial transmission. The index case returned from India.	[39]
2006	Italy	Lazio	Nosocomial transmission was reported as part of larger outbreak involving a total of 161 cases.	[69]
2006	Spain	Madrid	Nine cases were reported to occur in health care staff.	[34]
2006–07	Spain	Catalonia	Health care centers were identified as sources of infection in 37 cases.	[44]

Table 2. (Continued)

Period	Country	City/Region	Comments	Reference
2007	Netherlands	Amsterdam	Two health care workers and a medical student were affected by measles after contact with the index case in hospital.	[84]
2007	France	Unspecified	A small cluster occurred after the index case returned from Thailand infecting his doctor who subsequently infected his wife.	[40]
2007	Switzerland	Geneva	Transmission was reported to occur in a hospital waiting room in 1 case belonging to a small cluster of 11 cases.	[46]
2007–08	Italy	Countrywide	The outbreak that started in the region of Piemonte spread to other regions. Various settings were identified including hospitals.	[7]
2008	Sweden	Gothenburg	The outbreak that involved 2 visitors in the emergency department. The index case returned from France.	[41]
2008	Italy	Apulia	Of the 8 cases that were related to a nosocomial outbreak, 5 had been inpatients in the same infectious disease ward.	[85]
2008	UK	London	Nine cases were linked to a child admitted to a pediatric ward.	[83]
2008	Denmark	Copenhagen	Two cases were believed to have acquired measles at the waiting room of the general practitioner and another one at the hospital in which the index case was admitted. The index case returned from Nepal and India.	[43]
2008	France and Monaco	Reims, Nice and Monaco	An outbreak in Reims involved three health care staff. Patient-to-staff transmission was documented. The two nosocomial clusters in Nice and Monaco involved 17 cases. Patient-to-staff and patient-to-patient transmission was reported.	[40]
2008–09	Denmark	Copenhagen	A cluster of six confirmed cases of measles occurred among children admitted to the pediatric department of a hospital. The index case returned from East Africa.	[42]
Other settings				
2006–07	Switzerland	Countrywide	A large variety of different settings for transmission were identified including ski camps, sport clubs, a military accommodation facility, a cinema, airplanes, an airport, and so-called “measles parties” organized with the aim of voluntarily exposing children to an infected person.	[47]
2007	Germany	Southern Bavaria	One cluster of five cases was linked to a restaurant in which an employee fell ill.	[80]
2009	Austria	Styria	A billiard pub was implicated as a site of measles transmission.	[74]

and traditionalist religious schools. Hospitals and other health care facilities have also been foci for outbreaks, with transmission occurring between patients, from patients to hospital staff, and from hospital staff to patients. Table 2 shows the identified public settings where measles transmission occurred.

DISCUSSION

Improved efforts are needed to identify barriers to vaccine acceptance and to explore methods to target susceptible individuals and vulnerable groups that are not being reached with standard immunization programs. Strengthening immunization

programs requires a steady commitment by governments, health authorities, and decision makers, including immunization program managers. The availability of good-quality vaccines, maintenance of the cold chain, and easy access to vaccination are essential components of immunization programs. Reminders and recall systems have been shown to be effective for improving vaccination rates [48] and, together with accurate monitoring of vaccination coverage, should be incorporated into the implementation of immunization programs. Routine supervision of immunization programs should also have the ability to identify factors for suboptimum vaccination coverage, such as recent migration, large family size, and poor socioeconomic status [49]. Such factors should serve as alert signals to recognize families

and groups needing support for their children to be fully vaccinated. Identifying other reasons may require special studies, particularly to discover any special characteristics, changing attitudes, and awareness toward vaccination.

Adults without a history of vaccination against measles or of the illness may lack the motivation to be vaccinated. Therefore, issuing policies to do so may be unsuccessful. However, MMR vaccination should be strongly recommended to persons intending to travel to areas where measles is endemic and where outbreaks are reported. Susceptible travelers can also be infected at international airports where passengers from all across the world converge [50]. Several countries have well-established recommendations on pretravel measles vaccination [51–53]. Such recommendations should also be made before events involving mass gatherings (eg the Olympic Games and other international sporting events) if hosted in countries with ongoing outbreaks. This was done for the 2006 World Cup football championship held in Germany, where a measles outbreak was occurring at the time [54].

