

Actual immunization coverage throughout Europe: are existing data sufficient?

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Abstract

Assessing vaccine coverage is an essential component of vaccine programme monitoring and evaluation. Vaccine coverage data are available in EU/EEA countries at both national and subnational levels and are used for programmatic purposes at any level. European-wide data collection is performed by WHO through the Centralized Information System for Infectious Diseases, as part of the global data collection jointly conducted with UNICEF. Data quality and comparability are still challenging at an international level. According to available information, vaccination registries are available in 11 countries in the EU/EEA, but only in five countries do they have national coverage. In 2012 ECDC, through the VENICE II network, started the European Vaccination Coverage Collection System (EVACO project), with the final aim of improving the quality of vaccine coverage data at EU level, by defining and implementing standards.

Keywords: Mass vaccination, public health, vaccination coverage, vaccination programmes, vaccine epidemiology

Article published online: 27 November 2013

Clin Microbiol Infect 2014; **20** (Suppl. 5): 7–11

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What Is Vaccination Coverage?

Vaccination coverage can be defined as the number of persons belonging to a certain population (i.e. one birth cohort, a group targeted by vaccination campaigns, etc.) vaccinated against a specific disease, divided by the total number of individuals belonging to the same population. Such an apparently easy parameter is actually very tricky both to define and to assess adequately.

Several methods have been developed to assess vaccination coverage.

1. Administrative methods that are based on routine estimates of administered vaccine doses divided by the total estimated number of people in the target population. Administrative method estimates can be severely affected by inaccurate numerators or denominators.
2. Surveys: different survey designs have been developed to estimate the levels of immunization coverage at either national or subnational level, or even in selected population groups. Those are usually intended to provide coverage

estimates that can be used to verify data collected by administrative methods and eventually to provide additional information that is not available with administrative systems. Several different methodologies have been developed to conduct such surveys [1].

3. Seroprevalence surveys are designed to assess the actual level of immunity against a specific infectious disease. Serological surveys cannot distinguish between protection due to vaccination and naturally acquired immunity, and cannot estimate or verify vaccination coverage. In addition, they can be useful only when a clear correlate of protection from the disease is available after serology testing.
4. Immunization registries (immunization information systems): population-based, computerized registries, including individual records about all the residents within a certain area, can be used for assessing vaccination coverage. Immunization information systems are very useful tools to implement vaccination programmes and sustain high vaccination coverage; on the other hand, they are not extensively used for assessing vaccination coverage. Strengths and weaknesses of each methodology are summarized in Table 1.

Potential Issues That May Affect Vaccine Coverage Assessment

Methods used for defining vaccination coverage can affect the outcome. As an example, measles vaccination coverage can be defined as 'the percentage of 1-year-olds who have received at least one dose of measles containing vaccine in a given year' [2]. According to this definition, the statement '95% measles coverage in 2012 in country X' suggests that 95% of children living in country X in 2012 received one dose of measles vaccine before their 1st birthday. This looks apparently simple; nevertheless there are different options for assessing vaccination coverage using the definition above. The denominator should include children between 1 and 12 months of age living in country X in 2012; the numerator should account for those children among the population included in the denominator who received one dose of measles vaccine. If a one-point survey is used to assess vaccine coverage, then the numerator will report on the number of vaccinated children living in country X in 2012. In contrast, if an administrative method is used, very likely only those children vaccinated in 2012 will be counted (or even

measles vaccine doses distributed in 2012), and children who were still 12 months old in 2012 but who received their measles vaccination in 2011 will not be included in the numerator. This is not a trivial issue and represents only one of the potential problems related to the way vaccination coverage is defined. A correct definition of both numerator and denominator is essential for allowing comparison and interpretation of coverage data, as well as methodology used for the assessment.

Unfortunately, not only methodological issues can affect vaccination coverage assessment. In fact both numerator and denominator ascertainment could be severely biased. In the absence of a good information system, the denominator (i.e. the target population) can be underestimated because of the presence of uncensored population groups. This can be the case of illegal immigrants or travelling communities not captured by the system. On the other hand, the denominator can be overestimated because of the presence of emigration flows that are not promptly communicated and registered; for this reason, people no longer residing in the area may be still counted in the denominator and will dilute the coverage estimate. Similarly, ascertainment of vaccination status (numerator) could represent a challenge; lack of documentation of past vaccinations is one of the most frequent issues. Moreover, vaccine coverage assessment can be particularly challenging after supplementary immunization activities; in this specific case it is common to observe vaccination coverage levels >100%, because the number of distributed doses is often higher than the targeted population (i.e. children out of the targeted age groups are vaccinated).

