Præventis, the immunisation register of the Netherlands: a tool to evaluate the National Immunisation Programme

A van Lier (alies.van.lier@rivm.nl)[1], P Oomen[2], P de Hoogh[2], I Drijfhout[3], B Elsinghorst[2], J Kemmeren[1], M Conyn-van Spaendonck[4], H de Melker[1]

1. Department of Epidemiology and Surveillance (EPI), Centre for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands
2. Regional Coordination of Programmes/Purchase, Storage and Distribution (RCP/IOD), Centre for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands
3. Preparedness and Response Unit (LCI), Centre for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands
4. National Immunisation Programme Manager, Centre for Infectious Disease Control, National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands

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Vaccination coverage is an important performance indicator of any national immunisation programme (NIP). To monitor the vaccination coverage in the Netherlands, an electronic national immunisation register called 'Præventis' was implemented in 2005. Præventis has a link with the population register and can produce letters of invitation for the NIP, register and validate administered vaccinations. The database is used to monitor the vaccination process, produce reminder letters, control the stock of vaccines and provides information used for paying the fees to the different executive organisations involved. Præventis provides a crucial tool for the evaluation of the NIP by producing (sub)national vaccination coverage estimates with high accuracy and allowing additional research: identifying populations at high risk for low coverage based on existing data, conducting specific studies where individuals included in the immunisation register are approached for further research, using vaccination coverage data for the interpretation of (sero)surveillance data, and linking the immunisation register with disease registers to address vaccine safety or vaccine effectiveness. The ability to combine Præventis data with data from other databases or disease registers and the ability to approach individuals with additional research questions offers opportunities to identify areas of priority for improving the Dutch NIP.

Introduction

The Dutch National Immunisation Programme (NIP) started in 1957. Today, the immunisation schedule includes vaccination against diphtheria, tetanus, polio, pertussis, infection with *Haemophilus influenzae* type b, measles, mumps, rubella, meningococcal C disease, pneumococcal disease (10 serotypes), cervical cancer (human papillomavirus type 16/18) and hepatitis B (Table 1). In the Netherlands, vaccinations within the NIP are administered free of charge and voluntary.

The overall direction of the NIP rests on the programme manager at the Centre for Infectious Disease

TABLE 1

Immunisation schedule of the National Immunisation Programme, the Netherlands, 2011

Age	Vaccination-dose
At birth (<48 hours)	HepB-0[a]
2 months	DTaP-IPV-Hib-HepB-1[b] + PCV-1
3 months	DTaP-IPV-Hib-HepB-2[b] + PCV-2
4 months	DTaP-IPV-Hib-HepB-3[b] + PCV-3
11 months	DTaP-IPV-Hib-HepB-4[b] + PCV-4
14 months	MMR-1 + MenC
4 years	DTaP-IPV-5
9 years	DT-IPV-6 + MMR-2
12–13 years	HPV-1 + HPV-2 + HPV-3[c]

DTaP: diphtheria-tetanus-acellular pertussis vaccine; HepB: hepatitis B vaccine; Hib: *Haemophilus influenzae* type b vaccine; HPV: human papillomavirus vaccine; IPV: inactivated polio vaccine; MenC: meningococcal C-conjugate vaccine; MMR: measles-mumps-rubella vaccine; PCV: pneumococcal conjugate vaccine.

[a] Only for children whose mother tested positive for hepatitis B surface antigen (HBsAg).

[b] From August 2011 all newborns have received vaccination against hepatitis B; before August 2011 this vaccination was only offered to risk groups.

[c] Only for girls; three doses with vaccination scheme 0-1-6 months.

Source: [1].

Control of the National Institute for Public Health and the Environment (RIVM). She is responsible for implementing the ministry's vaccination policy in the NIP and defines the operational conditions. The execution of the NIP is coordinated operationally by the department Regional Coordination of Programmes/Purchase, Storage and Distribution (RCP/IOD). Five local offices of RCP/IOD coordinate the execution of the NIP in their own region. Vaccinations are administered at local level by the network of Child Health Clinics (CHC) and by Public Health Services (PHS). The Epidemiology and Surveillance (EPI) unit is responsible for evaluation of the NIP through surveillance and epidemiological research of the impact of (future) target diseases including vaccination coverage.