Improving the availability of high-quality information to both the public and health professionals is another key strategy stipulated in the WHO elimination plan [1]. As the incidence of measles decreases, so does awareness of the disease and motivation to vaccinate. Therefore, public and health professionals' knowledge and perception of measles, including the benefits and risks associated with vaccination, are important for health authorities seeking to increase and maintain high levels of vaccination coverage. As the incidence of measles decreases, there is also the risk of overemphasizing the rarely occurring adverse events after vaccination. Therefore, health authorities should focus more on reassuring the public on the benefits of measles vaccination and vaccine safety. The media and the Internet are powerful sources of health-related information to the public, and health authorities must actively work at providing valuable public communications and improved accessibility and quality of information on their own Web sites. Strategies to increase vaccination coverage through better information should also focus on family doctors and pediatricians, because they have a crucial role in the acceptance of childhood vaccinations [15]. Immunization modules and adequate training in public health aspects of vaccinology should be included in all medical and nursing curricula to improve vaccination knowledge and practices of future health care workers [55].

The outbreaks in the identified distinct groups and settings occurred wherever there was clustering of susceptible individuals sharing common risk factors. Transmission in some of these groups, both in their resident countries and across borders, is facilitated by demographic and social factors, such as high contact rates because of large family sizes, large social gatherings, and close interaction among their members. Even with overall high national vaccination coverage, measles outbreaks will continue to occur as long as such homogeneous low-coverage groups exist.

Roma, Travellers, and immigrants may not be benefiting from health care services and immunization programs available in their resident countries for various reasons. Some reasons, such as lack of information and misconceptions on vaccine safety, are common to those among the general population. However, such groups are often marginalized and discriminated against, resulting in their physical separation from the mainstream of social and economic life into segregated neighborhoods where health services are restricted or entirely unavailable. Full integration into a health care system may not be possible due to the mobility of some members of such groups. However, lack of citizenship [56] and registration with a health care facility may also act as barriers in obtaining health insurance coverage and social services [57, 58]. In Romania, in 2005, of an estimated 7% of the population that remained unregistered with a general practitioner, most were Roma [59]. Changing the health status of such groups is clearly a complex issue requiring long-term activities. Nevertheless, bringing vaccination services to segregated communities in outreach programs and implementing measures to reduce discrimination are examples of specific strategies that can better integrate vulnerable groups into health and social programs.

Convincing communities that harbor strong philosophical or religious objections to vaccination can be challenging even though numerous outbreaks continue to emerge from schools belonging to such communities. In Germany, the vaccination recommendations advertised by the public health authorities in local newspapers and handouts to parents and carers in schools and kindergartens, most of which embraced anthroposophy, were apparently ignored before the ensuing outbreak affected these communities [45]. Amongst ultra-orthodox Jewish communities, the reasons for not being vaccinated were not religious ones but believed to stem from poor motivation to be vaccinated against childhood diseases and community politics that opposed services provided by the health authorities [35, 60]. Other religious communities at risk are those belonging to the Christian Reformed Church in the Netherlands, whose members refrain from vaccination on religious grounds. They form a strongly coherent social group that has its own churches and schools and consists of large families. The 1999–2000 outbreak spread across the country along the so-called “Bible Belt,” a geographic area extending from the northeast to southwest of the country, where most such communities live [61].

Different strategies to improve vaccination coverage will be required in the different communities. Health authorities may need to involve sociologists, anthropologists and health communication experts to improve the understanding of peoples' attitudes toward vaccination and the social structure of vulnerable groups that are hard to reach by routine vaccination programs. Emphasis should be placed on identifying the key behavioral determinants of vulnerable groups. These behavioral profiles, together with any identified barriers to vaccination,

should be used to determine key messages. Communications profiling of susceptible groups should also be performed to better gauge which channels can be used to reach them. Investment in basic behavioral and communication operational research studies would also enable authorities to tailor future campaigns to better meet the informational needs of susceptible groups. Information on the disease and its prevention should be continually provided to such groups, and means to persuade parents in favor of vaccination should be explored. Ensuring the involvement of communities and key contact points, such as local leaders, in promoting vaccination, planning vaccination services, and informing families about the availability of vaccination services will be required.