TABLE 1. Strengths and weaknesses of different methodologies for assessing vaccination coverage

Method	Strengths	Weaknesses
Administrative methods	Based on routine collection, provide robust series of data. Integrated in the vaccination programme, do not require <i>ad hoc</i> implementation. Not expensive.	Can be severely affected by inaccurate numerator and/or denominator. Do not provide individual data if only number of administered doses is reported.
Surveys	Useful to assess data collected through administrative methods. Are the only source of information if administrative systems are not in place. Can provide additional information, i.e. on reasons for missed vaccination. Can be integrated into surveys with broader scope (nutrition, child health, education, etc.).	Require <i>ad hoc</i> implementation. Require <i>ad hoc</i> resources.
Seroprevalence surveys	Can provide information on the actual level of immunity in the target population. Extremely useful in population subgroups that are likely to be missed by administrative methods (hard-to-reach).	Impossible to distinguish between vaccination-acquired and naturally acquired immunity. Are suitable only when a clear serological correlate of protection is available. Expensive.
Immunization registries	Can provide very precise, individual information on immunization status. Can be linked to other health data sources for assessing other aspects of vaccination programme (safety, effectiveness, impact, etc.).	Are designed for improving service delivery (reminder systems, schedule compliance, etc.) more than providing vaccine coverage data. Estimates are strongly affected by the coverage of the registry. Are implemented at national level in few countries so far.

Why Vaccination Coverage Assessment Is Important

Vaccination, more than any other public health intervention, has not only an intrinsic value for the individual but also a great value for society. Beneficial externalities linked to vaccination programmes are related not only to the indirect protection effect, which non-immune people could benefit from, but also to broader societal benefits in the form of higher productivity (fewer working days lost), better education (lower school absenteeism) and economic gain (in the case of a positive cost–benefit ratio).

Traditionally, vaccines are used in the framework of a broad programme including planning, implementation and evaluation. Vaccine coverage is one of the primary output indicators of vaccination programmes: programme goals are usually expressed in terms of vaccine coverage levels (i.e. >90%, >95%, etc.) and a drop in vaccination coverage should lead to an urgent reaction by public health. More than the number of vaccinated individuals, what counts is the proportion of the

population that is vaccinated, namely the vaccination coverage; this is particularly important when herd immunity is expected as a positive effect of the vaccination, as is the case for most vaccination programmes. In fact, vaccination coverage estimates provide public health professionals with important information on both the level of protection of the community as a whole and the potential presence of pockets of susceptible individuals. Such information is particularly important for designing and implementing tailored intervention, i.e. in specific geographical areas or particular age groups. Last but not least, vaccination coverage is a very good indicator for allowing benchmarking at local, national and international level. In this respect, standardization of methods for vaccination coverage assessment is paramount. International benchmarking can also be used to raise awareness on the quality of the vaccination programme and for highlighting gaps and challenges.

Which Coverage Data Are Available in Europe (EU Level, National and Local Level) and Problems Related to Data Quality

Vaccination coverage is assessed in every district or region in the EU. Unfortunately, both the methods used and the frequency of assessment are highly variable, making comparison and benchmarking challenging. This has been one of the most important findings of the survey conducted by the VENICE network in 2007 in 27 EU/EEA member states [3]. According to the results from the VENICE survey, time intervals used for assessment range widely (from 1 month to 5 years); moreover, vaccination coverage is assessed either at 12 months, or at 24 months, or at age of school entry. The report also demonstrates that vaccination coverage data are validated in about half of the countries.

Vaccination coverage in EU countries is estimated using diverse methods. Administrative methods are most commonly used but a wide variety of parameters are used for assessment, including the number of subjects vaccinated, the number of vaccines administered, the number of vaccines distributed or collection of data from vaccination points like schools or well-baby clinics. Moreover, surveys are frequently used to validate administrative data collection, in the form of interviews, focus groups and household or school surveys [3]. Use of computerized systems will be discussed later in this paper.

