**Expanded Programme on Immunisation**

November 2022

1. Baseline vaccine coverage

The population is initialised on 1st Jan 2010 and a set of individual properties relating to vaccine coverage is assigned to every individual. The properties detail both the numbers of doses of each vaccine type and whether the person has had a full course of that vaccine (True/False).

The baseline coverage of immunisations in 2010 uses the WHO estimates which date from 1980 onwards. We assume that all vaccinations prior to 2010 were given to infants in the first year of life, we can therefore infer the coverage for each vaccine type in each birth cohort. For example, for a person aged 20 on 1st Jan 2010, there would be a 96% probability that they received the BCG vaccine, 87% probability of receiving 3 doses of DTIP etc. In this way we have a group of susceptible individuals in every age group dependent on the programme coverage estimates in the year of their birth. If a vaccine is not available in a given year, the probability is set to zero.

The WHO reported estimates for vaccine coverage between 1980 and 2009 are in Table 1. Table 2 lists the individual properties managed by the EPI module along with their descriptions and data type.

Table . WHO estimates of vaccine coverage

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | BCG | DTP1 | DTP3 | HepB3 | Hib3 | MCV1 | MCV2 | PCV3 | Pol3 | RCV1 | Rotavirus | AgeOn01Jan2010 |
| 1980 | 0 | 80 | 58 | 0 | 0 | 49 | 0 | 0 | 28 | 0 | 0 | 29 |
| 1981 | 86 | 86 | 66 | 0 | 0 | 64 | 0 | 0 | 57 | 0 | 0 | 28 |
| 1982 | 87 | 84 | 64 | 0 | 0 | 64 | 0 | 0 | 58 | 0 | 0 | 27 |
| 1983 | 81 | 84 | 63 | 0 | 0 | 58 | 0 | 0 | 58 | 0 | 0 | 26 |
| 1984 | 74 | 80 | 58 | 0 | 0 | 50 | 0 | 0 | 56 | 0 | 0 | 25 |
| 1985 | 87 | 78 | 55 | 0 | 0 | 49 | 0 | 0 | 55 | 0 | 0 | 24 |
| 1986 | 87 | 80 | 57 | 0 | 0 | 60 | 0 | 0 | 53 | 0 | 0 | 23 |
| 1987 | 92 | 92 | 78 | 0 | 0 | 79 | 0 | 0 | 78 | 0 | 0 | 22 |
| 1988 | 90 | 94 | 82 | 0 | 0 | 82 | 0 | 0 | 72 | 0 | 0 | 21 |
| 1989 | 96 | 95 | 87 | 0 | 0 | 84 | 0 | 0 | 90 | 0 | 0 | 20 |
| 1990 | 97 | 95 | 87 | 0 | 0 | 81 | 0 | 0 | 93 | 0 | 0 | 19 |
| 1991 | 96 | 95 | 87 | 0 | 0 | 85 | 0 | 0 | 96 | 0 | 0 | 18 |
| 1992 | 98 | 95 | 87 | 0 | 0 | 91 | 0 | 0 | 98 | 0 | 0 | 17 |
| 1993 | 96 | 97 | 91 | 0 | 0 | 87 | 0 | 0 | 91 | 0 | 0 | 16 |
| 1994 | 94 | 94 | 82 | 0 | 0 | 83 | 0 | 0 | 84 | 0 | 0 | 15 |
| 1995 | 97 | 96 | 89 | 0 | 0 | 90 | 0 | 0 | 90 | 0 | 0 | 14 |
| 1996 | 95 | 96 | 90 | 0 | 0 | 90 | 0 | 0 | 82 | 0 | 0 | 13 |
| 1997 | 99 | 98 | 95 | 0 | 0 | 87 | 0 | 0 | 94 | 0 | 0 | 12 |
| 1998 | 99 | 98 | 96 | 0 | 0 | 90 | 0 | 0 | 93 | 0 | 0 | 11 |
| 1999 | 87 | 98 | 85 | 0 | 0 | 82 | 0 | 0 | 77 | 0 | 0 | 10 |
| 2000 | 83 | 98 | 75 | 0 | 0 | 73 | 0 | 0 | 73 | 0 | 0 | 9 |
| 2001 | 93 | 99 | 90 | 0 | 0 | 81 | 0 | 0 | 86 | 0 | 0 | 8 |
| 2002 | 78 | 94 | 64 | 64 | 64 | 69 | 0 | 0 | 79 | 0 | 0 | 7 |
| 2003 | 91 | 99 | 84 | 84 | 84 | 77 | 0 | 0 | 85 | 0 | 0 | 6 |
| 2004 | 97 | 99 | 89 | 89 | 89 | 80 | 0 | 0 | 94 | 0 | 0 | 5 |
| 2005 | 99 | 99 | 93 | 93 | 93 | 82 | 0 | 0 | 94 | 0 | 0 | 4 |
| 2006 | 99 | 99 | 99 | 99 | 99 | 85 | 0 | 0 | 99 | 0 | 0 | 3 |
| 2007 | 95 | 96 | 87 | 87 | 87 | 83 | 0 | 0 | 88 | 0 | 0 | 2 |
| 2008 | 97 | 97 | 91 | 91 | 91 | 88 | 0 | 0 | 92 | 0 | 0 | 1 |
| 2009 | 95 | 97 | 93 | 93 | 93 | 92 | 0 | 0 | 93 | 0 | 0 | 0 |