Unvaccinated school children are at an increased risk to acquire and transmit measles in school settings [62, 63]. Children attending preschool facilities and daycare centers are particularly at risk, because many are not yet eligible for the second MCV dose. Children who attended anthroposophic schools were less likely to be fully vaccinated, compared with those attending other types of schools [64]. Therefore, schools predominantly attended by students with philosophical and religious exemptions have a greater potential for measles outbreaks. Some school authorities during school outbreaks in Austria and Switzerland excluded students without evidence of vaccination to limit measles transmission during school outbreaks [36, 38]. However, exclusion can result only in limited control and more active prevention measures, including routine immunization requirements before school entry, such as those in the United States, are an approach to consider adopting in Europe.

Nosocomial transmission is of great concern not only because of the potential of spread to the general population but also because of possible serious complications in infants and adults and particularly in immunodeficient patients who cluster in hospitals and health care settings. The risk of transmission is especially increased if there is a delay or failure to diagnose an infection. This results from physicians' inexperience with an increasingly infrequent disease and the possible absence of rash in severely immunodeficient patients [6]. Increased transmission can also be attributed to failure to isolate the infectious patient or to notify the case in time so that infection control measures can be implemented. As measles remains a risk for health care workers who have not acquired natural immunity and have not been vaccinated, all hospitals and health care settings need to have in place infection control guidelines on the prevention and control of measles. These should include pre- and post-exposure prophylaxis policies and measures to ensure that all health care workers are adequately protected [65]. Offering susceptible health care workers MMR vaccination has been made a quality standard for all health care staff in the United States [66], and a similar approach may also be warranted in Europe.

All countries should have the ability to detect measles cases rapidly and adopt preventive and control measures without delay

to limit measles transmission. Indeed, strengthening surveillance systems is another key strategy of the elimination plan [1]. Enhanced surveillance with the use of measles virus characterization tools is important to ascertain transmission chains, to assess country-specific risk, and for documenting the interruption of endemic measles transmission. Importations of measles have highlighted the presence of pockets of susceptible individuals among the general population and particular groups. Failure to identify who gets measles and implement the elimination strategies in all European countries raises concerns for the successful and sustainable elimination of measles in Europe.

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Appendix Background information on the particular groups affected by measles in Europe

Roma

- Roma form a significant ethnic group living mostly in Central and South-eastern Europe but also in other European countries, the Americas, the former Soviet Union, the Middle East, and North Africa. Current estimates of the total Roma population in the European Union range from 6 million to 8 million. Accurate estimations are however, difficult because of infrequent data collection, the Roma’s mobility, and their reluctance to register as "Roma" in censuses for fear of being stigmatized.
- The origins of the Roma people have for centuries been subject to speculations and debate. Today, based on linguistics, physical anthropology and ethnic similarities there is broad consensus that Roma originated in Northern India [86] which they left a thousand or more years ago. Their appearance in Europe was first recorded in the early 1300s in South-eastern Europe (Byzantium, Greece and the Balkans) from where they spread to Central and Eastern Europe in the 1400s and Western and Northern Europe in the early 1500s [86, 87].
- Roma comprise of several groups including the Kalderash, the Machavaya, the Lovari, the Churari, the Romanichal, the Gitanos (Calé), and the Sinti amongst others. Of numerous terms used to refer to these groups, the terms Rom, Roma, Romani, or Rroma, are preferred as the term “Gypsy” is considered derogatory. In this article the word “Gypsy” is only used in quotes from other authors.
- The Romani language spoken by Roma is of Indo-Aryan origin and has many variants. Roma have diverse culture and traditions and all groups have their own individual beliefs and customs. Today, the vast majority live in permanent housing. However, many are still mobile for family and economic reasons.

