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Work package 5 – Task 5.2

Report on standardized estimations of vaccination coverage

(Deliverable D5.3)

Report prepared by

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Tables and Figures

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Abbreviations

ECDC	European Centre for Disease Prevention and Control
EU/EEA	European Union/European Economic Area
IIS	Immunization Information Systems
M	Month since project start
MCV	measles containing vaccines
MMR	measles, mumps and rubella
MMRV	measles, mumps, rubella and varicella
NUTs	nomenclature des unités territoriales statistiques (from French)
PP	period prevalence
SRP	strategic response plan
SSI	Statens Serum Institut
WHO	World Health Organization
WP	work package

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Executive summary

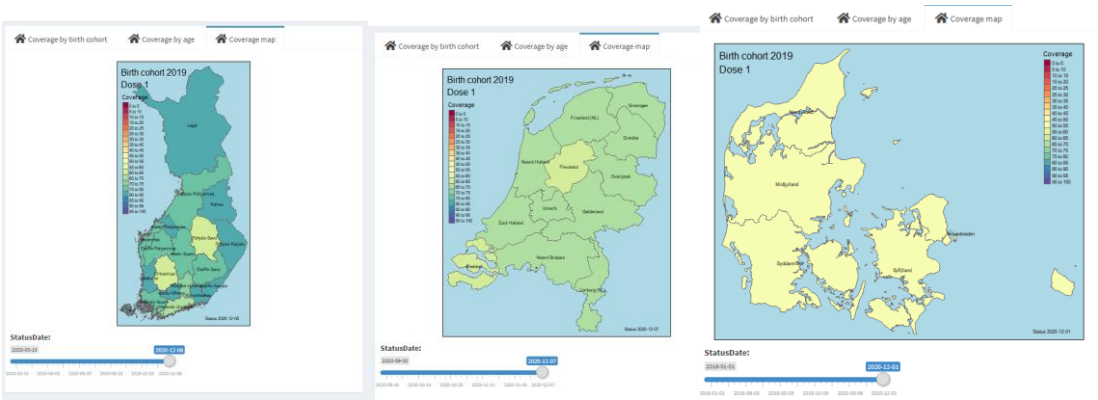
National measles containing vaccine (MCV) coverage is reported to WHO yearly. However, countries are using different methods to obtain data on vaccine coverage e.g. national or subnational surveys, administrative methods and vaccination registries and the data is published annually with several months delay.

In Task 5.2 it was the aim to establish common methodological guidelines, data structure and criteria for standardised assessment of vaccination coverage. To fulfil this aim, an R-package was developed as a tool to do timely and standardised estimations of MCV coverage within and between countries and to identify immunity gaps at national and regional level.

Three partners (Finland, The Netherlands and Denmark) from WP5 who had an IIS in place extracted population and vaccination data and estimated standardised MCV coverage using the R-package. The outputs from the R-package were MCV dose 1 and 2 coverage estimates by birth cohort and the age of vaccination. The coverage was also estimated per birth cohort at regional level (NUTs 3) and displayed on maps allowing each country to identify differences in coverage between regions.

All three countries extracted population and vaccination files real time at least three times. This allowed us to compare MCV dose 1 and 2 coverage between countries at the same point in time. The administration of MCV dose 1 is displaced in time from 12 months of age in Finland, 14 months of age in The Netherlands to 15 months of age in Denmark. The impact of this difference in recommend age of vaccination between the three countries is show in Figure A, where MCV 1 coverage in birth cohort 2019 is compared start December 2020. For MCV dose 2, the difference in recommended age at vaccination is even larger and varies from 4 years of age in Denmark to 9 years of age in the Netherlands, which inevitable will result in immunisation gaps.

Figure A. MCV dose 1 coverage in the 2019 birth cohort in Finland, The Netherlands and Denmark, start December 2020 (screenshots from the R-package)



With the age at vaccination shown as part of the R-package output, it was possible to identify if the observed differences in coverage between regions or countries was due to any delay in vaccination with regard to the national recommend age at vaccination.

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All three countries were able to prepare new population and vaccination data files within a short timeframe. This is very important, as this will allow us to prepare coverage maps quickly, if a measles outbreak is discovered and a vaccination campaign should be planned in relevant areas with short notice.

It was not possible to identify cross-border immunity gaps as none of the partners enrolled in this study had shared borders. However when comparing MCV coverage that was extracted at the same point in time between the three countries. It was very clear that immunity gaps were created due to differences in recommended age at vaccination.

Several European countries are setting up IIS systems and with real time excess to population and vaccination data the R-package and the pilot platform are powerful tools to identify immunisation gaps.

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Introduction

Measles is one of the most contagious diseases of humans. World Health Organization (WHO) recommends that two doses of measles vaccines should be standard for all national immunization programs. Countries aiming at measles elimination should achieve ≥95% coverage (1).

European Centre of Disease Control and Prevention (ECDC) and WHO have published reports describing resurgence of measles in Europe (2,3) and WHO has published a strategic response plan (SRP) for the measles emergency. Both reports states that the measles outbreaks in the European Region are driven by high rate of unvaccinated individuals and these outbreaks will continue as long as large pockets of unimmunized or under-immunized individuals are present (2,3). According to the SRP the European Region achieved 91% estimated coverage for the second dose of measles vaccination in 2018. While this level of coverage is an improvement from previous years, it is not uniform across the Region and high national-level coverage can mask pockets of low coverage at the local level that is undetected until outbreaks occur. This underlines the need for timely surveillance of measles vaccination coverage in finer geographical areas across Europe.

National measles containing vaccine (MCV) coverage is reported to WHO yearly. However, countries are using different methods to obtain data on vaccine coverage e.g. national or subnational surveys, administrative methods and vaccination registries and the data is published annually with several months delay. In May 2016, ECDC did a survey on immunization information systems (IIS) in 30 EU/EEA member states and found that 11 countries had IIS systems operating, three had a subnational IIS operating, while one country had an IIS that was being piloted (4). Currently many European countries and regions are in the process of developing IIS. Access to electronic vaccination data from IIS's in Europe can facilitate timely standardised estimations of vaccination coverage.

The main objective of this work package (WP) is to strengthen the interaction of IIS's in Europe. In Task 5.2 it is the aim to establish common methodological guideline, data structure and criteria for standardised assessment of vaccination coverage. In addition, it is the objective to test the feasibility of doing cross-Europe standardised MCV coverage using data from IIS and to identify immunity gaps at national and regional level.

To fulfil the aim of task 5.2, an R-package was developed as a tool to do timely and standardised estimations of MCV coverage within and between countries.

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Materials and Methods

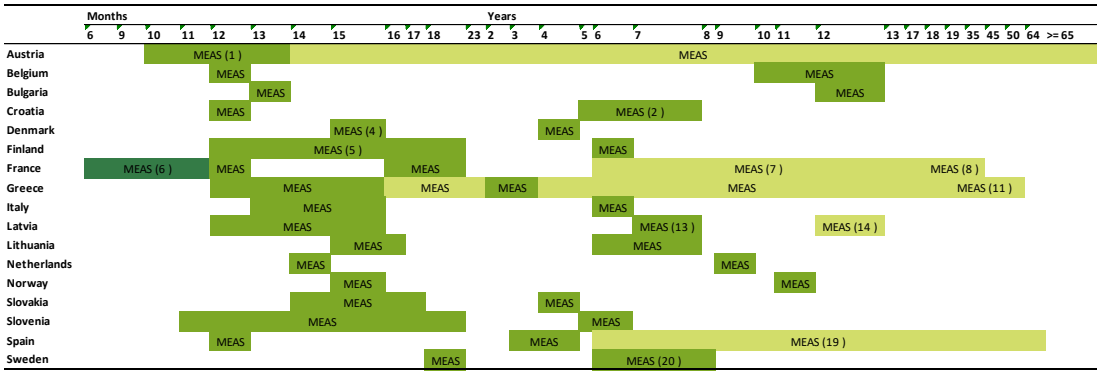
Type of measles vaccines used in Europe and MCV schedules in countries participating in WP5

In all European countries, combined MCV are used containing measles, mumps and rubella (MMR). However, Germany, Greece, Italy and Spain (some regions) use both MMR and MMRV (measles mumps rubella and varicella), while Luxembourg only use MMRV (5). Table 1 presents the MCV schedules in countries participating in WP5 (6).

In most countries participating in WP5, the first MCV dose is recommended between 12 and 15 month of age, except for Austria where it is from 10-14 months of age, in Finland from 12-18 months, Lithuania 15-16 months, in Slovakia 14-17 months, Slovenia 12-18 months and Sweden at 18 months of age. The recommended time of vaccination with the second MCV dose varies between countries from 16-18 months of age in France to 12 years of age in Belgium (Table 1).

Table 1. Recommended age for measles containing vaccines in countries participating in WP5 (Ref: ECDC https://vaccine-schedule.ecdc.europa.eu/Scheduler/ByDisease?SelectedDiseaseId=8&SelectedCountryIdByDisease=-1) Downloaded 13. November 2020.

Measles: Recommended vaccinations



General recommendation
Recommendation for specific groups only
Catch-up (e.g. if previous doses missed)

Footnotes:

1: If the first dose is given in the first year of life, the recommended interval between the doses is 3 months (minimal interval 4 weeks). If the first dose of MMR is given after the first birthday, the second dose is recommended as early as possible with a minimal interval of 4 weeks.
2: Given to grade 1 students
4: MMR vaccination possible from 9 months of age prior to visiting measles-endemic countries and areas where measles outbreaks are known to occur. The recommended two-dose vaccination schedule at 15 months and 4 years still need to be completed if first vaccination before 12 months.
5: Vaccination can be given from 6 months of age in case of travel abroad. If vaccination starts before 12 months of age, 2 doses are recommended (14-18 months and 6 years) The temporary recommendation of giving measles at 12 months of age was made a permanent recommendation; ie. now MMR should be given from 12-18 months except if travelling abroad to measles infected countries when it can be given from 6 months on. In case MMR is given at 6-11 months, the child needs a second and third dose to complete the series.
6: Update 28 June 2013:For a full description of recommendations, please refer to: http://www.hcsp.fr/explore.cgi/avisrapportsdomaine?clefr=362.
7: 2 doses of MMR one month appart if no previous vaccination ; 1 dose if only one dose previously
8: Two MMR doses in total among individuals born from 1980
11: For individuals born after 1970 (one or two doses depending on vaccination history and clinical history)
13: Six-year-old children may be vaccinated with vaccinations for 7-year-old children, if the child is beginning to study in an educational institution.
14: Catch-up for females not previously vaccinated, with no history of rubella vaccination or disease. 2-dose schedule recommended.
19: Two doses at 4 or more weeks interval recommended in individuals born in Spain since 1970 with no documented history of vaccination
20: Given to 1-2 grade students

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Questionnaire identifying the data sources

At a WP5 technical meeting held in Zagreb, The Netherlands, Spain, Sweden, Finland, Austria, Slovakia, Italy, Latvia, Greece, France and Denmark provided an overview of the MCV data available for coverage estimation in each country and the status of their IIS. Based on input from this meeting a questionnaire was developed to get detailed information on available MCV data, population data and the possibility to estimate MCV coverage at regional level. The questionnaire also explored with what frequency each country would be able to estimate and provide MCV coverage estimates for Task 5.2 and the expected delay in coverage estimation. The questionnaire is presented in Annex 1.

R-package

In order to estimate standardised MCV coverage an R-package was developed by SSI and shared among those partners who agreed to participate in Task 5.2. Based on predefined input files, the R-package estimates period prevalence (PP) MCV coverage by birth cohort and by age in month per birth cohort. The R-package is installed and run locally in each country (see the section “Installation Guide”).

Preparing input files for the R-package

In the section “Users Guide” it is explained how to prepare the input files (population and vaccination file) including required variables, their names and formats. The output from the coverage estimation is show on the local computer as graphs and maps.

MCV dose 1 and 2 coverage estimation will focus on birth cohorts 2005 -2019. If it is not feasible to provide data for all birth cohorts, the youngest birth cohorts should have the highest priority.

Two data files are required for MCV coverage estimation, a population file including all children in the selected birth cohorts and a vaccination file including all the vaccines administered to children in the selected birth cohorts.

The input data files for coverage estimation can both be individual data and aggregated data. Valid sets of input data will be one of the following combinations:

- Indiviudal population file + Individual vaccination file
- Indiviudal population file + Aggregated vaccination file
- Aggregated population file + Aggregated vaccination file

Coverage estimation

In the standardised coverage estimation, the period prevalence (PP) method was used to estimate MCV coverage based on the following definitions.

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Defining variables for coverage estimation

The **Denominator** is the total number of individuals who are registered in the population register at the time of data extraction. Individuals who immigrated or were born since the last data extraction should be included and those who emigrated or died should be excluded.

The **Nominator** is the number of children in each birth cohort, who is vaccinated with each of the MCV doses and registered in the IIS, at the time of data extraction. At the time of data extraction individuals who immigrated or were born since last data extraction should be included. Those who had emigrated or died should be excluded. Individuals present in the nominator should also be present in the denominator.

The **Coverage by birth cohort** is the number of children, in each birth cohort registered in the IIS, who is vaccinated, with each of the MCV doses (nominator) divided by the total number of children in the birth cohort and registered in the IIS (denominator).

PP by birth cohort$_j$:

Coverage is estimated for those individuals present in the population register at the date of data extraction (DateExtract). Startdate is the date an individual entered the register (birthdate or immigrations date) and Enddate is the date and individual emigrated or died.

Coverage by birth cohort *j* and dose *i* is estimated as PP

$$PP_{MCVi\ j} = \frac{\text{Number of individuals in birth cohort } j \text{ where Vacdate}_i \leq \text{EndDate}}{\text{Number of individuals in birth cohort } j \text{ where (StartDate} \leq \text{DateExtract} \leq \text{Enddate)}}$$

The **Coverage by age in months** is calculated for each birth cohort and for each age in months. This is the number of children by birth cohort and age in months, who is vaccinated with each of the MCV doses and registered in the IIS at the time of coverage estimation, divided by the total number of children in the birth cohort at the same age in months, who are registered in the IIS at the time of coverage estimation. As an example, in the 2012 birth cohort, the number of children who were 12 months of age and vaccinated with MCV dose 1 is divided by the total number of children in the 2012 birth cohort, who are 12 months of age. At 13 months of age, the number of children in the 2012 birth cohort vaccinated with MCV dose 1 is divided by the total number of children in the 2012 birth cohort who are 13 months of age etc.

PP by birth cohort *j*, dose *i* and *k* month of age:

$$PP_{MCVi\ jk} = \frac{\text{Number of individuals in birth cohort } j \text{ at } k \text{ month of age where Vacdate}_i \leq \text{EndDate}}{\text{Number of individuals in birth cohort } j \text{ and at } k \text{ month of age where (StartDate} \leq \text{DateExtract} \leq \text{Enddate)}}$$

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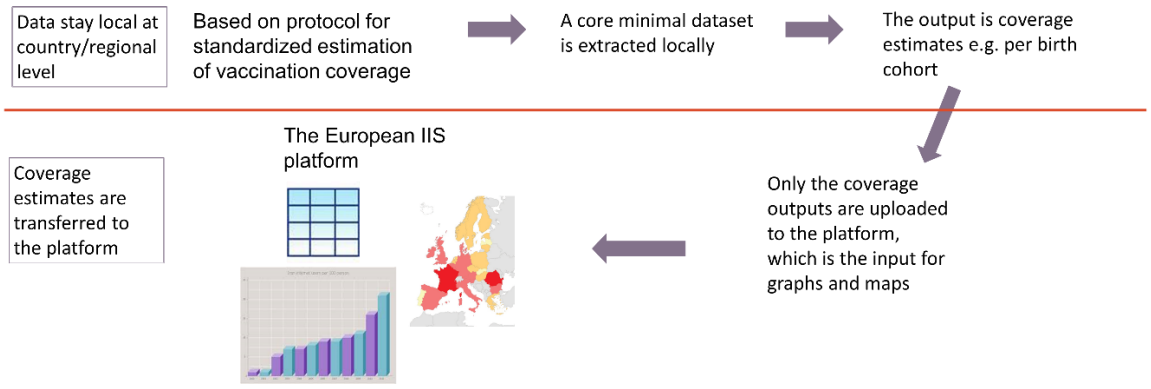
Pilot platform for cross-border vaccine coverage assessment

It is the objective to test the feasibility of doing cross-Europe standardised MCV coverage estimation, and to deploy a common pilot platform, where vaccine coverages can be shared.

Description of the common platform is available in Deliverable **D5.1 Functional specifications for the pilot platform**.

The outputs from the R-package is MCV dose 1 and 2 coverage estimates that are shown at the local computer as graphs and maps. In addition, an output file is generated containing the estimated coverage per birth cohort and per age in months per birth cohort (Figure 1). This output file is uploaded to the pilot platform where graphs and maps similar to the output at the local computer are shown. **This means that none of the input data files are uploaded to the common platform, only the aggregated coverage estimates.**

Figure 1. Coverage data flow from local computer to pilot platform



Results

Questionnaire data

The responses from WP partners showed that six partners had an IIS in place at either national level or regional level. Three WP5 partners were piloting IIS systems and finally six partners had no IIS implemented. The three partner who were piloting IIS were not able to provide data for this task, within the scheduled timeframe. A summary of the obtained data is presented in Annex 1, Tables A1 and A2.

We asked the partners with no IIS, if it would be possible to report administered MCV doses per month in order to identify time periods with decrease in administered doses. Only one partner responded that this would be possible. It was therefore decided to focus on those partners with an IIS in place and who had signed up to Task 5.2 (Annex 1, Table A3).