The only system currently in place for collecting vaccination coverage data at international level is run jointly by WHO and UNICEF [4]. All countries, including the EU member states, are asked yearly to fill in the WHO/UNICEF Joint Reporting Form on Immunization [5]. The Joint Reporting Form is a

complex tool that aims at collecting data and elaborating indicators for monitoring and evaluating vaccination programmes. To improve the quality and assure comparability of data, WHO and UNICEF report a vaccine coverage estimate based on the information included in the Joint Reporting Form after applying a complex algorithm [6]. According to this algorithm, if multiple figures are available for a given country, an effort is made to create a consistent pattern over time from the data source that has the least potential for bias. Interpolation is used to assign values for years for which data are not available. If there are no data available for the most recent estimation period, the estimate will stay the same as in the previous year. Notes are added to the published data to better explain how the data were reported but in some cases they are not enough to understand all the figures.

Based on data reported in the Joint Reporting Form, the Centralized Information System for Infectious Diseases (CISID) is the system used by WHO to collect, analyse and present data on vaccination coverage in the European region [7]. Due to the methodological issues discussed above, occasionally the figures on vaccination coverage presented by CISID are not the same as the figures presented on the WHO general website, which poses another difficulty in interpreting these data [8,9]. Even though the reliability of these data is still a challenge, nevertheless WHO CISID is the only robust source for comparing vaccination coverage in the EU at present (Table 2). To improve data quality, international standards should be agreed by Member States and compliance to the reference standard should be part of regular monitoring. This is still a challenge in Europe, where implementation of vaccination programmes is the exclusive task of the national authorities. The large variety of delivery systems and vaccination schedules makes developing EU standards very difficult.

How Available Vaccine Coverage Data Can Be Used

Vaccine coverage data could be used not only for monitoring the quality of vaccination programmes but also for identifying and prioritizing targeted interventions. In fact, gaps in the immunity in selected population groups (geographical areas, specific age groups, hard-to-reach communities, etc.) can be identified by means of a thorough analysis of vaccination coverage data. In the presence of good quality data, vaccination coverage can provide good estimates of the real level of immunity in the population, as further discussed in this paper. In contrast, when vaccination coverage data are not reliable, only seroprevalence studies can identify immunity gaps and inform targeted actions [10].

TABLE 2. Vaccine coverage data available at international level

WHO/Europe's centralized information system for infectious diseases (CISID)	WHO/Europe's programme on vaccine-preventable diseases and immunization collects data on vaccination coverage in each Member State. These data are collected annually, using the WHO/United Nations Children's Fund (UNICEF) joint reporting form (JRF). Source: Country national coverage reports and WHO/UNICEF coverage estimates. Data reported are the result of an estimate based on a tailored algorithm.
WHO/UNICEF estimates of national immunization coverage at global level	The most likely true level of immunization coverage is estimated and reported annually, based on data officially reported to WHO and UNICEF by Member States as well as data reported in the published and grey literature. Whenever possible local experts have also been consulted for additional information regarding the performance of specific local immunization services.
ECDC/VENICE annual survey on influenza vaccination	Since 2007, ECDC has organized an annual survey—conducted by the VENICE project—on seasonal influenza coverage. Information on how influenza vaccination programmes are organized in the EU is also available.
ECDC/VENICE EVACO project	ECDC, through the VENICE network, started in 2011 the European Vaccine Coverage Project (EVACO). Main aim of the project is to provide reliable and standardized vaccine coverage data in the EU. A standard for data collection has been agreed and a piloting phase has been concluded. Discussion is ongoing on integration of EVACO into the CISID system.

Availability of relatively long time series of vaccine coverage data can provide a rough estimate of the susceptible population that accumulated over a certain period. As an exercise, vaccination coverage data reported to WHO by France have been used to estimate the population that was susceptible to measles in 2011. Based on number of unvaccinated children, not accounting for natural boosters and estimating vaccine of 95% after one vaccine dose, the size of susceptible population per age group has been estimated (Fig. 1).

Number of measles cases reported in France during the outbreak that occurred in 2011, distributed by age group (data reported to ECDC Tessy [11]), are shown in Fig. 2.

Even being the result of a very rough estimate, the distribution of cases reported during the large outbreak in 2011 fits very well with the distribution of the estimated susceptible population. Definitively, in the presence of robust vaccination coverage data, some disease forecast can be performed without using sophisticated modelling. In particular, population immunity gaps could be identified and addressed by specific supplementary immunization activities.