- Throughout history, Roma have been marginalised and their basic human rights abused. Following the political changes in Eastern Europe in the 1990s anti-Roma sentiment in Europe have rekindled. Roma remain the least integrated people of Europe. Discrimination against Roma in employment, education, health care, administrative and other services has been reported [88].
- In many countries, health indicators such as life expectancy, child mortality, rate of infection and chronic diseases among Roma communities indicate drastic differences compared with the health indicators among the general population [89]. Research on the health of the Roma is limited and difficult to access [90] but some studies suggested a fourfold increase in infant mortality and a 10-year deficit in life expectancy [91].
- A political commitment by European governments to improve the socioeconomic status and social inclusion of Roma is being made through the initiative - *Decade of Roma Inclusion 2005–2015*, [92]. It represents the first multinational project in Europe to improve the socio-economic status and social inclusion of Roma in Europe by focusing on the priority areas of education, employment, health, and housing and commits governments to take into account other core issues such as poverty and discrimination.

Travellers

- Travellers are a nomadic people of Irish origin forming a minority group living mostly in Ireland and Great Britain. Arguably, they are sometimes collectively referred to as Irish Travellers. Travellers have their own language, values, beliefs and customs. Their language has two names, Gammon (or Gamin) and Cant, although academic linguistics often refer to it as Shelta.
- It is difficult to establish accurately the number of Travellers in Britain as they are not identifiable as a separate ethnic group in the census although they are recognised in British law as an ethnic group [93]. As a result estimates of the Traveller population in Britain vary widely—from 82,000 to 300,000 [93]. The Traveller population on the island of Ireland was estimated at 40,129 in 2008; 36,224 in the Republic of Ireland and 3,905 in Northern Ireland [94].
- The historical origin of Travellers as a group has been a subject of academic and popular debate [95]. However, many are thought to be descendants of people who were dispossessed of their land in the 16th century while others were left homeless as a result of the Irish potato famine in the 19th century. Further back to the 12th Century there is evidence of a group of travelling crafts people who played an important role in Irish society and Irish economy. Others were nomadic tradesmen dating back to 200 AD [96]. They travelled throughout Ireland and also across to Great Britain where they settled particularly in the 1950s and 1960s. Many live on sites, both council and private, some have moved into houses and many still have nowhere to camp and live on unauthorised sites constantly being moved on. According to the annual Caravan Count completed by local governments in 2009 there were 17,437 caravans belonging to Gypsy and Traveller families in England [97].

- Hybrid groups have sometimes emerged particularly in England as a result of cultural and social exchanges between Travellers and Roma. Indeed, separating groups of Roma from Travellers is often arbitrary [87]. The terms “Travelling People” and “Gypsy-Travellers” have been used to describe nomadic people.
- The *All Ireland Traveller Health Study* showed that compared with the general population, Travellers across the island of Ireland, North and South, have poorer outcomes in the areas of health, education and employment [94]. Travellers are reported to have higher rates of mortality in all age cohorts including infants and high rates of miscarriages and stillbirths [94,98].
- While access to health services was recently reported to be good on the island of Ireland [94], UK studies have shown the most common problem for Travellers is difficulty in accessing primary care through general practitioners because of their insistence in having a permanent address. Some general practitioners only register families as temporary residents, resulting in exclusion from a range of services, such as screening. Others allegedly refuse to register “Gypsies” and Travellers at all [99–101]. Difficulties in accessing health services such as minor injuries units and immunization programs have been described [102]. Low levels of immunization for children can be a particular problem where families are highly mobile, continuity of care is lacking, and specialist health visitors for the Roma and Traveller communities are not always available [103–105].