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Coverage estimation using the R-Package

Three countries adopted the R-package, extracted the required input files and provided coverage estimates at three time points as a minimum. For all three countries, MCV coverage estimates was compared in November and December 2020. In March and September 2020 MCV coverage was compared between two countries (Table 2)

Table 2. Data extraction dates and birth cohorts included

Country	Date of data extration	Birth cohorts included
Finland	10.03.2020, 16.11.2020, 08.12.2020	2009-2020
The Netherlands	30.09.2020, 06.11.2020, 07. 12.2020	2005-2019
Denmark	Monthly from 01.01.2018 until 01.12.2020	2005-2019

For all three participating countries, we describe the estimated MCV coverage in the birth cohorts who were vaccinated during 2020.

In this report, MCV dose 1 and 2 coverage by birth cohort and age in month are presented at national level (Figure 2, 4, 6, 8 10 and 12). In the R-package these graphs are also available at regional (NUTs 3) level.

Finland

MCV dose 1

At the 10 March 2020, MCV dose 1 coverage was approximately 13% in birth cohort 2019 (pink line) (Figure 2), which is expected as the recommend time of vaccination with dose 1 is 12 month of age, and only a small proportion of birth cohort 2019 had reached the recommended age of vaccination at the date of data extraction. On the 16 November 2020 and 8 December 2020, MCV dose 1 coverage in birth cohort 2019 has increased to approximately 65% and 70%, respectively, (Figure 2). Although the majority of children were vaccinated with MCV dose 1 at 12 months of age, a smaller proportion of children in each birth cohort were vaccinated before 12 month of age. Figure 2 also indicate that that the age where children received MCV dose 1 had changed from 18 months of age in the 2009 birth cohort till 12 months of age in the younger birth cohorts.

Regional differences in MCV dose 1 coverages were observed in birth cohort 2019, from 0-5% to 20-25% between regions in March 2020. In December 2020, the coverage variation was from 60-65% to 80-85% (Figure 3). In the 2018 birth cohort the regional differences varies from 85-90% to 95-100% (Figure 3).

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MCV dose 2

In Finland, the recommended age of MCV dose 2 vaccination is six years (72 months of age). At the time of data extraction 10 March 2020, birth cohort 2013 were all 6 years of age and the coverage was approximately 40%. At the last data point on the 8 December 2020, this coverage is a few percentage higher. For birth cohort 2012, coverage was app 60% by 10 March 2020 and almost unchanged at the 8 December 2020. During the same period, dose 2 coverage for birth cohort 2014 increased from approximately 8% in March to above 25% in December. In Finland, a few large regions had some problems submitting the vaccination records, which seems to have affected particularly MCV dose 2 coverage in the birth cohorts 2012, 2013 and 2014.

Figure 5 compares the MCV dose 2 coverage at NUTS 3 level in selected cohorts from March to December 2020. In birth cohort 2012, MCV dose 2 coverage varied from 60-65% to 70-75% between regions. In December 2014, MCV dose 2 coverage varied form 20-25% to 30-35% between regions.

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Figure 2. MCV dose 1 coverage in the birth cohorts 2009-2019 (top row) and coverage by age of vaccination (bottom row), on the 10. March (to the left), 16. November 2020 (in the middle) and 8. December 2020 (to the right), Finland (screenshots from the R-package)

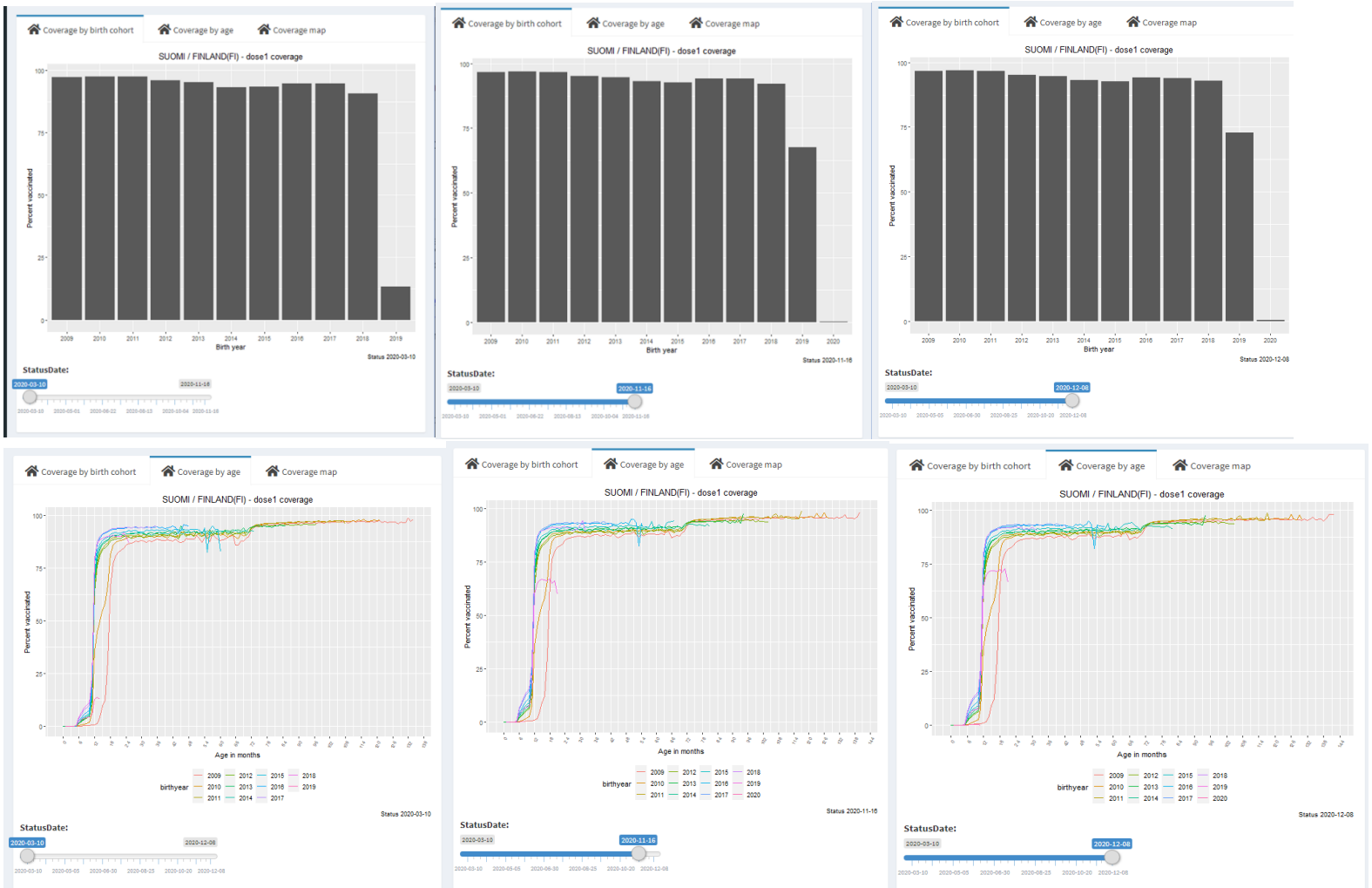


Figure 3. MCV dose 1 coverage in the birth cohorts 2018 (top row) and 2019 (bottom row) by NUT3 level on the 10 March (to the left), 16 November 2020 (in the middle) and 8 December 2020 (to the right), Finland (screenshots from the R-package)

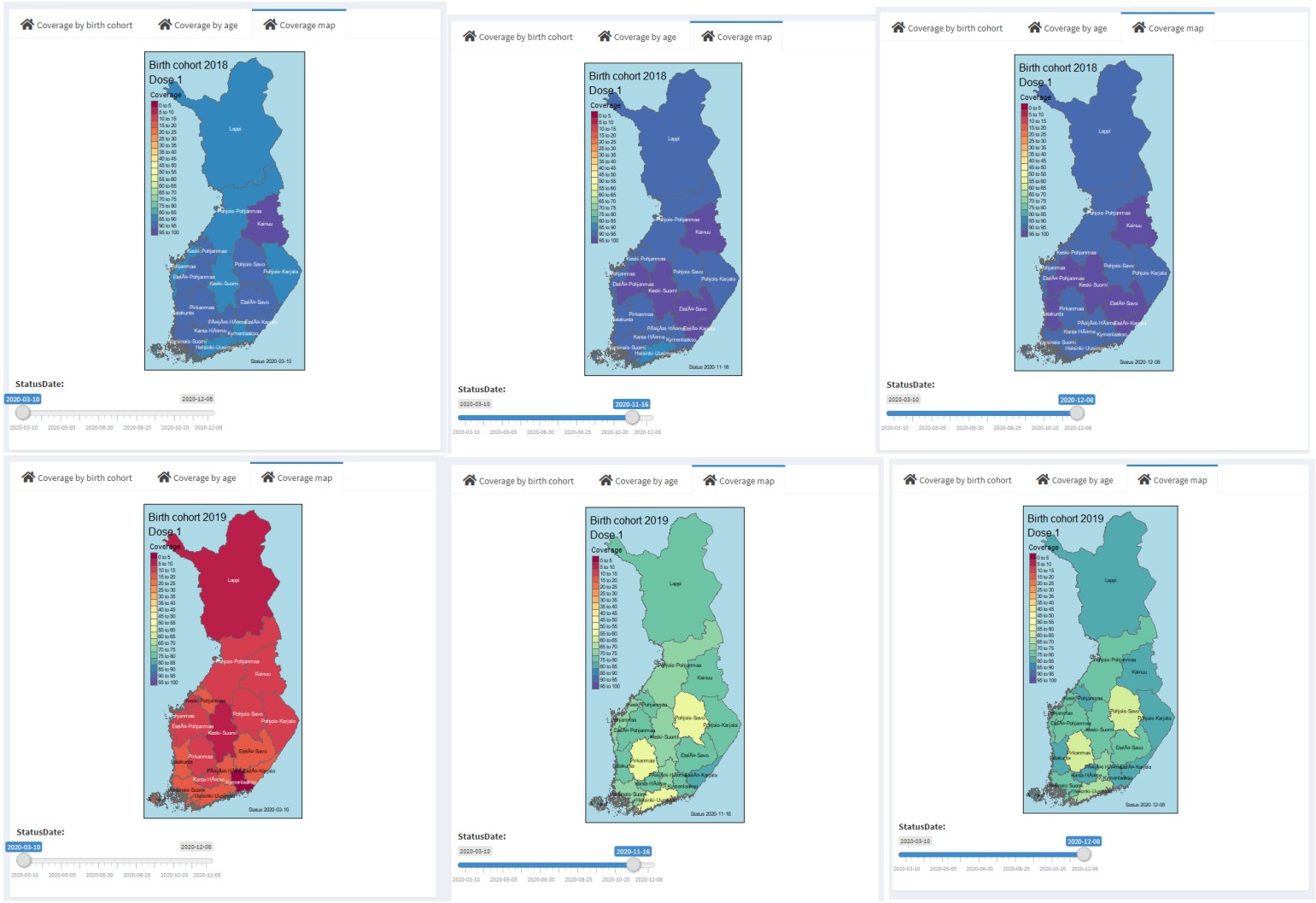


Figure 4. MCV dose 2 coverage in the birth cohorts 2009-2019 (top row) and coverage by age of vaccination (bottom row), on the 10 March (to the left), 16 November 2020 (in the middle) and 8 December 2020 (to the right), Finland (screenshots from the R-package)

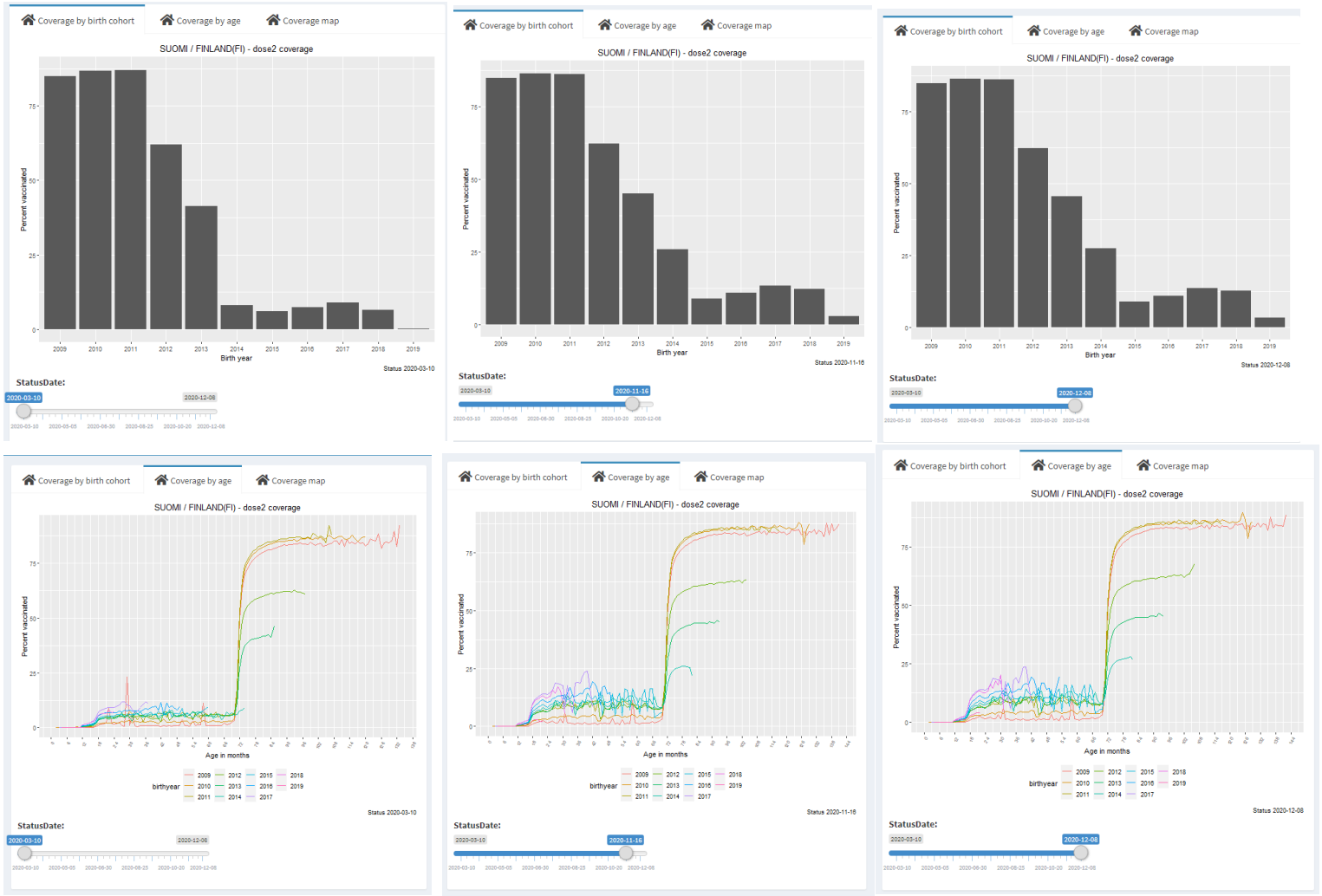
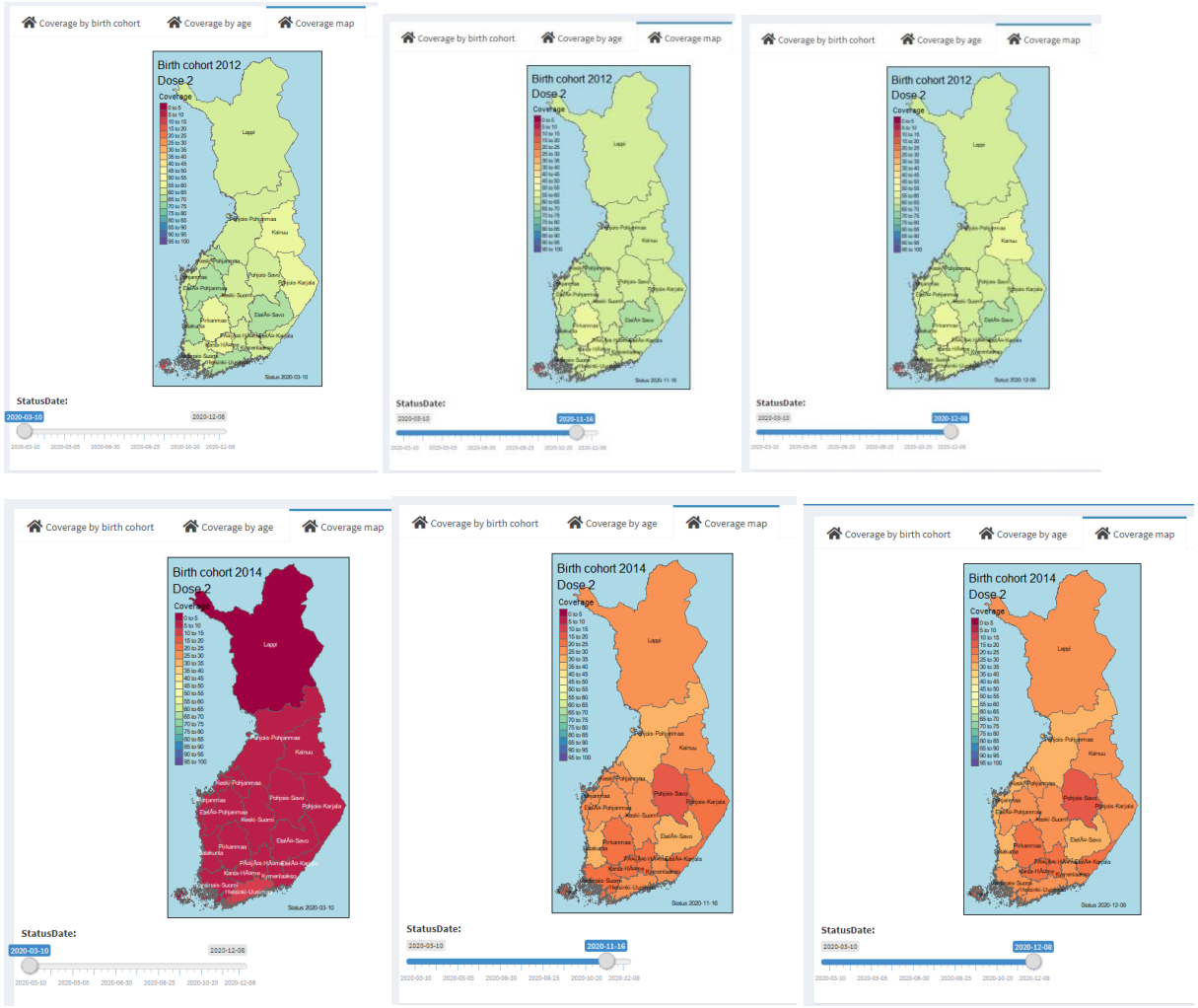


Figure 5. MCV dose 2 coverage in the birth cohorts 2012 (top row) and 2014 (bottom row) by NUT3 level on the 10 March (to the left), 16 November 2020 (in the middle) and 8 December 2020 (to the right). Finland (screenshots from the R-package)



The Netherlands

MCV dose 1

In the Netherlands, MCV dose 1 is scheduled at 14 months of age and from 30. September 2020 to 7. December 2020, approximately a 25% increase in MCV dose 1 coverage was observed for the 2019 birth cohort from app. 40% to 65% (Figure 6).