Vaccine Coverage Versus Seroprevalence Data

Well-designed, well-conducted seroprevalence surveys are the best tool to assess the real immunological status of the

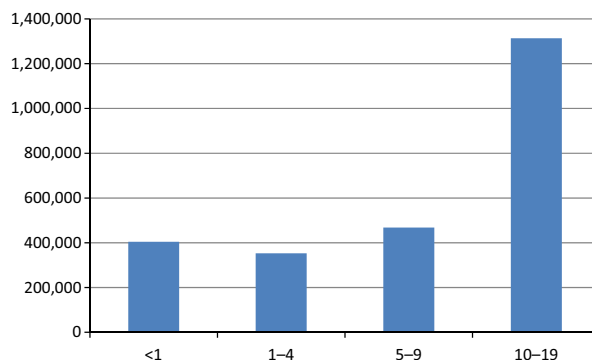


FIG. 1. Estimate of the population susceptible to measles in France in 2011, based on vaccine coverage data reported in Centralized Information System for Infectious Diseases; assuming vaccine efficacy of 95% after one dose and not taking into account the effect of potential natural boosting.

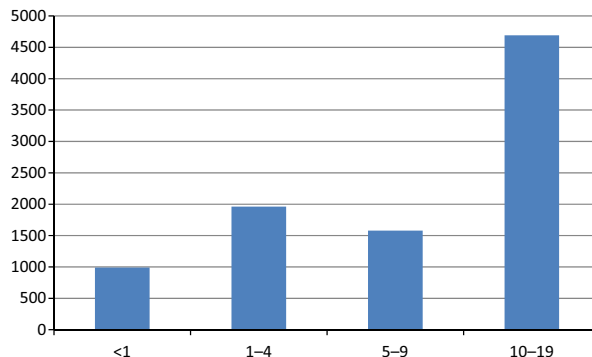


FIG. 2. Number of measles cases reported in France in 2011. Source ECDC/Tessy (The European Surveillance System).

population and identify immunity gaps. In addition, factors predicting low coverage can be identified and waning immunity can be explored [1, 12]. In the presence of low circulation of the infectious agent, seroprevalence data can be a good proxy of the vaccination coverage and, at least, validate data collected through vaccine coverage surveys or administrative methods. On the other hand, serosurveys are expensive and their routine use is limited. Moreover, in the presence of good-quality vaccine coverage data, the value-added of serosurveys for informing vaccination programmes is limited [12]. Combining these to wide-scope studies (health interviews/surveys during childhood or adolescence) or using lower-cost methodologies (use of residual sera) could optimize the use of resources and make them more suitable for public health purposes.

Vaccination Registries in Europe

Vaccination registries, better defined as Immunization information systems, are computerized databases that record each

vaccine dose provided to persons resident in a defined area. They represent a very powerful tool both at the vaccination point of care and at population level. Locally they support many operational aspects of the vaccination programme, like managing recall/reminding systems, monitoring safety of administered vaccines, managing vaccine stocks, etc. At a population level, immunization information systems provide information (first of all vaccination coverage) useful for identifying gaps and improving vaccination coverage. Privacy and confidentiality are an essential aspect of immunization information systems. Data must be protected and treated as sensitive information. Policies and guidelines on data confidentiality are available in Europe [1,13].

A description of immunization registers in six European countries has been published by Pebody [14]. Additionally, according to a recent VENICE survey conducted in 24 EU/EEA member states, immunization information systems are available in 11 countries but only in five countries do they have national coverage. Nevertheless, the situation is rapidly evolving as a further nine countries reported an intention to implement immunization information systems in the near future [1].

Conclusions

Assessing vaccine coverage is an essential component of vaccine programme monitoring and evaluation. At present, CISID is the only reliable source of robust vaccine coverage data at a European level. Nevertheless, lack of standards for data collection and reporting prevents international comparison and benchmarking.

In 2012 ECDC, through the VENICE II network, started the European Vaccination Coverage Collection System (EVACO project), with the final aim of improving the quality of vaccine coverage data at an EU level, by defining and implementing standards. This represents the first attempt at an EU level to improve vaccine coverage data quality and encourage the adoption of standards for data collection. According to the preliminary piloting of the project, out of 29 invited EU countries, 25 were able to provide data according to the EVACO standard. Nineteen countries also reported data at a subnational level (EVACO preliminary results, personal communication with P.F. D'Ancona). Thereby preliminary results were promising. During the implementation phase of the EVACO project integration with the CISID system will be carefully considered to avoid duplication and benefit of synergies.

Transparency Declaration

The authors declare no conflicts of interest.

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