With regard to evaluation of the NIP, vaccination coverage is an important performance indicator. To be able to monitor the Dutch vaccination coverage, an electronic national immunisation register called 'Præventis' was implemented in 2005 and is managed by RCP/IOD. Before the introduction of Præventis, different regional immunisation registers were in place, producing invitation letters and reminders and registering vaccinations. Præventis has these functionalities and moreover includes an algorithm to validate administered vaccinations. The database is used to monitor the vaccination process, to produce reminder letters and to control the stock of vaccines, and it provides information used for paying the fees to the different executive organisations involved in the vaccination process. Thus Præventis provides a crucial tool for the evaluation of the NIP by producing vaccination coverage reports and allowing additional research. In this paper we describe this in more detail.

The immunisation register Præventis

All children under the age of 19 years eligible for the NIP are registered in the national immunisation register Præventis (files are stored for a period of 15 years, until the age of 34 years). Through a link with the population register (gemeentelijke basisadministratie, GBA), Præventis receives continuous updates on all newborn and deceased children and on changes in the address of children (due to movement within the country or immigration/emigration). In general, these GBA updates are processed automatically with the use of the personal public service number (burgerservicenummer, BSN) as a unique identifier; only in case of a problem with processing an update, manual validation takes place by an employee of RCP/IOD. For each newborn or immigrated child a new NIP record with a unique client number is automatically created in Præventis. Therefore, Præventis includes a record for each child, irrespective of participation in the NIP. Præventis is used as the national immunisation register but is also the database to facilitate other collective preventive programmes such as maternal screening for hepatitis B, syphilis, infection with human immunodeficiency virus (HIV), blood group and irregular antibodies, as well as neonatal screening for congenital diseases such as inborn errors of metabolism.

Vaccination process through Præventis: from invitation to registration

The letters to invite parents to get their child(ren) vaccinated according to the NIP are automatically created in Præventis and sent by RCP/IOD for all children at the age of one month, around four years, and around nine years, as well as for girls around 12 years. This invitation includes personalised vaccination cards that parents need to bring along at each vaccination (Table 1) of their child. Vaccinations are administered by the CHC for children up to the age of four years and by PHS for school-aged children. Subsequently, administered vaccinations (vaccine characteristics, dose, date of administration, executive organisation) as well as possible principal objections to vaccination are registered on the vaccination cards. The CHC and PHS return the vaccination cards by post to one of the five local offices of RCP/IOD, where the data are entered in Præventis with a barcode reader. Alternatively, the CHC and PHS can choose to enter the data directly in Præventis through an internet application 'RVP Online' (i.e. NIP online), which is increasingly used. Parents of children that do not respond to the initial invitation to get their child(ren) vaccinated within a certain time limit receive a reminder by letter by the RCP/IOD centrally or on request at regional level by one of the local executive organisations.

Validation

RCP/IOD is responsible for managing the registration process in both Præventis and RVP Online. The local organisations are only allowed to make corrections in their own regional data. Præventis includes criteria to judge the validity of each vaccination within the current NIP guidelines. This means that in some cases administered vaccinations are registered in Præventis but automatically rejected, for example because they are not administered at the right moment (the time interval between two vaccinations was too short) or with a deviant vaccine product. If needed, the parents of the concerned child receive a new invitation for additional vaccination.

Authorisation and confidentiality

Access to Præventis is only allowed to people who need to administer or register vaccinations and to the medical advisors and regional managers of the NIP. The data are saved on the level of the individual (i.e. they are not anonymous) but are only accessible at individual level for people who need to register vaccinations or assess the immunisation status of a particular child. All data requests made for the purposes of additional research through Præventis are assessed by a multidisciplinary team, specifically with regard to privacy aspects.

Residents do not have access to Præventis but they are able to request information on their vaccination history at the local organisation responsible for the

execution of the NIP in their own region. Furthermore, there is no connection between healthcare records of clinicians and Præventis but a link with the electronic youth health files that are used by the CHC and PHS to monitor the child's health on different aspects, is being developed.