In general, the age at MCV dose 1 vaccination was very similar between birth cohorts (Figure 6). The coverages did not vary much between regions at the time of data extraction; however, there was a tendency towards a lower coverage in the south-west region, compared to other regions (Figure 7).

MCV dose 2

Dose 2 is scheduled at 9 years of age and children born in 2011 turned 9 years during 2020. However, dose 2 vaccination was postponed due to the covid-19 pandemic but resumed during autumn 2020. This imply that birth cohort 2011 will receive the vaccine at a later age compared to the previous birth cohorts. Figure 8 shows that birth cohort 2011 was 3-6 month older when they receive dose 2 compared with previous birth cohorts.

Figure 9 shows MCV dose 2 coverage for birth cohort 2011. A very large variation in coverage between regions (NUTS3) was observed from 0-50% coverage by the end of September to 25-80% in the first week of December 2020 and with some regions going from 0% coverage in September to 75% by the beginning of December.

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Figure 6. MCV dose 1 coverage in the birth cohorts 2005-2019 (top row) and coverage by age of vaccination (bottom row), on the 30 September (to the left), 6 November (middle) and 7 December 2020 (to the right), The Netherlands (screenshots from the R-package)

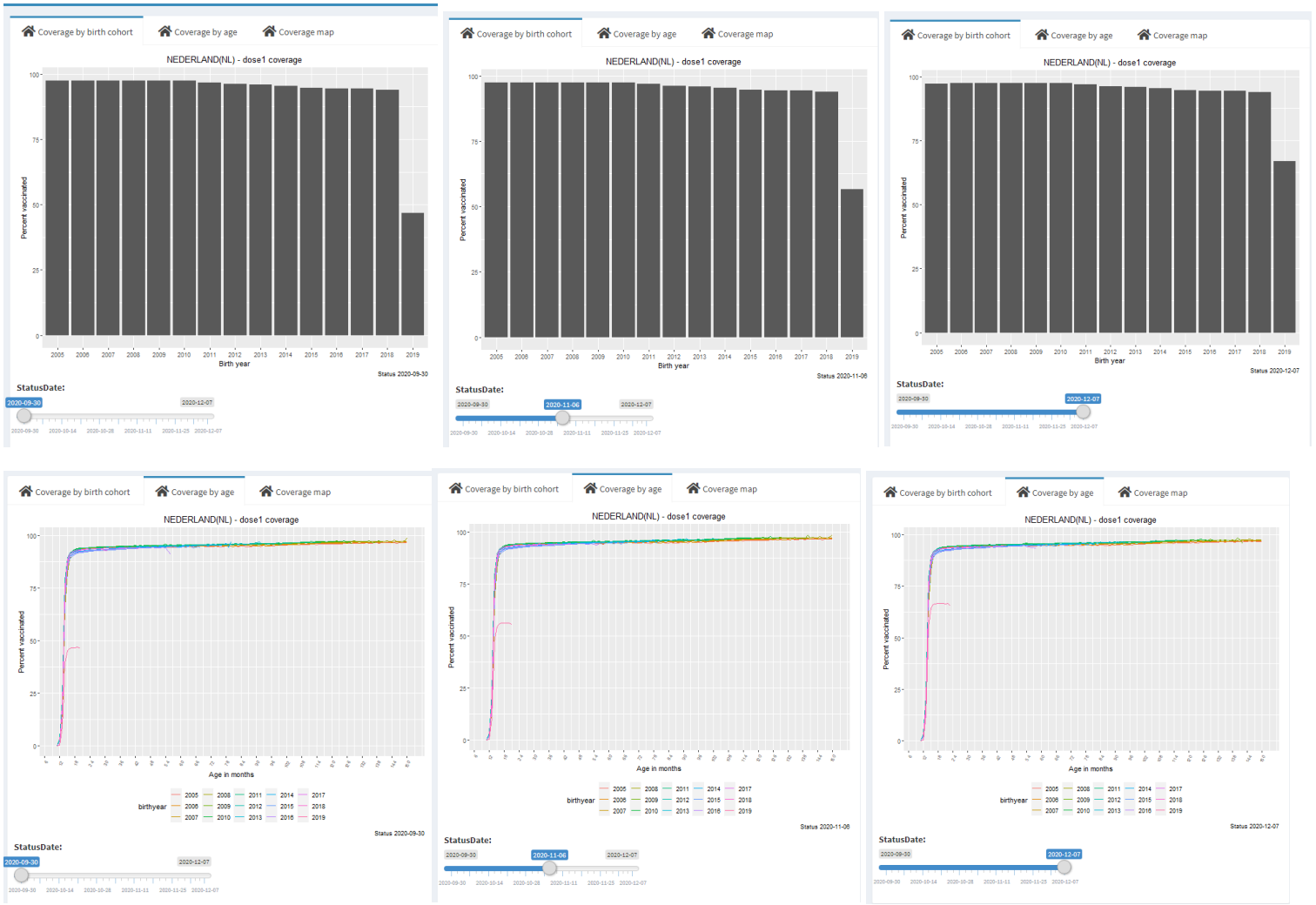


Figure 7. MCV dose 1 coverage in the birth cohorts 2018 and 2019 on the 30. September (to the left), 6. November (middle) and 7. December 2020 (to the right), The Netherlands (screenshots from the R-package)

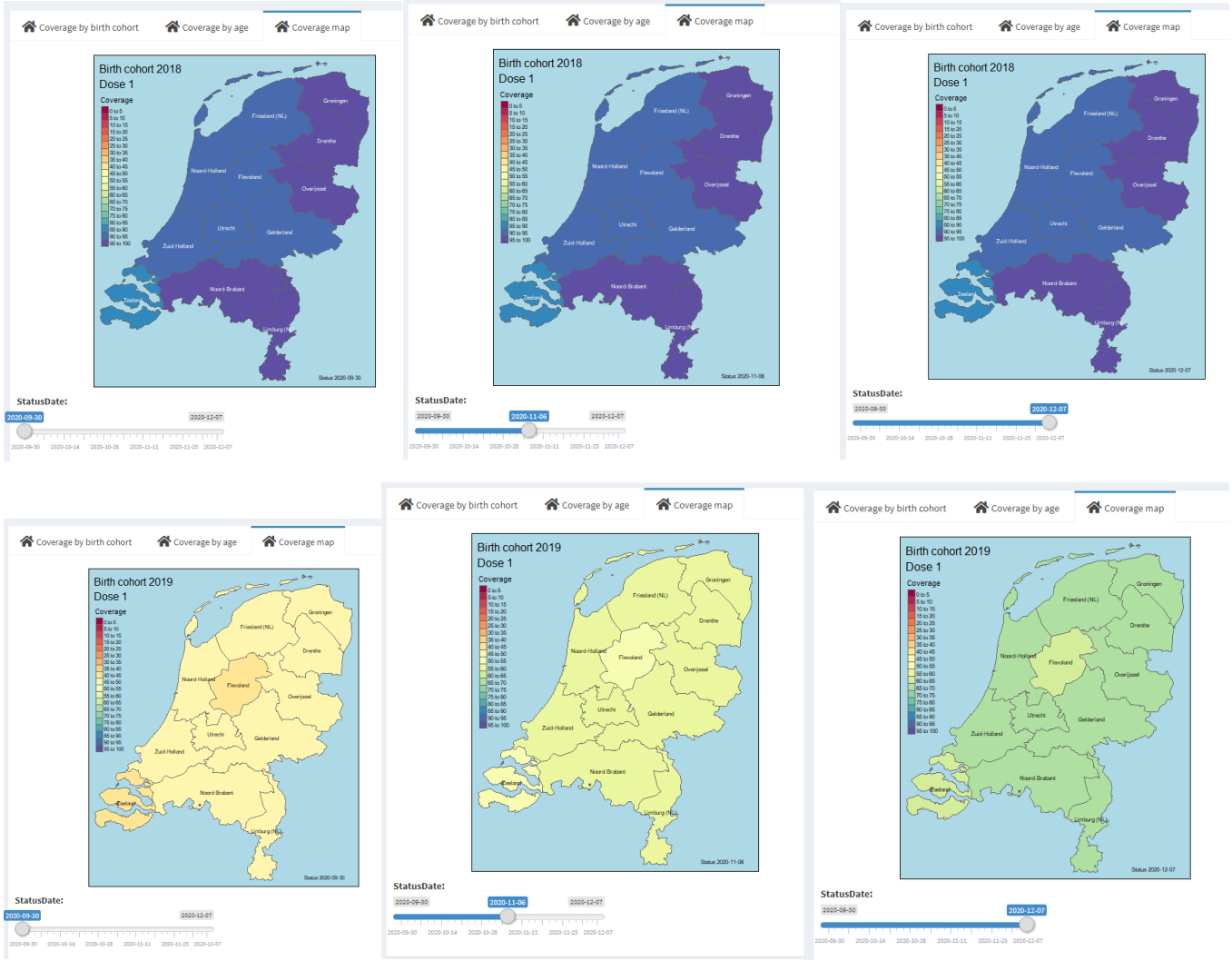


Figure 8. MCV dose 2 coverage in the birth cohorts 2005-2019 (top row) and coverage by age of vaccination (bottom row), on the 30 September (to the left), 6 November (middle) and 7 December 2020 (to the right), The Netherlands (screenshots from the R-package)

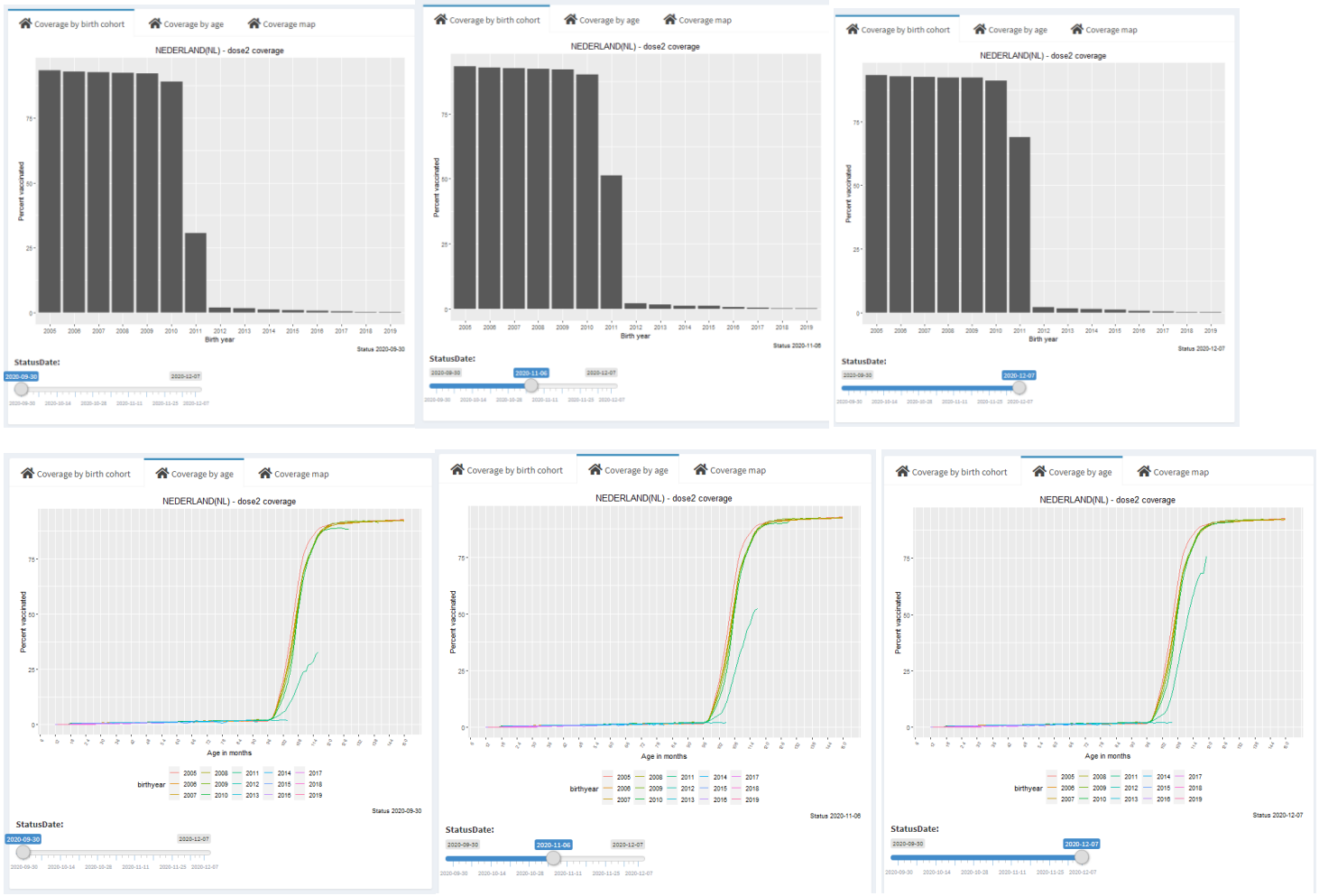
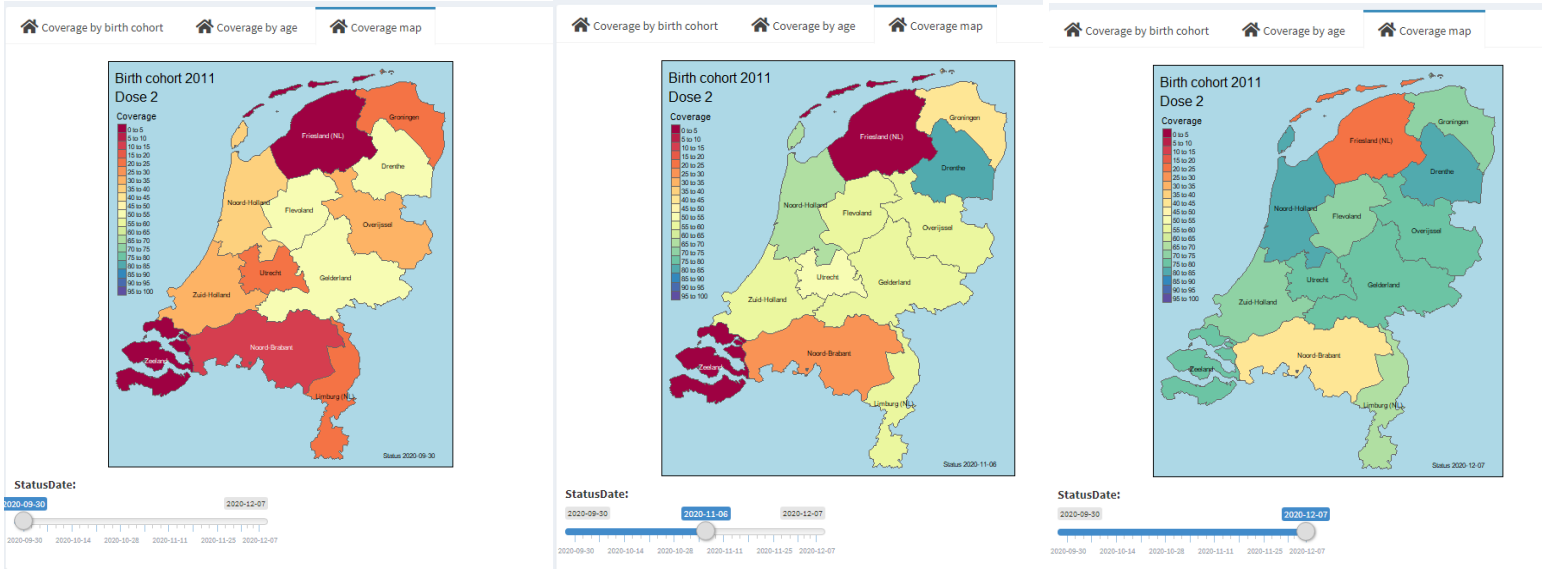


Figure 9. MCV dose 2 coverage in the birth cohorts 2011 on the 30 September (to the left), 6 November (middle) and 7 December 2020 (to the right), The Netherlands (screenshots from the R-package)



Denmark

MCV dose 1

In Denmark, MCV dose 1 is scheduled at 15 months of age, which means that during 2020 it was the birth cohorts 2018 and 2019 who were vaccinated with MCV dose 1. From 1 March 2020 to 1 December 2020, the MCV dose 1 coverage increased from 75% to 90% in birth cohort 2018 and from approximately 0% to 50% in birth cohort 2019 (Figure 10). The age at vaccination with MCV dose 1 was very similar for all birth cohort. The highest MCV dose 1 coverages were observed in the youngest birth cohorts. The increase in MCV dose 1 coverage in birth cohorts 2018 and 2019 was similar between regions (NUTS 3) from September to December (Figure 11).