Anthroposophic communities

- Anthroposophy is a spiritual philosophy based on the teachings of Austrian-born Rudolf Steiner (1861–1925), who described it as “a way of knowledge—a cognitive path—that leads the spiritual in the human being to the spiritual in the universe” [106].
- Historically, anthroposophy originated from a tradition of esoteric thoughts on occult wisdom that gained a measure of popularity in the Anglo-Saxon world and in Germany during the 1880s. Anthroposophic concepts stem from European and Christian traditions and beliefs together with Eastern ones, including reincarnation and karma [107]. They have found applications in a variety of fields, including education, medicine, architecture, arts and agriculture.
- Steiner viewed the development of human life from the beginning of its existence in four stages: a physical body, common to the inorganic world; a etheric (life) body, common to plants, animals and humans; an astral (conscious) body, common to all animals and humans; and the ego (self-awareness), unique to humans [107]. The physical body is believed to develop during the first seven years of life, until the loss of deciduous teeth. Thereafter, the etheric body is unfolded and develops in a second step which lasts until puberty, when the astral body begins to develop.
- Steiner considered disease and healing processes as crises in which conflicts of an earlier earthly existence with the present bodily existence are resolved. Hence, measles, and other childhood diseases are perceived as opportunities for the development of the physical and the etheric body. After puberty, measles is no longer seen as helpful in this developmental process,

as a higher risk of complications is well recognized. Hence, anthroposophic physicians usually refrain from supporting measles immunization programs in early childhood but do not oppose parents' decisions to immunise their children.

- The number of individuals who adhere to anthroposophy and of physicians who offer anthroposophic medicine is not known. However, as of January 2011, there were reportedly 998 Steiner (also known as Waldorf) schools worldwide which follow anthroposophic concepts of education, with 222 schools in Germany and 464 schools in other European countries. In addition, there were about 1,500 Waldorf kindergartens worldwide [108], and more than 100 centers known as Camphill communities that provide opportunities for individuals with learning disabilities, mental health problems and other special needs [109].
- Recent statements have challenged further adherence to a nonvaccination strategy in the light of changing measles epidemiology. In 2008, the German Association of Anthroposophic Physicians issued a directive on measles and measles vaccination [110]. While maintaining the view that the overcoming of a disease such as measles, may contribute to the strengthening of children during their physical development, it is stated that Rudolf Steiner was not an adversary of immunizations, and that a spiritual education may compensate for the protective effects of immunizations against disease. A controversial debate among anthroposophic physicians on the subject is ongoing [111].
- Not all parents of children attending Steiner educational institutions adhere to the anthroposophic school of thought on immunizations. Some parents simply choose such alternative educational institutions for their children in favour of more general ones. Some may even be unaware of the philosophy and others may be vaccine sceptics. Therefore, a variety of reasons explaining the low immunization levels in these institutions need to carefully be considered.

Ultra-orthodox Jewish communities

- Members of the ultra-orthodox Jewish communities follow a theologically conservative form of Judaism called Haredi Judaism. Use of the term "ultraorthodox" is considered controversial, even pejorative as it implies extremism [112]. The communities are not part of a homogeneous population and represent many subgroups that differ in specific cultural and religious practices, each tending to follow their specific spiritual and rabbinic authorities. They constitute about 38% of the Jewish population of Jerusalem and about 8% of the general population in Israel [113], with sizeable communities in other countries mainly UK, USA, Canada, France, Belgium, Australia and Argentina.
- In Israel, these communities lean toward large families, overcrowded living conditions and a relatively low socio-economic status. They are very self-sufficient, with independent schools and community-supported welfare networks. Social contact with people outside the community is limited. The communities centre their lives on religious study, prayer and family. They do not rely on commercial television, secular films or publications. News and information are transmitted mainly by community specific print media. Frequent large social gatherings play a fundamental element of their community lifestyle. Rabbis or religious leaders enjoy utmost respect; their followers refer to them for guidance and advice on matters not necessarily related to religious practice or observance.
- Recommended vaccinations are generally accepted and the overall vaccination coverage for vaccine-preventable disease is satisfactory. Nevertheless, several small ultra-orthodox subgroups evade services provided by governmental agencies and health authorities. Thus, they would not register their children in public child well-baby clinics and not comply with the recommended childhood vaccinations. Consequently, these groups have been the focus of vaccine-preventable diseases outbreaks [37]. To avoid alienation and animosity, health organizations endeavouring to provide health services are adopting a more culturally sensitive approach.