Tool to evaluate the National Immunisation Programme

Besides a powerful tool to facilitate the daily delivery of the NIP with high quality, Præventis is also a very useful tool to evaluate the coverage of the NIP. The information in the register enables evaluation by various approaches. Here we describe these approaches and present our experiences with the immunisation register.

To measure (sub)national vaccination coverage

Monitoring vaccination coverage is important in order to follow the progress towards goals for controlling and/or eliminating vaccine-preventable diseases. Præventis does not include a standard threshold to indicate low vaccination coverage. An additional reporting tool, 'Præmis', was developed to be able to compose different reports on vaccination coverage. At central level, the RIVM determines annually the national vaccination coverage for specific birth cohorts. On individual level and at different moments in life we determine if, according to the NIP guidelines, sufficient vaccinations have been given before a fixed age. Table 2 gives an overview of the different ages at which the vaccination coverage is determined for each of the (combination of) vaccines.

Besides determination of the national vaccination coverage it is also important to have insight into the vaccination coverage at subnational level since a high national vaccination coverage is no guarantee for a high vaccination coverage at subnational level and consequently no guarantee against outbreaks of vaccine-preventable diseases [3-6]. Annually, the vaccination coverage is reported by province (n=12) and by municipality (n=415 on 1 January 2012).

The data on (sub)national vaccination coverage are disseminated in the form of an annual RIVM report that is publicly available [2]. Through this annual report we inform not only the Ministry of Health and other organisations such as the European Centre for Disease Prevention and Control and the World Health Organization but also the CHC and PHS. With the subnational data in this report the latter are able to evaluate their local efforts to reach high vaccination coverage in their own region. An example of the standard geographical presentation in the annual report of the vaccination coverage by municipality is presented in the Figure. These maps are also available online through the Dutch National Atlas of Public Health [7]. This website shows the current and historical vaccination coverage in each municipality simply by clicking on one of the municipalities. If needed the five local offices of RCP/IOD are also able to break down the regional vaccination coverage at a lower level, such as the four-digit postcodes. Furthermore, they are able to produce more timely management information at any time during the year to be able to monitor the progress in regional participation more closely than through the annual report.

To identify populations at high risk for low vaccination coverage based on existing data

Understanding reasons for a low vaccine uptake is important to provide recommendations to improve vaccination coverage and to determine which aspects

TABLE 2

Individual age at which vaccination coverage is determined per (combination) vaccine, the Netherlands, 2011

Newborns 3rd day of life	Infants 1 year	Toddlers 2 years	Preschool children 5 years	School children 10 years	Adolescent girls 14 years
	DTaP-IPV-3	DTaP-IPV-4	DTaP-IPV-5	DT-IPV-6	
	Hib-3	Hib-4			
	PCV-3	PCV-4			
		MMR-1		MMR-2	
		MenC			
					HPV-3
HepB-0[a]		HepB-3/4			

primary immunisation | basic immunity | revaccinated | fully immunised

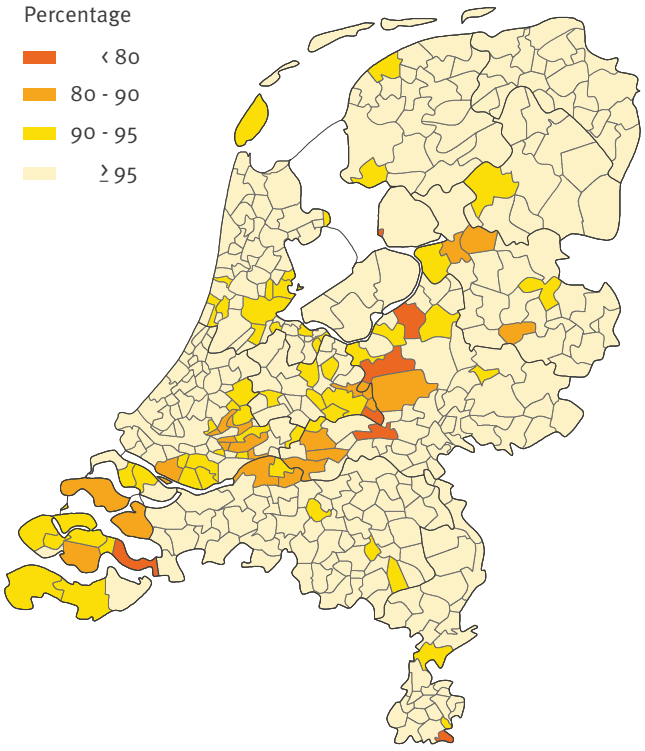
DTaP: diphtheria-tetanus-acellular pertussis vaccine; HepB: hepatitis B vaccine; HiB: *Haemophilus influenzae* type b vaccine; HPV: human papillomavirus vaccine; IPV: inactivated polio vaccine; MenC: meningococcal C-conjugate vaccine; MMR: measles-mumps-rubella vaccine; PCV: pneumococcal conjugate vaccine.