MCV dose 2

Dose 2 is scheduled at 4 years of age, meaning that birth cohort 2016 should receive the second MCV dose 2 during 2020. MCV dose 2 coverage increased from approximately 5-10% on the 1 March to 75% on the 1 December 2020. For birth cohort 2015, MCV dose 2 coverage increased from 75% to 90-95% during the same time period. The age of vaccination with MCV dose 2 was very similar between birth cohorts. However, similar to MCV dose 1 the highest coverage was observed in the youngest birth cohorts. The increase in MCV dose 2 coverage was similar between regions (NUTS 3) from March to December (Figure 12) except for a 5% lower coverage in the eastern part of Denmark.

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Figure 10. MCV dose 1 coverage in the birth cohorts 2005-2019 (top row) and coverage by age of vaccination (bottom row), on the 1 March (to the left), 1 September (middle left), 1 November (middle right) and 1 December 2020 (to the right), Denmark (screenshots from the R-package)

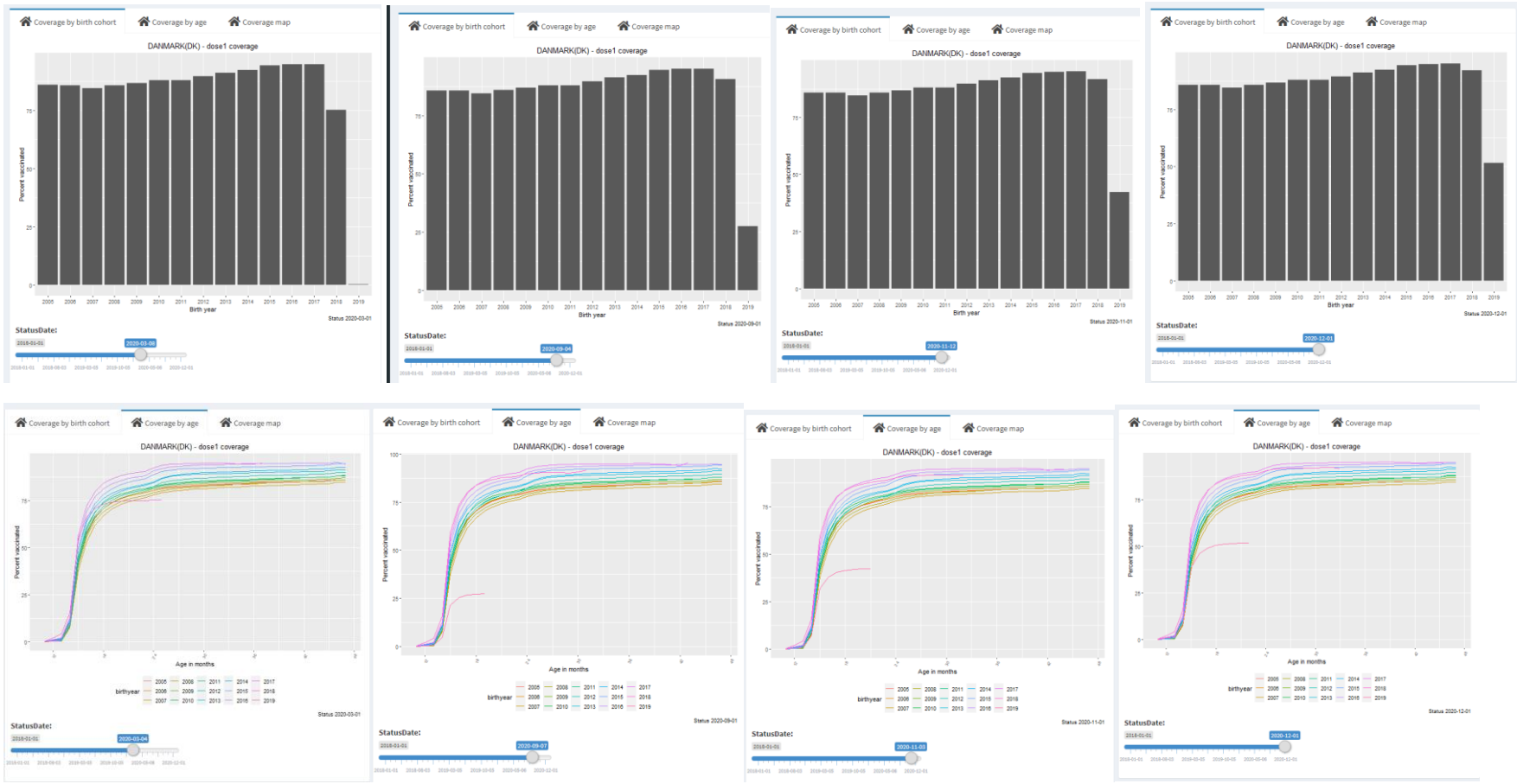


Figure 11. MCV dose 1 coverage in the birth cohorts 2018 and 2019 on the 1 March (to the left), 1 September (middle left), 1 November (middle right) and 1 December 2020 (to the right), Denmark (screenshots from the R-package)

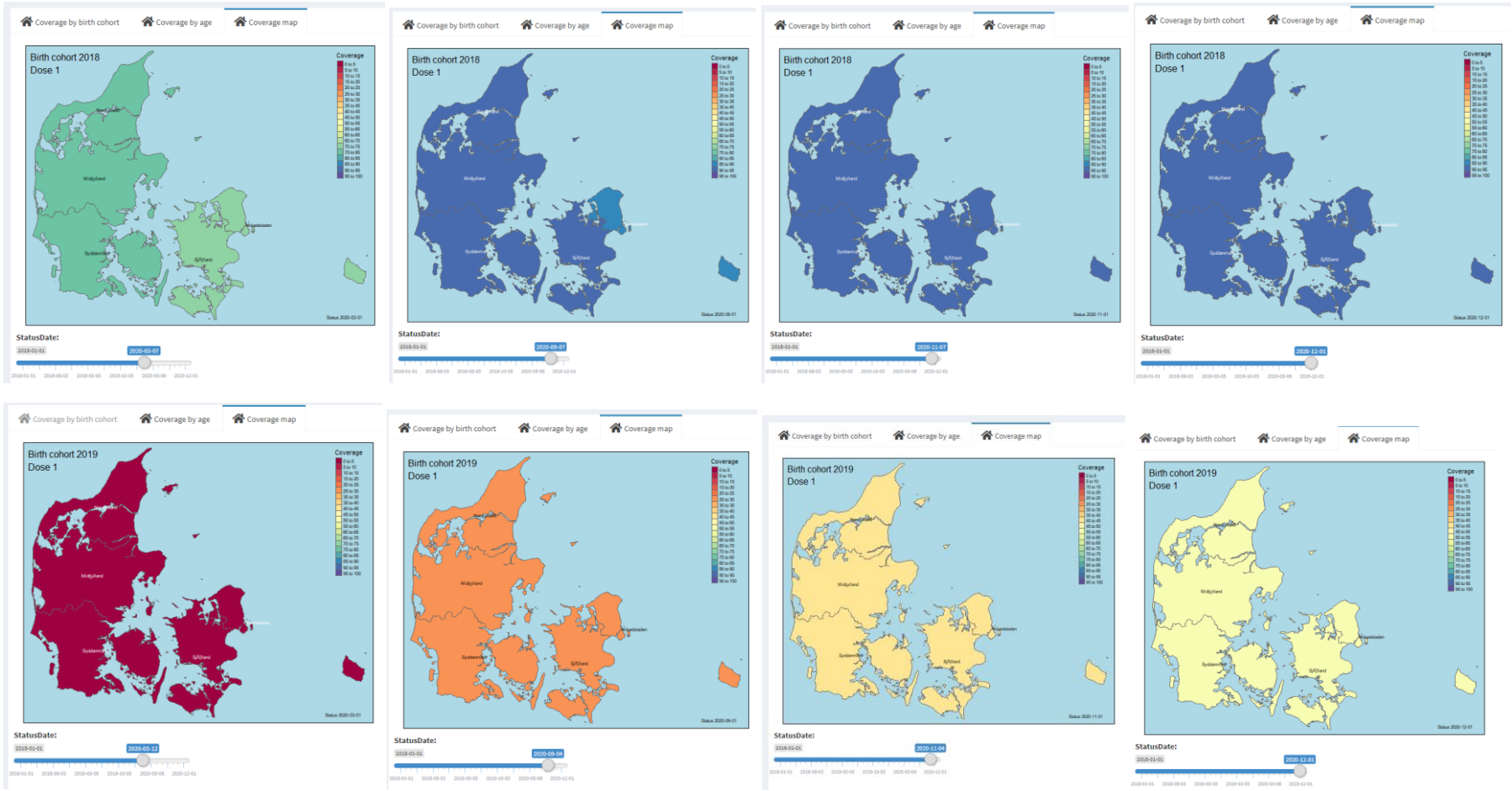


Figure 12. MCV dose 2 coverage in the birth cohorts 2005-2019 (top row) and coverage by age of vaccination (bottom row), on the 1 March (to the left), 1 September (middle left), 1 November (middle right) and 1 December 2020 (to the right), Denmark (screenshots from the R-package)

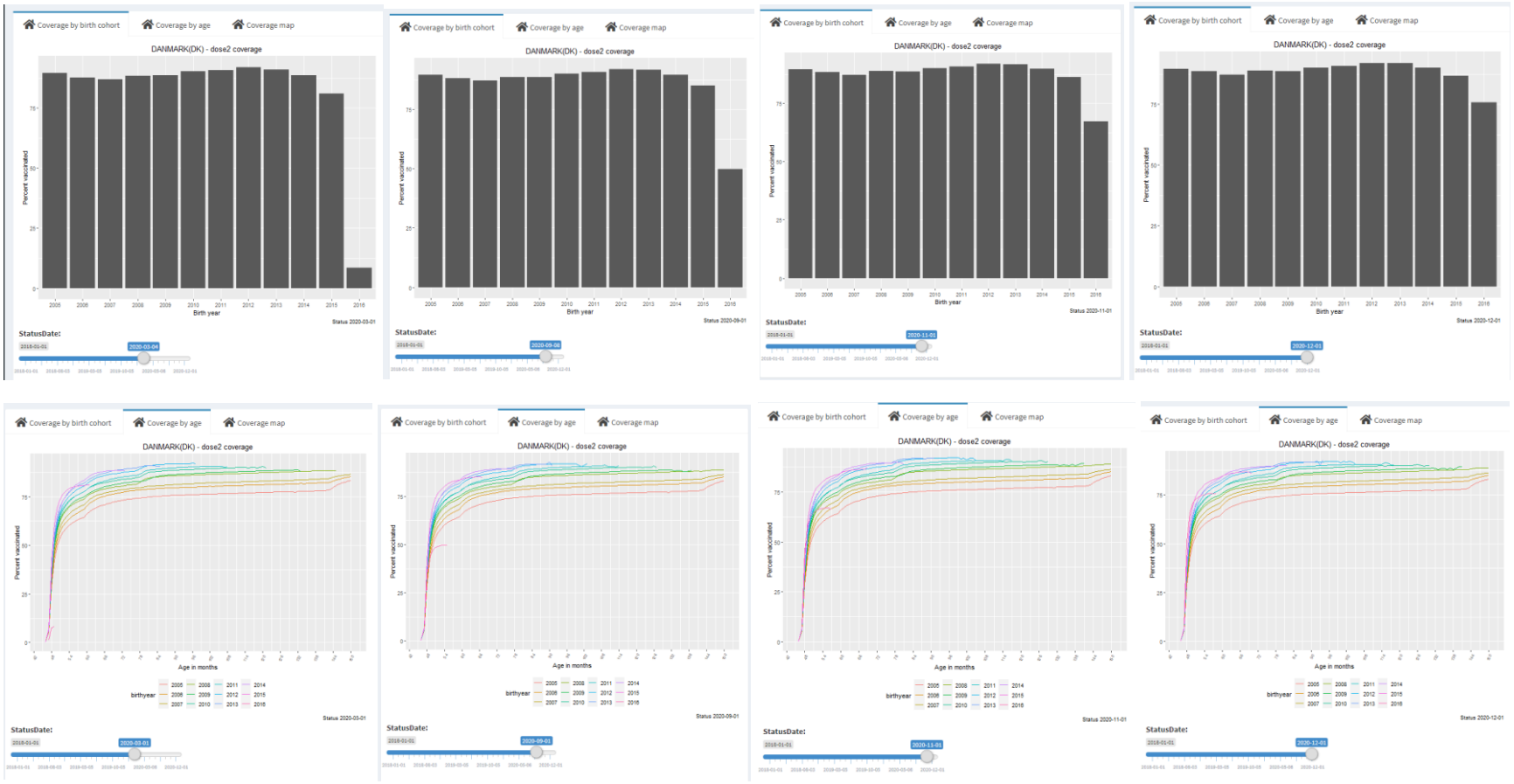
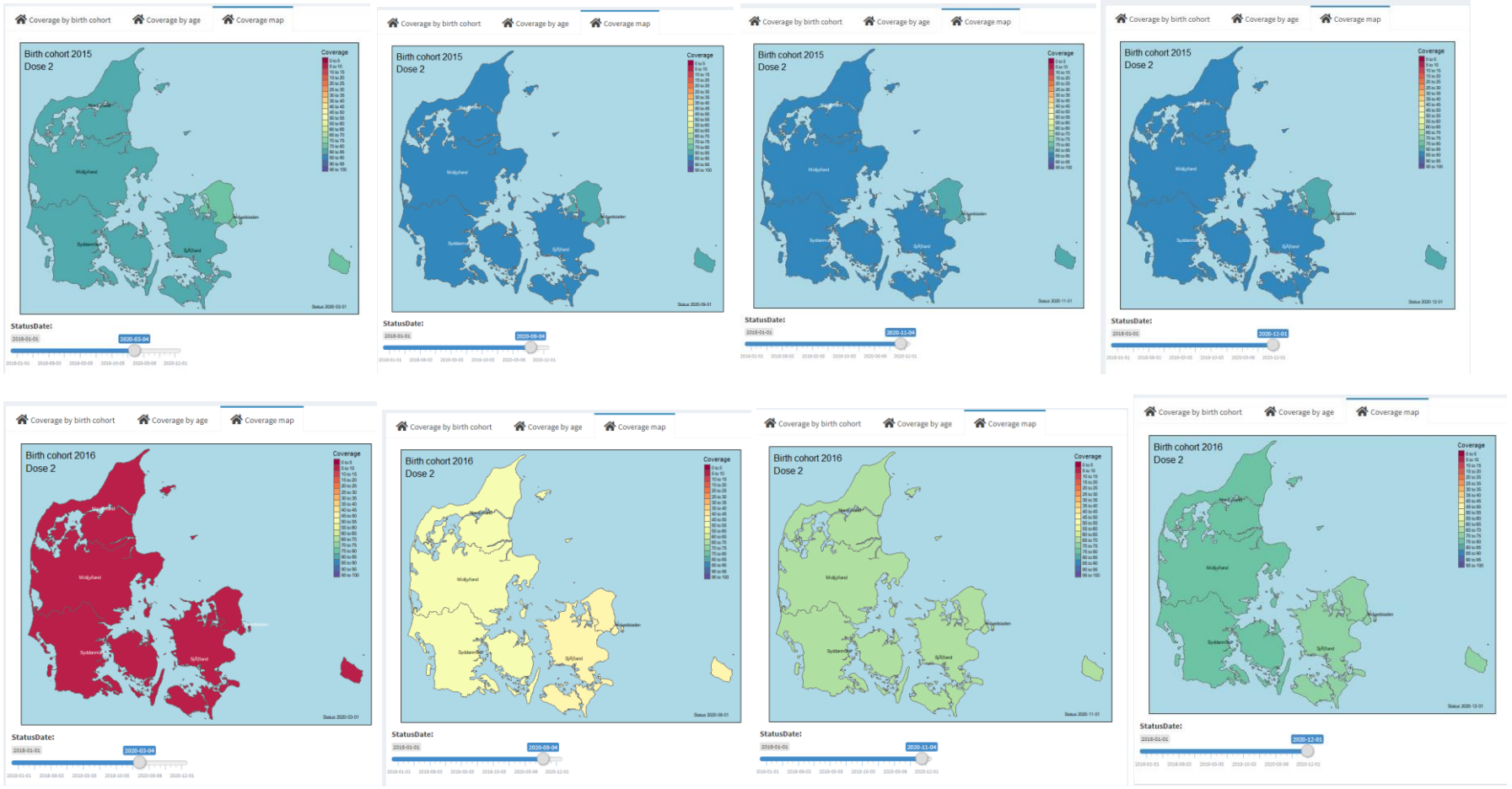


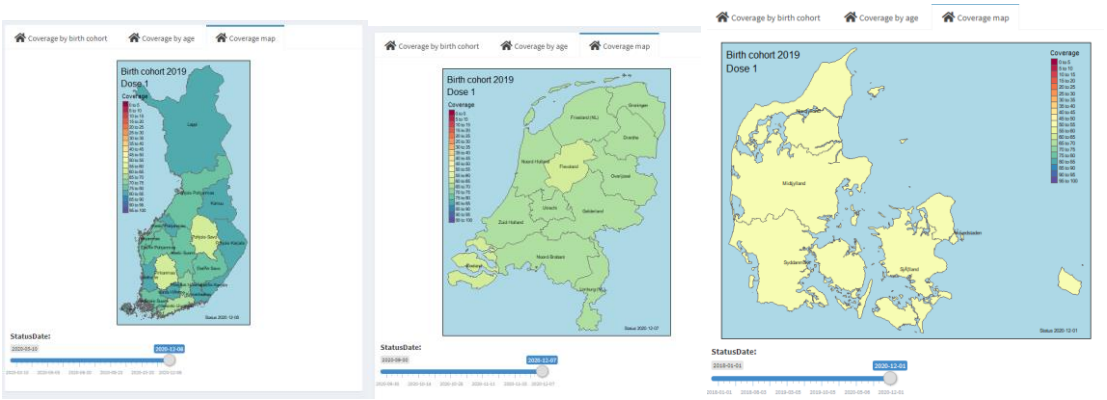
Figure 13. MCV dose 2 coverage in the birth cohorts 2015 and 2016 on the 1 March (to the left), 1 September (middle left), 1 November (middle right) and 1 December 2020 (to the right), Denmark (screenshots from the R-package)



Cross-country comparison of coverage

The administration of MCV dose 1 is displaced in time from 12 months of age in Finland, 14 months of age in The Netherlands to 15 months of age in Denmark. When comparing MCV dose 1 coverage at a given point in time e.g. the observed coverage can be different between countries due to different recommended age of vaccination, but also due to delayed vaccination. Figure 14 compares MCV dose 1 coverage in start December 2020. The lowest coverage was observed in Denmark where the recommended age of vaccination is 3 months later than in Finland and 1 month later than in the Netherlands. Delay in vaccination can be checked at the graphs call “coverage by age”, where the actual age of vaccination is shown.