[a] Only for children whose mother tested positive for hepatitis B surface antigen (HBsAg).

Source: [2].

Figure

Vaccination coverage for the first measles-mumps-rubella vaccination in birth cohort 2008 (determined at the age of two years), by municipality, the Netherlands, 2011



Source: [8].

future studies should focus on. Besides data on vaccination history, some background characteristics are also available on individual level through Præventis (sex, age, country of birth of the parents). Since Præventis includes all children in the Netherlands, these data can be used to determine whether there are differences in background characteristics between vaccinated and unvaccinated children so as to identify risk groups.

Præventis also makes it possible to combine immunisation data with other existing databases, even if these data are not available on an individual level. An example of this is a study on human papillomavirus (HPV) vaccination coverage: voting data for two political parties (Reformed Political Party (SGP) with predominant orthodox reformed adherents and Christen Union (Christen Unie) with Christian adherents) by municipality from Statistics Netherlands and socioeconomic status data by postcode from the Netherlands Institute for Social Research were incorporated in the analysis of possible determinants of HPV vaccination coverage since information on religion and socioeconomic background was not available in Præventis [9]. A similar analysis was conducted for other vaccinations (data not shown).

Future research areas

In the future we would like to determine vaccination coverage per school to identify risk schools that need priority attention during an outbreak situation. This is important for the Dutch situation since people belonging to the orthodox Protestant minority and anthroposophists, who more often object to vaccination, tend to cluster at school level [10]. At first, possible privacy issues with regard to combining data from Præventis with data from schools (who is going to which school?) need to be explored. Another future research area is to find out if premature newborns follow the NIP guidelines in the same way as the rest of the newborns by combining data from Præventis with data on pregnancy duration from neonatal screening. Based on literature the hypothesis is that premature newborns receive their first vaccination somewhat later than full-term children [11,12] and could therefore be more at risk for vaccine-preventable diseases.

To approach individuals included in the immunisation register for further research

Participants of studies aimed at evaluating the NIP can be recruited through the immunisation register: Præventis enables the inclusion of both vaccinated and unvaccinated individuals. These individuals are asked by post whether they are willing to participate in a specific study. Such studies include questionnaire studies (e.g. on hepatitis B vaccination acceptance [13]), vaccination trials (e.g. pneumococcal disease), studies with focus groups (e.g. acceptance of the NIP) and vaccine effectiveness studies (e.g. mumps outbreak [14]). Individual vaccination records are regularly used for this kind of studies. When informed consent is obtained from participants in a specific study, their vaccination history can be checked in Præventis. Thus information on immunisation status can be obtained that is more reliable than self-reported vaccination history. In the nationwide serum collection [15] used to evaluate the NIP and in a mumps outbreak study [14] this information was retrieved from Præventis for all participants.

To use vaccination coverage data for the interpretation of (sero)surveillance data

With reliable nationwide data on vaccination coverage we can interpret observations from other surveillance sources on the occurrence of particular diseases and on immunity profiles. The screening method can be used to estimate vaccine effectiveness using the proportion of cases vaccinated [14,16]. This proportion is compared to the nationwide vaccination coverage. To prevent bias in this method, it is essential that the cases' vaccination history as well as the nationwide data are reliable. This method is particularly suitable to study changes in vaccine effectiveness over time and was used in the Netherlands to interpret the re-emergence of pertussis [17]. Also to interpret seroprofiles measuring the immunity in the population by assessing specific antibodies, vaccination coverage is needed, since the immunity of the population reflects the result of the level of vaccination coverage, vaccine effectiveness and occurrence of natural infection.