Figure 14. MCV dose 1 coverage in the 2019 birth cohort in Finland, The Netherlands and Denmark, start December 2020 (screenshots from the R-package)



MCV dose 2 is recommend at very different ages in Europe. In the three countries included in this study, the recommended age at vaccination varies from 4 years of age in Denmark to 9 years of age in the Netherlands. In Denmark, MCV dose 2 coverage was 75% in birth cohort 2016, and 80% and above in previous birth cohorts. In the Netherlands, MCV dose 2 coverage was 65-70% in birth cohort 2011 and below 5% in the 2012-2016 birth cohorts. In Finland, dose 2 coverage was 60-65% in the 2012 birth cohort and lower in the younger cohorts (Figure 15). Figure 15 illustrates very clearly that due to the recommend age of MCV dose 2 vaccination, immunity gaps are present between countries. The differences in MCV dose 2 coverage in birth cohort 2016 was expected due to the differences in recommended age of vaccination (Figure 16). The differences in MCV dose 2 coverage observed in birth cohort 2014 was not only due to the difference in recommended age of vaccination. In Finland, a few large regions had problems submitting data on administered doses which resulted in lower MCV dose 2 coverage for birth cohort 2014 (Figure 16).

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Figure 15. MCV dose 2 coverage in the birth cohorts 2009-2019 in Finland, 2005-2019 in The Netherlands and 2005-2016 in Denmark (screenshots from the R-package)

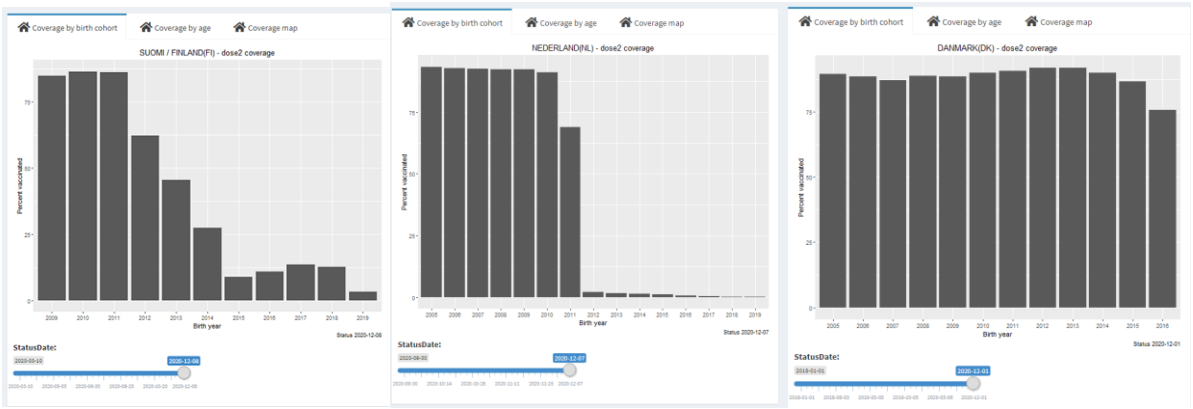
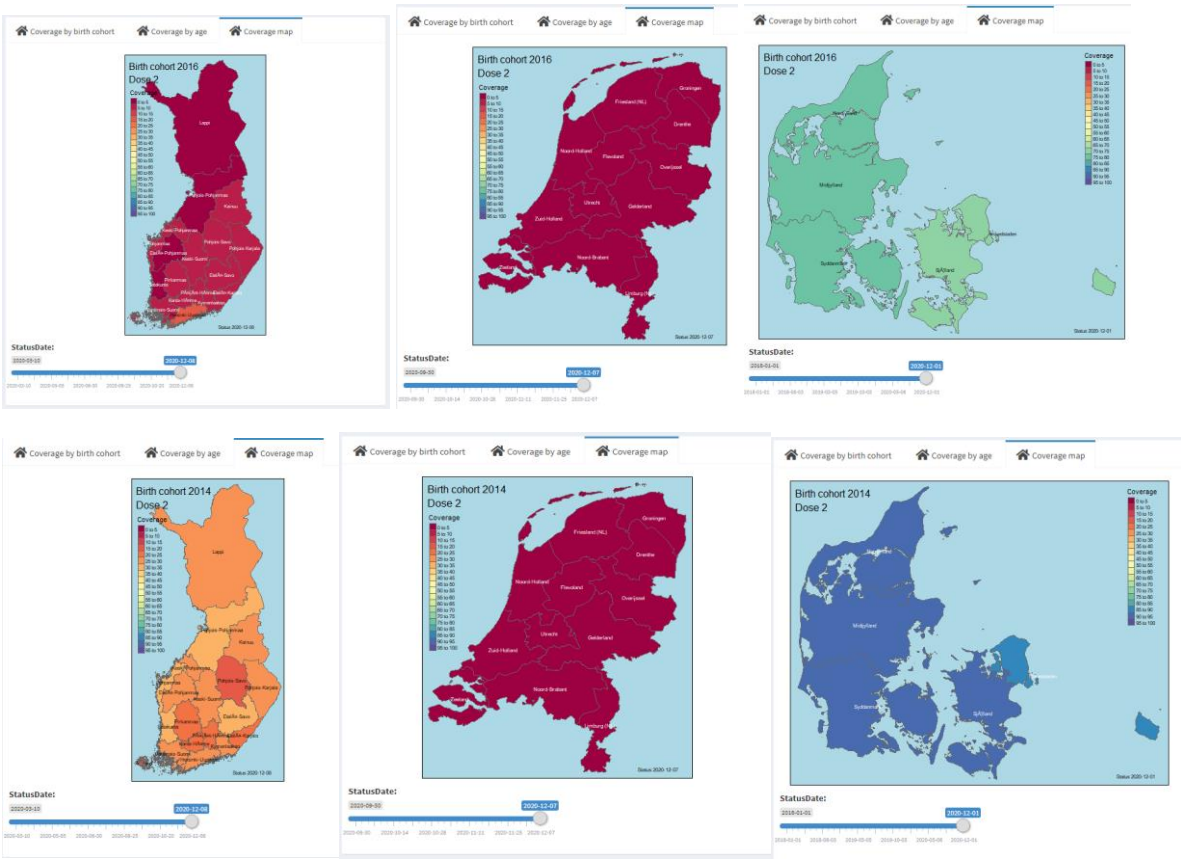


Figure 16. Comparison of MCV dose 2 coverage in birth cohorts 2016 and 2014 in Finland, The Netherlands and Denmark, start December 2020 (screenshots from the R-package)



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Discussion

With this R-package it is possible to estimate MCV dose 1 and 2 coverage real time and in a standardised way in different countries. In addition, we are able to compare coverage between countries at the same point in time, which allow us to identify actual gaps in coverage. Age at vaccination is shown both nationally and regionally, thereby we are able to explore, if there are any delay in vaccination with regard to the recommend age at vaccination.

We have shown that the difference in recommend age of vaccination result in immunisation gaps between countries, which was also highlighted by ECDC and WHO (2,6). In particular, the large differences in recommend age for MCV dose 2 administration that varies from 16-18 month to 12 years among the WP5 partners will inevitable result in immunisation gaps. However, the differences in recommended age at vaccination is not the only reason for immunisation gaps, delayed vaccination may also be the reason. In the Netherlands, the administration of MCV dose 2 for birth cohort 2011 was postpone due to the covid-19 pandemic, thereby birth cohort 2011 were older than recommended, when they received the second dose. When the administration of dose 2 started, an uneven increase in coverage was observed between regions (Figure 9). In Finland, MCV dose 2 coverages are almost unchanged in birth cohorts 2012-2014 from March to December 2020. This was due to problems submitting the vaccination records in a few large regions (Figure 4).

The R-package comes with a User guide, describing how to prepare the input files. It was our experience in Denmark that the setup of the data extraction could be a little time consuming, because the variable names and formats had to follow the description provided in the User Guide. When the format of the input files were in place, both Finland and the Netherlands were able to prepare new population and vaccination files within a short timeframe. This is very important, as this will allow us to prepare coverage maps quickly, if a measles outbreak is discovered and a vaccination campaign should be planned in relevant areas with short notice.

The short timeframe for preparing input files also allow us to prepare frequent updates of coverage at the pilot platform e.g. weekly, biweekly or monthly.

Another advantage of this R-package is the R-shiny output. Each time coverage is estimated locally in the countries, the estimated coverage is shown as graphs and maps locally. These graphs and maps are similar to what will be shown on the pilot platform described in Deliverable 5.1. These outputs can be used at national and regional level to identify regions with delayed vaccination. The local output also allow the countries to identify potential errors in the data extraction.

The real time estimation of vaccine coverage also has disadvantages. For countries to get the full benefit of the R-package, real time access to data on national populations and administered vaccines is required. This will allow weekly or monthly updates of vaccine coverage. However if data is updated less frequently e.g. quarterly, half yearly or yearly, it is still possible to use the R-package but it will be more difficult to identify immunisation gaps.

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When coverage estimates are uploaded to the pilot platform from various countries and potential coverage gaps are identified, it is important to clarify if the gaps are not due to delay in vaccination or in delay in registration of the vaccines. It is not expected that all countries can upload coverage with the same frequency, this will create apparent immunity gaps. Therefore, the immunity gaps identified at the pilot platform should be further investigated, before any initiatives are introduced.

I case there are subpopulations that travel between regions or countries and therefore do not have a permanent address, regional coverage might not be accurate and can be both over and underestimated, depending on the coverage in the mobile populations.

The recent measles outbreaks in Europe was the main reason why measles coverage was chosen as a case for the pilot platform. However, the covid-19 pandemic has overtaken the measles outbreaks and by the end of December 2020, the first covid-19-vaccines were available in Europe. It would be very tempting to build further on this R-package and include covid-19 coverage as the next vaccine.

It was not possible to identify cross-border immunity gaps as none of the partners enrolled in this study had shared borders. However when comparing MCV coverage that was extracted at the same point in time between the three countries. It was very clear that immunity gaps were created due to differences in recommended age at vaccination.

In conclusion, several European countries are setting up IIS systems and with real time excess to population and vaccination data the R-package and the pilot platform are powerful tools to identify immunisation gaps.

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References

1. World Health Organization. Measles vaccines: WHO position paper [Internet]. 2017. Available from: https://apps.who.int/iris/bitstream/handle/10665/255149/WER9217.pdf;jsessionid=AE9A0BA5E09255FEED62DD7EE794C8A2?sequence=1

2. WHO Europe. Strategic Response Plan for the measles emergency in the WHO European Region September 2019–December 2020 [Internet]. Available from: http://www.euro.who.int/__data/assets/pdf_file/0020/414182/WHO-Measles-Emergency-v8a_hires_pages.pdf?ua=1

3. European Centre for Disease Prevention and Control. Who is at risk for measles in the EU/EEA? Identifying susceptible groups to close immunity gaps towards measles elimination. [Internet]. ECDC Stockholm; 2019. Available from: https://www.ecdc.europa.eu/sites/default/files/documents/RRA-Measles-EU-EEA-May-2019.pd

4. Derrough T, Olsson K, Gianfredi V, Simondon F, Heijbel H, Danielsson N, et al. Immunisation Information Systems - useful tools for monitoring vaccination programmes in EU/EEA countries, 2016. Euro Surveill Bull Eur Sur Mal Transm Eur Commun Dis Bull. 2017 Apr 27;22(17).

5. World Health Organization. Immunization, Vaccines and Biologicals [Internet]. Immunisation schedules section 6. Available from: https://www.who.int/immunization/monitoring_surveillance/data/en/

6. ECDC. Vaccine Scheduler [Internet]. Pertussis: Recommended vaccinations. Available from: https://vaccine-schedule.ecdc.europa.eu/Scheduler/ByDisease?SelectedDiseaseId=3&SelectedCountryIdByDisease=-1

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Annex 1

Questionnaire

Below is the questionnaire that was send to WP5 partners. The questionnaire was a joined questionnaire between Task 5. 2 and 5.1 to explore the content of the IIS in place in each country and questions regarding interoperability.

Survey on Interoperability of Immunisation Information Systems (IIS)

Dear Colleagues,

As a part of EU-JAV project Work package 5, we are launching a survey on electronic Immunisation Information Systems (IIS) in the EU and other non-member states. IIS is any electronic system that records vaccinations at the individual level. The term IIS hence encompasses terms such as Electronic Immunisation Records, and includes electronic systems that allow aggregation of individual-based records for monitoring of the vaccination programme (e.g. monitoring of vaccination coverage). Some EU Member States have national systems, others have one or more than one regional or provincial systems that may or may not allow exchange of data with each other. Others still have not yet established IIS.

EU-JAV aims to strengthen cooperation between European countries to fight vaccine-preventable diseases. The final goal of Work package 5 is to strengthen the interaction of Immunization Information Systems (IIS) in Europe in order to increase vaccine surveillance capabilities and to increase vaccination coverage.

The first step in reaching the goals of the project is to identify how interoperable different European IIS systems are, and that is the purpose of this survey.

Several questions in this survey are similar to the questions asked by ECDC in their survey (Immunisation Information Systems Survey (IIS)-EU/EEA from May 2016, and are asked again in order to have an update on the development of the IIS in your country/region.

This survey can be revisited several times before being submitted and doesn't require the respondent to have all information at hand in one session.

The survey may be followed up by an interview

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We would appreciate responding to this survey no later than _____.

This survey has been approved by _____.

For further contact(questions) on the survey, even while completing, please do not hesitate to contact _____.

We thank you in advance for your participation and for the time you will spend on it. It is expected to take approximately 30 minutes to respond according to the specific situation in your country.

1 Respondent information (A)

1.1 Please indicate your name:
1.2 Please indicate your e-mail
1.3 Please indicate your telephone number:
1.4 Please indicate your country
1.5 Please indicate region if applicable:

General information (B)

In this section we would like you to indicate current situation on recording vaccination data in your country

1.6 Please indicate the option that best describes vaccination records in your country(ECDC, 2017):

a) A national IIS is operational (GO TO 2.6)
b) A national IIS is currently being piloted (GO TO 2.6)
c) One sub-national IIS is operational (GO TO 2.5)
d) More than one sub-national IISs are operational (GO TO 2.2)
e) One sub-national IIS is currently being piloted (GO TO 2.5)
f) More than one sub-national IISs are currently being piloted (GO TO 2.2)
g) No IIS implemented (GO TO AM1.1)

1.7 If more than one sub-national IISs are operational, please further specify if(ECDC, 2017):

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a) They have **similar structures**, characteristics or data elements and **data can be shared among systems**
b) They have **different structures**, characteristics or data elements, but **data can be shared among systems**
c) They have different structures, characteristics or data elements and **data sharing among systems is not possible**

1.8 If more than one sub-national IISs are operational in your country, please indicate the number of existing systems(ECDC, 2017)

1.9 If more than one sub-national IISs are operational in your country, please indicate for each of them the approximate size of the population living in the areas covered by the systems(ECDC, 2017)

1.10 If possible, please mention which geographical areas are covered by the sub-national system/systems, using the NUTS classification (see this link for NUTS class.) (ECDC, 2017)

1.11 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017)

Description of IIS (C)

This section will explore the national IIS or, if a national system is not in place in your country, the sub-national IIS you are describing. All the following questions are referring to the system you are describing.

This section is also applicable for systems at national or sub-national level that are currently being piloted and should reflect plans foreseen.

1.12 Please indicate the name of the IIS(ECDC, 2017)
1.13 Is it a national system? (ECDC, 2017)
a) Yes (GO TO 3.5)
b) No, it is a sub-national system (GO TO 3.3)
1.14 If sub-national, please approximatively indicate the approximate size of the of the population living in the areas covered by the systems(ECDC, 2017)
1.15 If sub-national, please indicate which area is covered by the IIS, using the NUTS classification(ECDC, 2017)
1.16 Does the description of your IIS fits with the following definition of an IIS? (ECDC, 2017)

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Immunization information systems (IIS) are confidential, population-based, computerized databases that record all immunization doses administered by participating providers to persons residing within a given geopolitical area. At the point of clinical care, an IIS can provide consolidated immunization histories for use by a vaccination provider in determining appropriate client vaccinations. At the population level, an IIS provides aggregate data on vaccinations for use in surveillance and program operations, and in guiding public health action with the goals of improving vaccination rates and reducing vaccine-preventable disease (According to CDC)

a) Yes (GO TO 3.7)
b) No (GO TO 3.6)

1.17 If no, please specify the definition that would best describe your system(ECDC, 2017)

1.18 In what year was the IIS first established in routine use? [or year of planned implementation for systems being piloted] (ECDC, 2017)

1.19 Which organisation or institution holds the governance for the IIS? Multiple answers possible(ECDC, 2017)

a) National Institute of Public Health (or equivalent)
b) Regional Institute of Public Health (or equivalent)
c) Ministry of Health
d) Regional Health Authorities
e) National health insurance organisation
f) Other:

1.20 If other, please specify(ECDC, 2017)

1.21 Are **public** vaccination providers required by law or regulations to record individual vaccinations in the IIS? (ECDC, 2017)

a) Yes (GO TO 3.11)
b) No (GO TO 3.12)

1.22 Please choose which **public** vaccines registration is required by law:

a) Vaccinations given in childhood vaccination programme
b) Vaccinations given in other programmes (eg. Influenza vaccines)
c) All vaccinations

1.23 Are **private** vaccination providers required by law or regulations to record individual vaccinations in the IIS? (ECDC, 2017)

a) Yes
b) No

1.24 Please choose which **private** vaccines registration is required by law:

a) Vaccinations given in childhood vaccination programme
b) Vaccinations given in other programmes (eg. Influenza vaccines)
c) All vaccinations

1.25 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here: (ECDC, 2017)

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Characteristics of the system (D)

This section of the questionnaire will explore the population that is covered by the IIS and how individuals included in the register are identified.

1.26 **All** vaccinations provided (regardless of recommendations, age, risk factors etc..) are recorded in the IIS(ECDC, 2017)
   a) Yes
   b) No

1.27 Childhood vaccinations included in the national/regional immunisation programmes are recorded in the IIS(ECDC, 2017)
   a) Yes
   b) No

1.28 Adolescents vaccinations included in the national/regional immunisation programmes are recorded in the IIS. (ECDC, 2017)
   a) Yes
   b) No

1.29 Adults vaccinations included in the national/regional immunisation programmes are recorded in the IIS. (ECDC, 2017)
   a) Yes
   b) No

1.30 Vaccinations included in the recommended school-based vaccination programme are recorded in the IIS. (ECDC, 2017)
   a) Yes
   b) No
   c) Not applicable

1.31 Is each immunised individual, recorded in the IIS, identified with a unique identifier? (ECDC, 2017)
   a) Yes (GO TO 4.8)
   b) No (GO TO 4.7)
   c) I do not know

1.32 If No, please describe how each immunised individual is identified in the database (GO TO 4.9)(ECDC, 2017)

1.33 How is the unique personal identifier generated? (ECDC, 2017)
   a) The IIS uses the unique identifier given to citizens at birth or immigration
   b) The IIS uses the unique identifier used for healthcare services
   c) The IIS uses a unique identifier specific for the immunisation registry
   d) Other

1.34 If other, please specify(ECDC, 2017):

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1.35 What is the minimal set of data variables to be recorded for an immunisation record to be valid (please list) (ECDC, 2017)?

1.36 Can vaccinations administered in the past be recorded in the IIS? (ECDC, 2017)

a) Yes
b) No

1.37 Can vaccinations administered in a foreign country be recorded? (ECDC, 2017)

a) Yes
b) No

1.38 In case of sub-national systems, can vaccinations administered in another region be recorded? (ECDC, 2017)

a) Yes
b) No
c) Not applicable

1.39 How is the data that identifies the vaccine administered recorded? One answer possible. (ECDC, 2017)

a) Manually
b) Electronically with the help of a bar code reader
c) By selecting from a list of vaccines included in the registry
d) By linking to a product database
e) Other (specify)

1.40 If other, please select(ECDC, 2017)

1.41 How are vaccinations recorded in IIS? Multiple answers possible

a) Vaccinations recorded by trade name
b) Vaccinations recorded by local coding (GO TO 4.17)
c) Vaccinations recorded by batch/lot number
d) ATC classification
e) By antigen
f) Other:

1.42 Are the local codes uniform for the whole country or can they differ between regions?

a) Yes, they are uniform
b) No, codes differ (GO TO 4.18)

1.43 Please, specify how codes differ:

1.44 Please specify who is responsible for the coding system:

a) Country medicinal authority (or equivalent)
b) Regional medicinal authority (or equivalent)
c) Ministry of Health (or equivalent)
d) Health Insurance Fund (or equivalent)
e) Public Health Institution (or equivalent)
f) Other:

1.45 Is dose number recorded (eg. D1 as Dose 1, D2 as Dose2 etc.)

a) Yes
b) No (GO TO 4.21)

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1.46 Please, specify how are measles containing doses identified:

1.47 Do you have access to vaccination data on regional/country level?

a) Yes
b) No

1.48 Will you be able to prepare a vaccination file including all measles containing vaccine doses (e.g. D1 and D2) administered to children belonging to the birth cohorts 2005 - 2019 including the following core variables per vaccine dose per PersonID

Variable name	Can prepare	Cannot prepare	Not applicable
PersonID			
Date			
Vacname			
Vactype			
ATC			
Dose			

Variable name	Meaning	Format
PersonID	Person Identifier	
Date	Date of administration	Format YYYYMMDD.
Vactype	Type of vaccine (antigens)	Three letter code per antigen (Mea-Mum-Rub-Var)
ATC	Type of vaccine	ATC code, 7 digits.
Dose	Dose received as specified in database or determined by the database custodian based on knowledge of the local immunization schedule	
	possible values	Description
	D1	For first dose
	D2	For second dose

1.49 Is measles containing vaccine information available for all 15 birth cohorts (2005-2019)?,

a) Yes
b) No (GO TO 4.25)

1.50 Please, specify for which birth cohorts can you prepare a vaccination file:

1.51 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017)

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4a Characteristics of the system (DA)

This section of the questionnaire will explore the population that is covered by the IIS and how individuals included in the register are identified.

Please answer for both currently operating system and the system being piloted.

For systems being piloted, please indicate the population that is planned to be included in the system.

DA4.1 **All** vaccinations provided (regardless of recommendations, age, risk factors etc..) are recorded. (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		

DA4.2 Childhood vaccinations included in the national/regional immunisation programmes are recorded. (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		

DA4.3 Adolescents vaccinations included in the national/regional immunisation programmes are recorded. (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		

DA4.4 Adults vaccinations included in the national/regional immunisation programmes are recorded. (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		

DA4.5 Vaccinations included in the recommended school-based vaccination programme are recorded. (ECDC, 2017)

	Current system	IIS being piloted
Yes		

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No		
Not applicable		

DA4.6 Is each immunised individual, recorded in the current system, identified with a unique identifier? (ECDC, 2017)

a) Yes (GO TO DA4.7)
b) No (GO TO DA4.8)
c) I do not know

DA4.7 How is the current systems' unique personal identifier generated? (ECDC, 2017)

a) The IIS uses the unique identifier given to citizens at birth or immigration
b) The IIS uses the unique identifier used for healthcare services
c) The IIS uses a unique identifier specific for the immunisation registry
d) Other

DA4.8 If No, please describe how each immunised individual is identified in the current system database (ECDC, 2017)

DA4.9 Is each immunised individual, recorded in the piloted IIS, identified with a unique identifier? (ECDC, 2017)

a) Yes (GO TO DA4.10)
b) No (GO TO 4.11)
c) I do not know

DA4.10 How is the piloted IIS unique personal identifier generated? (ECDC, 2017)

a) The IIS uses the unique identifier given to citizens at birth or immigration
b) The IIS uses the unique identifier used for healthcare services
c) The IIS uses a unique identifier specific for the immunisation registry
d) Other

DA4.11 If No, please describe how each immunised individual is identified in the IIS being piloted database (ECDC, 2017)

DA4.12 Please indicate for the current system - what is the minimal set of data variables to be recorded for an immunisation record to be valid (please list) (ECDC, 2017)?

DA4.13 Please indicate for the IIS being piloted - what is the minimal set of data variables to be recorded for an immunisation record to be valid (please list) (ECDC, 2017)?

DA4.14 Can vaccinations administered in the past be recorded in the IIS? (ECDC, 2017)

	Current system	IIS being piloted
Yes		

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No		

DA4.15 Can vaccinations administered in a foreign country be recorded? (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		

DA4.16 In case of sub-national systems, can vaccinations administered in another region be recorded? (ECDC, 2017)

	Current system	IIS being piloted
Yes		
No		
Not applicable		

DA4.17 Please indicate for the current system - how is the data that identifies the vaccine administered recorded? One answer possible. (ECDC, 2017)

a) Manually
b) Electronically with the help of a bar code reader
c) By selecting from a list of vaccines included in the registry
d) By linking to a product database
e) Other (specify)

DA4.18 Please indicate for the IIS being piloted - how is the data that identifies the vaccine administered recorded? One answer possible. (ECDC, 2017)

a) Manually
b) Electronically with the help of a bar code reader
c) By selecting from a list of vaccines included in the registry
d) By linking to a product database
e) Other (specify)

DA4.19 How are vaccinations recorded in the current system? Multiple answers possible

a) Vaccinations recorded by trade name
b) Vaccinations recorded by local coding (GO TO DA4.20)
c) Vaccinations recorded by batch/lot number
d) ATC classification
e) By antigen
f) Other:

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DA4.20 Please indicate for the current system - are the local codes uniform for the whole country or can they differ between regions?

a) Yes, they are uniform
b) No, codes differ (GO TO DA4.21)

DA4.21 Please, specify how codes differ:

DA4.22 How are vaccinations recorded in the IIS being piloted? Multiple answers possible

a) Vaccinations recorded by trade name
b) Vaccinations recorded by local coding (GO TO DA4.23)
c) Vaccinations recorded by batch/lot number
d) ATC classification
e) By antigen
f) Other:

DA4.23 Please indicate for the current system - are the local codes uniform for the whole country or can they differ between regions?

a) Yes, they are uniform
b) No, codes differ (GO TO DA4.24)

DA4.24 Please, specify how codes differ:

DA4.25 For the current system - please specify who is responsible for the coding system:

a) Country medicinal authority (or equivalent)
b) Regional medicinal authority (or equivalent)
c) Ministry of Health (or equivalent)
d) Health Insurance Fund (or equivalent)
e) Public Health Institution (or equivalent)
f) Other:

DA4.26 For the IIS being piloted - please specify who is responsible for the coding system:

a) Country medicinal authority (or equivalent)
b) Regional medicinal authority (or equivalent)
c) Ministry of Health (or equivalent)
d) Health Insurance Fund (or equivalent)
e) Public Health Institution (or equivalent)
f) Other:

DA4.27 For the current system - is dose number recorded (eg. D1 as Dose 1, D2 as Dose2 etc.)

a) Yes
b) No (GO TO DA4.28)

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DA4.28 For the current system - please, specify how are measles containing doses identified:

DA4.29 For the IIS being piloted - is dose number recorded (eg. D1 as Dose 1, D2 as Dose2 etc.)

a) Yes
b) No (GO TO DA4.30)

DA4.30 For the IIS being piloted - please, specify how are measles containing doses identified:

DA4.31 Do you have access to vaccination data on regional/country level?

	Current system	IIS being piloted
Yes		
No		

DA4.32 Will you be able to prepare a vaccination file including all measles containing vaccine doses (e.g. D1 and D2) administered to children belonging to the birth cohorts 2005 - 2019 including the following core variables per vaccine dose per PersonID (Please see data example in Annex 1

Variable name	Can prepare	Cannot prepare	Not applicable
PersonID			
Date			
Vacname			
Vactype			
ATC			
Dose			

Variable name	**Meaning**	**Format**
PersonID	Person Identifier	
Date	Date of administration	Format YYYYMMDD.
Vactype	Type of vaccine (antigens)	Three letter code per antigen (Mea-Mum-Rub-Var)
ATC	Type of vaccine	ATC code, 7 digits.
Dose	Dose received as specified in database or determined by the database custodian based on knowledge of the local immunization schedule	
	possible values	Description
	D1	For first dose
	D2	For second dose

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DA4.33 Is measles containing vaccine information available for all 15 birth cohorts (2005-2019)?,

a) Yes
b) No (GO TO DA4.34)

DA4.34 Please, specify for which birth cohorts can you prepare a vaccination file:

DA4.35 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017)

Input (E)

This section will explore in detail the links established between the IIS and other registries in your country or region including civil registries and other health-related registries.

1.52 Is information included in the IIS fed by any population registry? Multiple answers possible. (ECDC, 2017)
a) No, data are entered manually only at time of a person encounter for immunisation
b) Yes, by civil population registries
c) Yes, by healthcare population registries
d) Other (specify)

1.53 Is an individual vaccination record set-up automatically in the IIS at the time of the registration of a live birth (or a certain time later)? (ECDC, 2017):
a) Yes
b) No

1.54 Is an individual vaccination record set-up automatically in the IIS at the time of immigration (or a certain time later)? (ECDC, 2017):
Yes
No

1.55 What is the estimated time between vaccination and the information being entered into the IIS?
(only one response possible) (ECDC, 2017)
a) Data are entered at the time of vaccine administration
b) Within 1 day
c) Within 1 week (7 days)
d) Within 2 weeks
e) Within 1 month
f) 1-3 months
g) Other, specify (e.g. estimated time not mentioned above; depending on vaccination or method used or sub-national area, etc…)

1.56 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017):

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5a Input (EA)

This section will explore in detail the links established between the IIS and other registries in your country or region including civil registries and other health-related registries.

Please answer for both currently operating system and the system being piloted. For systems being piloted, please indicate the plans foreseen.

EA1. Is information included in the current system fed by any population registry? Multiple answers possible. (ECDC, 2017)

a) No, data are entered manually only at time of a person encounter for immunisation
b) Yes, by civil population registries
c) Yes, by healthcare population registries
d) Other (specify)

EA2. Is information included in the IIS fed by any population registry? Multiple answers possible. (ECDC, 2017)

a) No, data are entered manually only at time of a person encounter for immunisation
b) Yes, by civil population registries
c) Yes, by healthcare population registries
d) Other (specify)

EA3. Is an individual vaccination record set-up automatically in the IIS at the time of the registration of a live birth (or a certain time later)? (ECDC, 2017):

	Current system	IIS being piloted
Yes		
No		

EA4. Is an individual vaccination record set-up automatically in the IIS at the time of immigration (or a certain time later)? (ECDC, 2017):

	Current system	IIS being piloted
Yes		
No		

EA5. What is the estimated time between vaccination and the information being entered into the current system? (only one response possible) (ECDC, 2017)

a) Data are entered at the time of vaccine administration
b) Within 1 day
c) Within 1 week (7 days)
d) Within 2 weeks
e) Within 1 month

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f) 1-3 months
g) Other, specify (e.g. estimated time not mentioned above; depending on vaccination or method used or sub-national area, etc…)

EA6. What is the estimated time between vaccination and the information being entered into the IIS being piloted? (only one response possible) (ECDC, 2017)

a) Data are entered at the time of vaccine administration
b) Within 1 day
c) Within 1 week (7 days)
d) Within 2 weeks
e) Within 1 month
f) 1-3 months
g) Other, specify (e.g. estimated time not mentioned above; depending on vaccination or method used or sub-national area, etc…)

EA7. If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017):

Denominator calculation (F)

1.57 What is the smallest administrative area for which you can compute aggregated vaccination uptake/coverage? (only one response possible) (ECDC, 2017)

a) NUTS 1

b) NUTS 2

c) NUTS 3

d) Other than listed above (GO TO 6.2)

e) It is not possible to calculate vaccination uptake/coverage (GO TO 6.3)

1.58 Please, specify the smallest administrative area for which you can compute aggregated vaccination uptake/coverage:

1.59 Please, specify why is it not possible to calculate vaccination uptake/coverage:

1.60 What are the sources of denominator data for the IIS? (ECDC, 2017)

a) Civil population registries

b) Healthcare population registries

c) Other than listed above, please specify:

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1.61 What is the delay between birth and immigration and registration in population register:

a) Within 1 day
b) Up to a week
c) Up to a month
d) Other, please specify:

1.62 What is the delay between death and emigration and exit from the population register:

a) Within 1 day
b) Up to a week
c) Up to a month
d) Other, please specify:

1.63 Do you have access to population data at regional/country level?

a) Yes
b) No

1.64 Will you be able to prepare a population file containing all individuals from the birth cohorts 2005- 2019 including the following core variables per PersonID:

Variable name	Can prepare	Cannot prepare	Not applicable
PersonID			
Birthdate			
Gender			
NUTS ID			
Startdate			
Enddate			

Annex 2

Variable name	Meaning	Format
PersonID	Person Identifier	Unique
Birthdate	Date of birth	YYYYMMDD
Gender	Gender	F for Female M for Male
NUTS ID	NUTs identification e.g DK050, DK041, DK042….	