To link the immunisation register with disease registers to address vaccine safety or vaccine effectiveness

Secondary use of healthcare data may advance medical knowledge especially with regard to disease aetiology and outcome. Extending linkages between databases will create a useful tool for knowledge discovery in the area of disease aetiology and outcome. In the Netherlands we plan to link Præventis to a large, well-established population-based medical record database, IPCI (Interdisciplinary Processing of Clinical Information [18]). The linkage itself will be done by a trusted third party (TTP). This TTP will store the linkage file that comprises the patient identifier of Præventis, the IPCI identifier and a matching weight which indicates the probability that record pairs may be accepted as links. The researchers will receive a study file with data from the linked databases but without patient identifiers.

At present, we are performing a study on the validity of the linkage of Præventis and IPCI. The association between measles-mumps-rubella (MMR) vaccination with febrile convulsions (true positive association) and fractures (true negative association) will be tested. Based on the results of this study future linkage studies can be performed to monitor effectiveness and safety of vaccination.

Another example is an ongoing study to estimate the association between the HPV vaccination status of daughters and the participation of their mothers in cervical cancer screening. The aim of this study is to identify risk groups for inclusion in (educational) campaigns in order to increase participation in cervical cancer prevention programmes. It uses data from Præventis combined with data from the cervical cancer screening, which was also linked by a TTP [19].

Discussion

A survey on vaccination coverage assessment among the countries in the Vaccine European New Integrated Collaboration Effort network (VENICE) in 2007 showed that 15 countries in Europe had national or local computerised immunisation registers in place and five countries had future plans to develop such a register [20]. The VENICE survey on functional standards for computerised immunisation registers in Europe revealed that in a number of countries such as Belgium, Spain, Italy, Ireland and the United Kingdom (UK), the register does not consist of one national immunisation register, such as in the Netherlands since 2005, but of different local immunisation registers [21].

An important advantage of Præventis is that it is one registration system with a central database that covers the whole country. Therefore, there are almost no linkage and definition problems between local regions any more compared to the period before 2005 when different regional immunisation registers were in place. Having one national immunisation register also simplifies evaluation of the NIP, since the data can be extracted from the register at a central level instead of combining several data sets extracted at regional level. In the Netherlands, the vaccination coverage in the NIP is evaluated annually and published in an RIVM-report. In the UK, the vaccination coverage is evaluated quarterly by COVER (Cover of Vaccination Evaluated Rapidly), which might allow earlier detection of changing trends [22]. However, in the Netherlands the vaccination coverage has been very stable for a long time [2,23] and the five local offices of RCP/IOD are able to produce timely management information at any time during the year to be able to monitor the progress in regional participation more closely than through the standard annual report. Furthermore, in specific situations such as during the introduction of HPV vaccination, the national participation is evaluated ad hoc and more frequently than annually.

Another advantage of Præventis is that it is continuously updated by data from the population register (GBA) and can therefore produce an accurate figure of the denominator for calculating vaccination coverage. This in contrast to some other immunisation registers such as in the UK where the denominator is based on a combination of general practitioner registration and place of residence for unregistered patients, and where children can sometimes be registered more than once because they are not always removed from a system when they move to a different area [22].

Because only one immunisation register has been in place since 2005, the system is also vulnerable. Different operations such as regular backups are established to guarantee the continuous accessibility of Præventis. Regular changes in the NIP require regular adjustments of Præventis. These changes in the software carry certain risks for the continuation of the registration process. Good standard procedures, for example standard procedures for implementing changes and test reports are necessary and have been formulated and implemented for Præventis. At this moment, only vaccinations included in the NIP are registered in Præventis. Certain vaccinations are therefore not registered, for example seasonal influenza vaccination which is covered by a separate programme (vaccinations administered by the general practitioners), travel related vaccinations, and all other vaccinations that are administered outside the NIP.

Conclusion

The Dutch immunisation register Præventis does not only support the daily delivery of the NIP but allows the assessment of vaccination coverage with high accuracy at both national and subnational level. The ability to combine Præventis data with data from other databases or disease registers and the ability to approach individuals with additional research questions depending on their vaccination history offers opportunities to explore areas of priority to improve the Dutch NIP.

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