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Startdate	Date from which the person is registered in the registration system (date of birth, date of immigration).	YYYYMMDD
Enddate	Date after which the person is no longer registered in the registration system (e.g death or emigration)	YYYYMMDD

1.65 Are you allowed to prepare the proposed vaccination and populations files?
- a) Yes
- b) No

1.66 Are **you** allowed to estimate MMR1 and MMR2 coverage based on the algorithm developed and shared and upload the regional coverage estimates to a common platform?
- a) Yes
- b) No

1.67 Are we allowed to show regional coverage estimates that you provide on a common platform?
- a) Yes
- b) No

1.68 How often would be feasible to extract data?
- a) Daily
- b) Weekly
- c) Monthly
- d) Biannually
- e) Annually

1.69 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here(ECDC, 2017)

Challenges and barriers (G)

This section will explore challenges that may have been faced at various stages of the implementation of the IIS. We are listed common challenges and would like to explore to what extent they had an impact on developments in your country.

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1.70 For each of the following factors, please indicate how much they represented a challenge to be overcome **before** a decision was taken to set up the IIS or before a decision was taken to pilot an IIS. (ECDC, 2017)

	Yes	Somewhat	No
1.Need to vote a legislation to govern the use of the IIS			
2.Need to establish governance and ownership (defining who was in charge of responsibility of the system)			
3.Data protection issues			
4.Lack of funding			
5.Lack of human resources			
6.Definition of users and stakeholders to be involved			
7.Decentralisation of immunisation programmes			
8.Lack of efficient infrastructure that could support the IIS (e.g. lack of computer or Internet connection at the local level)			
9. Low information literacy			

1.71 If you met other relevant challenges (not mentioned above) in the decision to set up the IIS, please feel free to describe further(ECDC, 2017):

1.72 For each of the following factors, please indicate how much they represented a challenge to be overcome during the design phase of the IIS(ECDC, 2017)

	Yes	Somewhat	No
1.Expanding the existing infrastructure/lack of efficient infrastructure (e.g. lack of computer or Internet connection at the local level)			

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2.Lack of standards as point of reference for developing the system			
3.Defining the functions required by the systems			
4.Defining the core data set of information to be collected			
5.Defining rules for access rights to different users (national agency, local health officers, health providers…)			
6.Defining rules for data sharing among different users (national agency, local health officers, health providers…)			
7.To find out how to register information on the vaccine administered			
8.Integration with the population registries feeding the IIS			
9.Linkage to other health outcome registers, e.g. notifiable diseases			
10. Low information literacy			

1.73 If you met other relevant challenges (not mentioned above) in the decision to set up the IIS, please feel free to describe further(ECDC, 2017):

1.74 For each of the following factors, please indicate how much they represented a challenge to be overcome during the early use of the IIS [Please thick *not applicable* for systems currently being piloted] (ECDC, 2017)

	Yes	Somewhat	No	Not applicable
1.Acceptance of the system by the vaccination providers				

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2.Training needs of vaccine providers for using of the system				
3.Timely assistance of health providers				
4.Lack of efficient IT infrastructure				
5.Lack of resources in term of staff working with vaccine administration				
6.Quality control of data completeness				
7.Quality control of data consistency				
8.Validation of data entered by different users				
9.Experience of errors like sending invitation to not targeted individuals (e.g. already vaccinated individuals, dead persons)				
10.Experience of people not wanting to be monitored or identified through unique identification numbers				
11.Entering of retrospective data				
12.Difficulties to avoid data duplication				
13.Importation/merge of existing vaccination data from other health data sources				
14.Defining a denominator for coverage calculation				
15. Low information literacy				

1.75 If you met other relevant challenges (not mentioned above) in the set-up phase of the IIS, please feel free to describe further (ECDC, 2017):

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Comments

8.1 Please add any additional information or links to references or websites to further describe the IIS in your country(ECDC, 2017)

Vaccine coverage estimation by administrative method (No IIS)

AM1 General

AM1.1 What is the closest model of reporting vaccines administrated?

a) National
b) Sub-national without sharing on national level
c) Sub-national with sharing on national level
d) Other:

AM1.2 How is data for vaccination reported?

a) Type of vaccination by general name (MMR, Influenza, HPV etc.)
b) By dose
c) ATC codes
d) Other:

AM1.3 How often do you receive administrative data?

a) Once a week
b) Twice a month
c) Monthly
d) Quarterly (year)
e) Other:

AM1.4 What are the sources of denominator data when estimating coverage? (ECDC, 2017)

a) Civil population registries
b) Healthcare population registries
c) Population estimation made by relevant authority (statistics bureau or equivalent)
d) Other:

AM1.5 Which organisation or institution is responsible for vaccination coverage estimates? Multiple answers possible(ECDC, 2017)

g) National Institute of Public Health (or equivalent)
h) Regional Institute of Public Health (or equivalent)

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i) Ministry of Health
j) Regional Health Authorities
k) National health insurance organisation
l) Other:

AM1.6 How often is coverage estimated for each birth cohort?

a) Monthly
b) Half-year
c) Yearly
d) Every second year or other frequency

AM1.7 Is coverage estimated for all MMR doses?

a) Yes
b) No

AM2 Barriers and plans for the future

AM2.1 For each of the following factors, please indicate how much they represented a barrier to the plan/implement an IIS in your country. (ECDC, 2017)

	Yes	Somewhat	No
1.Lack of funding			
2.Lack of human resources			
3.Need to vote a legislation to govern the use of the IIS			
4.Need to establish governance and ownership (defining who was in charge of responsibility of the system)			
5.Data protection issues			
6.Definition of users and stakeholders to be involved			
7.Decentralisation of immunisation programmes			
8.Lack of efficient infrastructure that could support the IIS (e.g. lack of computer or Internet connection at the local level)			

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9.Lack of standards as point of reference for developing the system			
10.Defining rules for access rights to different users (national agency, local health officers, health providers…)			
11. Low information literacy			

AM1.8 If you have any additional comments that you would like to share to better understand the situation in your country, please write them here (ECDC, 2017)

Example showing Vaccination file

PersonID	Date	Vactype	ATC	Dose
180	20060425	Mea	J07BD01	D1
180	20100127	Mea	J07BD01	D2
425	20140823	Mea-Mum-Rub	J07BD52	D1
425	20180520	Mea-Mum-Rub	J07BD52	D2
630	20190210	Mea-Mum-Rub	J07BD52	D1

Example showing population file

PersonID	Birthdate	Gender	NUTS ID	Startdate	Enddate
180	20050119	M	DK050	20050119	20121016
425	20130519	F	DK041	20130519	20190403
630	20181204	F	DK042	20181204	20190403

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Summary of the responses from the questionnaire regarding IIS in place among WP5 partners

Table A1. Characteristics of information immunization systems (IIS) among JAV partners based on questionnaire data collected by WP5

Country	National	If regional provide name of region	Lowest Nuts level available	Can a population file with individual level data be prepared for coverage estimation	Can a vaccination file with individual level data be prepared for coverage estimation	Available birth cohorts	Data extraction frequency	Are you allowed to estimate MMR coverage at regional level and share on a common platform	Are you allowed to show regional estimates on a common platform
Belgium	No	Flanders	BE1 + BE2 (postal code)	Need juridical advice	Need juridical advice	2005-2019	Annually	yes	yes
Denmark	yes		NUTS 3, Municipalities	yes	yes	2005-2019	weekly	yes	yes
Finland	Yes		Municipalities	yes	Yes	2011-	weekly	yes	yes
Netherlands	yes		Zip code	Yes	Yes	2005-2019	Monthly	yes	yes
Norway	Yes		Municipalities	yes	Yes	2005-2019	Daily	yes	yes
Sweden	yes		NUTS 3	No, only aggregated data	yes	2012-	Annually	yes	yes
Italy	yes, piloted		NUTS 3	?	?	In operation from 2020	Monthly	yes	yes
Spain*	yes, piloted		NUTS 2	?	?	In operation from 2020			Not yet
Slovenia**	Yes, operational		NUTS1, health region	yes	yes	2017-, piloted	Daily, piloted	yes	yes

*SIVAMIN is a repository of information. This section is about "how individuals included in the register are identified". It is not applicable

** all health care providers who vaccinate are not inluded

Table A2. Characteristics of the systems used to estimate coverage among JAV partners with no information immunization systems

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Country	ISS	Smallest administrative aerea	How often do you receive data	Coverage estimates	Denominator	Vaccinated reported by	Comment
Bulgaria	No IIS implemeted	Sub-national shared nationally	Quarterly	Twice yearly	Civil and health population registries	dose	
Croatia	No IIS implemeted,	Sub-national shared nationally	Quarterly	Annually	No of children suitable for vaccination	Type of vaccine, dose, ATC	
Latvia	No IIS implemeted,	Sub-national shared nationally	Monthly	Twice yearly	Statistics bureau	Type of vaccine, dose, ATC	
Lithuania	No IIS implemeted,	national	Monthly	Annually	Health population registries and statistics bureau	Type of vaccine, dose	
Greece	No IIS implemeted,		National population based surveys from specific cohorts	Every second year or other frequency	statistics bureau	Type of vaccine, dose	In 2012, an electronic prescription database was established
Slovakia	No IIS implemeted,		Annually	Anually	Number of children liable for vaccination born in certain year	Certain cohorts per year	Plan IIS from 2022

Table A3. Partners in WP5 responded to a questionnaire circulated during the summer 2019 regarding the availability of Immunisation Information Systems (IIS) in their countries

WP5 Partners	Signed up for Task 5.2	National IIS	Rgional IIS	No IIS
France, INSERM		(x)	(x)	
Belgium, VAZG,	x		x	
Bosnia & Herzegovina, MoCA				?
Bulgaria, MoH-HPDPD				x
Croatia CIPH	x			x
Denmark SSI	x	x		
Finland, THL	x	x		
Greece, HCDCP				x
Italy, ISS			x	
Latvia, CDPC				x
Lithuania, SAM				x
Netherlands, RIVM	x	x		
Norway, FHI		x		
Slovakia, SK MoH	x			x
Slovenia, NIJZ		x*		
Spain, FMS			x	
Sweden, FoHM	x	x		

* Not fully operational

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Installation Guide

Install R-package

The package demand R 3.5.0 or later.

The project R package MCVCovLoc can be installed from GitHub:

To do this the package devtools are needed and can be installed from cran:

```
install.packages("devtools")
```

To install the MCVCovLoc package:

```
devtools::install_github("JensXII/MCVCovLoc", build_vignettes = TRUE)
```

For older version of R or devtools, this does not work e.g. the vignettes users_guide and install_guide are not build. Then try:

```
devtools::install_github("JensXII/MCVCovLoc", build_opts = c("--no-resave-data", "--no-manual"))
```

If this doesn't work either, you can download the source-code and install this: - you may not be able to do this with Windows Explorer, but have to use Crome or another web-browser.

1. https://github.com/JensXII/MCVCovLoc
2. press 'Clone and download'
3. press 'Download ZIP'
4. unzip and save the downloaded to a designeded folder
5. in the folder double-click the MCVCovLoc R-project file
6. run:

```
devtools::install(build_vignettes = TRUE)
```

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Users Guide

Introduction

Data on coverage of measles containing vaccines are extracted at calender dates e.g. monthly or quarterly. Thus being cross sectional inventories of measles contaning vaccination coverages.

When more cross sectional coverage-data have been collected, it will be possible to follow coverage over calendar time.

The structural setup is shown in figure 1 and 2, input datasets and variables in section Input data and the combined output R data in section Combined R data.

Figure 1. Setup

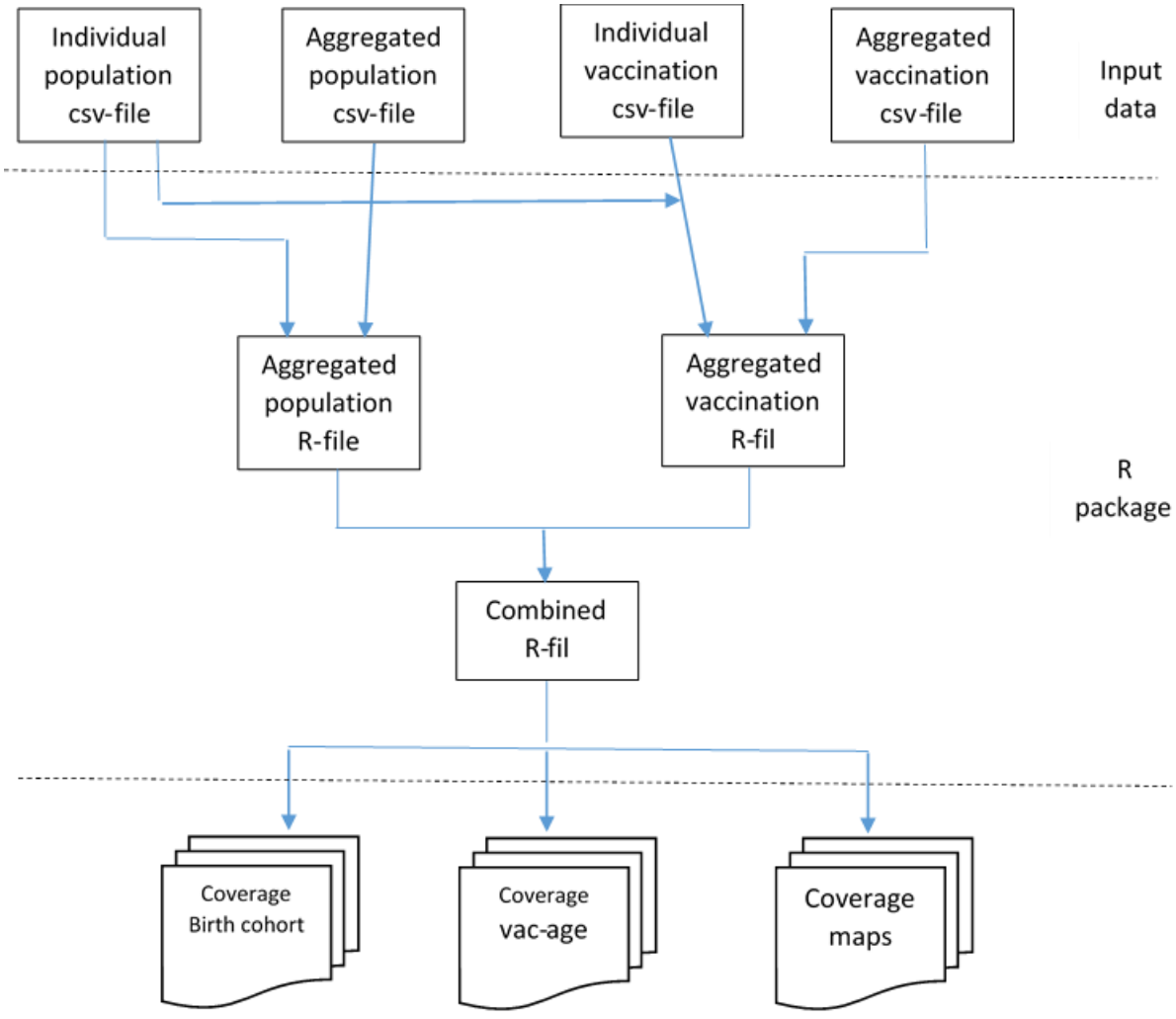

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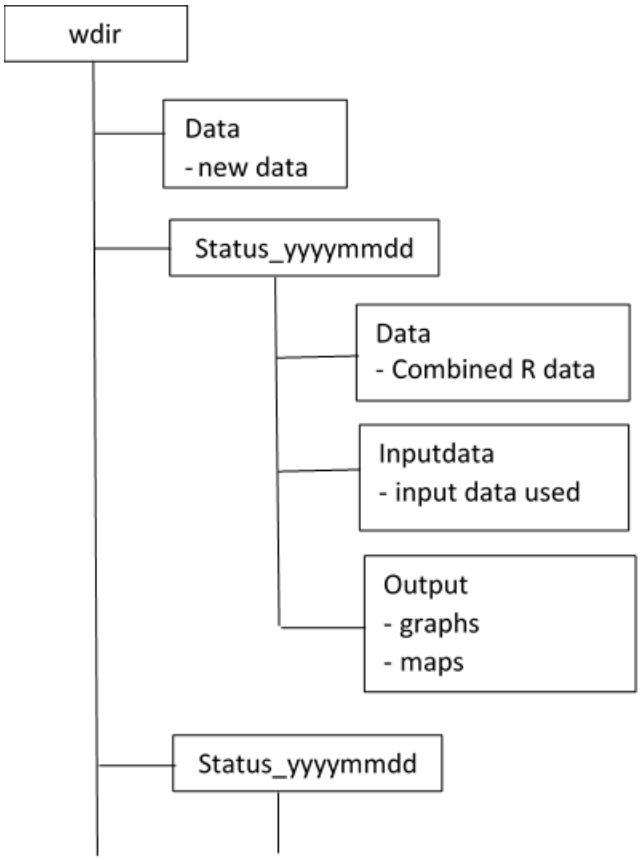
Figure 2. Structure on disk



Input data

Both information on population and vaccinations are needed. Why input data always have to consist of a set of two data-files.

Valid sets of input data will be one of the following:

- Indiviudal population file + Individual vaccination file
- Indiviudal population file + Aggregated vaccination file
- Aggregated population file + Aggregated vaccination file

while the combination Aggregated population file + Individual vaccination file will not be a valid set of input data.

Data in a set of input data should be extracted simultanously or as close in time to one another as possible.
It is recommend to include date-of-extraction in the naming of the files.

Note:

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- The input data csv-files must be semicolon-separated csv-files
- Persons with year of birth < 2005 should not be included in the input data
- For NUTS, minimum NUTS0 i.e. countrycode (two characters), must be included
- NUTS detailing can maximum be level 3
- If NUTS-levels more detailed that NUTS0 are used, then all NUTS must be at the same level – in both input files.

Scripts

Initially, create a dedicated directory for this project (wdir), and a subdirectory in this call data. The later is where input ;-seperated input files must be located

Example:

- Project directory: S:/Data/MCVCovLoc_wdir_DK
- Subdirectory: S:/Data/MCVCovLoc_wdir_DK/data

New data

For each inventory/status i.e. dates where a valid set of input data are available execute InputData.

Example, with an individual population and an individual vaccination file:

```
MCVCovLoc::InputData(
  wdir = "S:/Data/MCVCovLoc_wdir_DK",
  StatusDate = "2019-10-01",
  IndividuelPopulationFile = "DKIndPop20191001.csv",
  IndividuelMCVFile = "DKIndVac20191001.csv",
  AggregatedPopulationFile = NA,
  AggregatedMCVFile = NA,
  AdministrativeMCVFile = NA
)
```

This will create a subdirectory wdir/Status_20191010 containing three subdirectories:

- Inputdata – containing the inputdata used
- Data – containing the AggPop, AggVac and combined R files
- Output – containing coverage graphs on NUTS-level 0 for both doses.

This project has received co-funding from the European Union's Health Programme under Grant Agreement no. 801495

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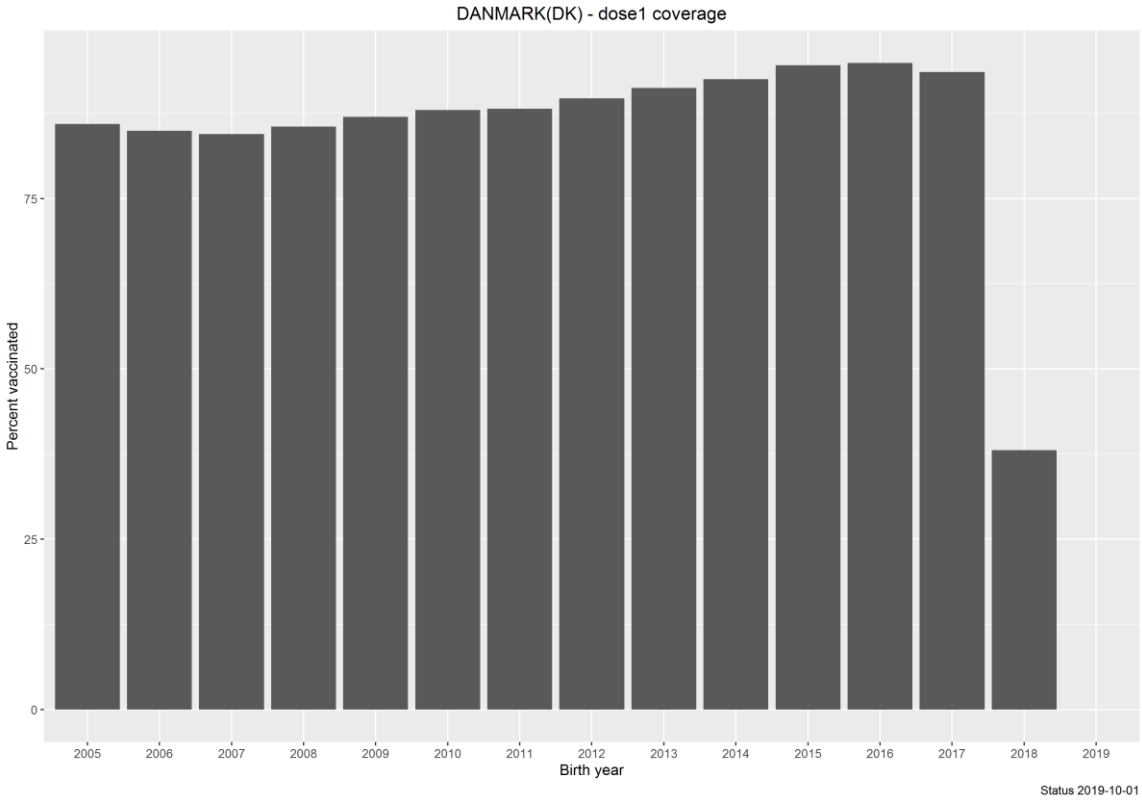
Coverage graphs by Birth cohort

Following the example above, to have a graph of dose 1 coverage by Birth cohort/year in the NUTS DK01 area:

```
MCVCovLoc::VacCovBd(
  wdir = "S:/Data/MCVCovLoc_wdir_DK",
  StatusDate = "2019-10-01",
  NUTS = "DK01",
  dose = 1,
  save = TRUE
)
```

which creates this graph in the directory wdir/Status_20191001/Output

Do you only want to see the graph, but not store it on disk, use save = FALSE



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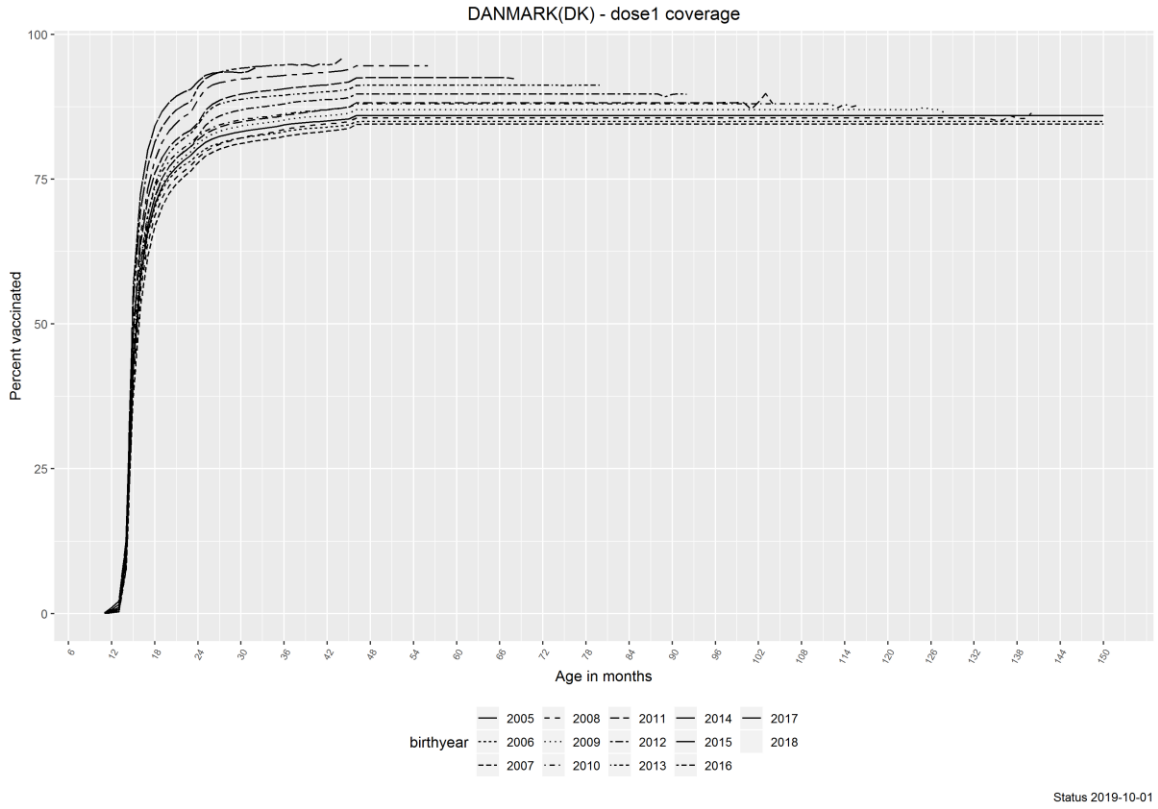
Coverage graphs by age of vaccination

Following the example above, to have a graph of dose 1 coverage by age in months at vaccination in the NUTS DK01 area:

```
MCVCovLoc::VacCovAge(
  wdir = "S:/Data/MCVCovLoc_wdir",
  StatusDate = "2019-10-01",
  NUTS = "DK",
  dose = 1,
  save = TRUE
)
```

Which creates this graph in the directory wdir/Status_20191001/Output

Do you only want to see the graph, but not store it on disk, use save = FALSE



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Coverage maps

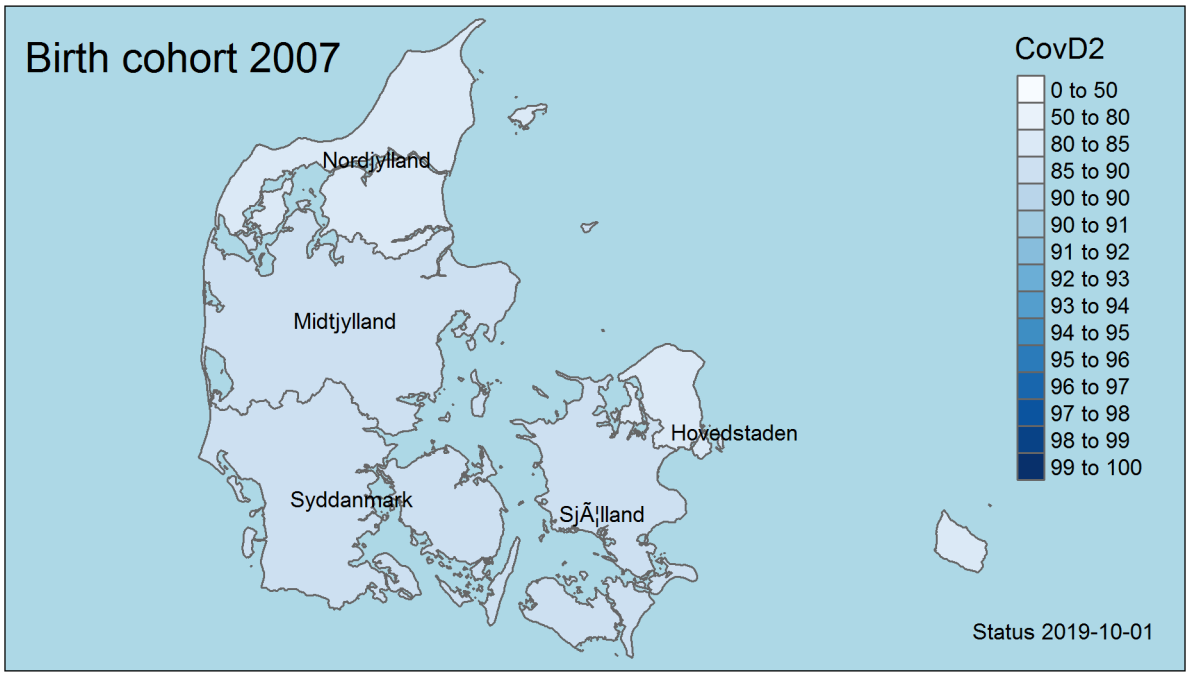
A map of the coverage in a birth-cohort may be drawn on different NUTS-levels.

Following the example above, for birth-cohort 2005 and dose 2:

```
MCVCovLoc::MapCov(
  wdir = 'S:/Data/MCVCovLoc_wdir_DK',
  StatusDate = '2019-12-01',
  BirthCohort = 2005,
  NUTS = 'DK01',
  dose = 2,
  save = TRUE
)
```

which creates this map in the directory wdir/Status_20191001/Output

Do you only want to see the map, but not store it on disk, use save = FALSE



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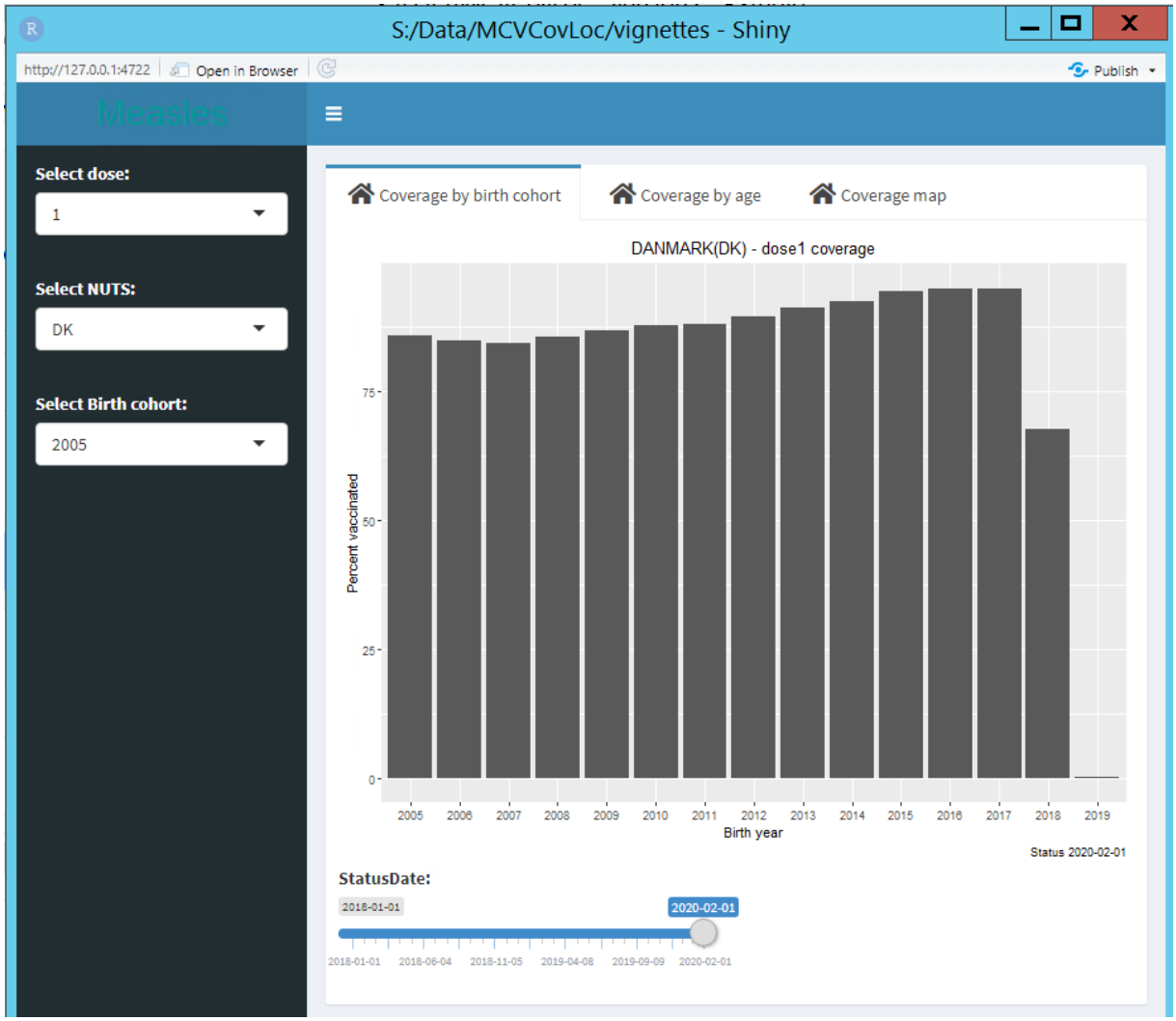
Shiny dashboard

To have a dashboard showing all your registered data:

```
MCVCovLoc::ShowCov(
  wdir = "S:/Data/MCVCovLoc_wdir_DK"
)
```

This will start a Shiny daskboard:



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Inputdata

Minimal means that these variables must be in the files, with the specified names. There may also be other variables in data e.g. gender, but these are not included in the coverage calculations and output.

Minimal individual population file

Variable name	Meaning	Format
PersonID	Unique person identifier that allows linking the individual population and individual vaccination files	Character
NUTS	NUTS Id for where the person had residence at date of data extraction	Character
BirthDate	Date of birth	YYYY-MM-DD

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Minimal individual vaccination file

Variable name	Meaning	Format
PersonID	Unique person identifier that allows linking the individual population and individual vaccination files	Character
VacDate	Date of vaccination	YYYY-MM-DD
DoseRecorded	Dose received	1 – first dose 2 – second dose

Minimal aggregated population file

Variable name	Meaning	Format
NUTS	NUTS Id for where the person had residence at date of data extraction	Character
BirthYear	Birth cohort	YYYY - Integer(4)
Count	Number of persons	Integer

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Minimal aggregated vaccination file

Variable name	Meaning	Format
NUTS	NUTS Id for where the person had residence at date of data extraction	Character
BirthYear	Year of birth	Integer(4)
VacAgeMonth	Age in months, when vaccinated	Integer
DoseRecorded	Dose received	1 – first dose 2 – second dose
Count	Number of vaccinated persons	Integer

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Combined R data

Variable name	Meaning	Format
StatusDate	Date of inventory	YYYY-MM-DD
NUTS	NUTS Id for where the person had residence at StatusDate	Character
BirthYear	Year of birth	Integer(4)
VacAgeMonth	Age in months, when vaccinated	Integer
DoseRecorded	Dose received	1 – first dose 2 – second dose
Count	Number of vaccinated persons	Integer

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