Source: WHO/UNICEF Estimates of National Immunization Coverage (WUENIC). Accessed March 2020.

https://www.who.int/teams/immunization-vaccines-and-biologicals/immunization-analysis-and-insights/global-monitoring/immunization-coverage/who-unicef-estimates-of-national-immunization-coverage

Table . Individual properties managed by the EPI module

|  |  |  |
| --- | --- | --- |
| Individual property | Description | Values |
|  |  |  |
| Properties for the number of doses received of each vaccine | | |
| va\_bcg | number of doses of BCG vaccination | 0, 1 |
| va\_opv | number of doses of OPV vaccine received | 0, 1, 2, 3, 4 |
| va\_dtp | number of doses of DTP vaccine received | 0, 1, 2, 3 |
| va\_hib | number of doses of Hib vaccine received | 0, 1, 2, 3 |
| va\_hep | number of doses of HepB vaccine received (infant series) | 0, 1, 2, 3 |
| va\_pneumo | number of doses of pneumococcal vaccine received | 0, 1, 2, 3 |
| va\_rota | number of doses of rotavirus vaccine received | 0, 1, 2 |
| va\_measles | number of doses of measles vaccine received | 0, 1, 2 |
| va\_rubella | number of doses of rubella vaccine received | 0, 1, 2 |
| va\_hpv | number of doses of HPV vaccine received | 0, 1 |
| va\_td | number of doses of tetanus/diphtheria vaccine received by pregnant women | 0, 1 |
|  |  |  |
| Properties to indicate whether the full number of doses have been received | | |
| va\_bcg\_all\_doses | whether all doses have been received of the BCG vaccine | True, False |
| va\_opv\_all\_doses | whether all doses have been received of the OPV vaccine | True, False |
| va\_dtp\_all\_doses | whether all doses have been received of the DTP vaccine | True, False |
| va\_hib\_all\_doses | whether all doses have been received of the Hib vaccine | True, False |
| va\_hep\_all\_doses | whether all doses have been received of the HepB vaccine (infant series) | True, False |
| va\_pneumo\_all\_doses | whether all doses have been received of the pneumococcal vaccine | True, False |
| va\_rota\_all\_doses | whether all doses have been received of the rotavirus vaccine | True, False |
| va\_measles\_all\_doses | whether all doses have been received of the measles vaccine | True, False |
| va\_rubella\_all\_doses | whether all doses have been received of the rubella vaccine | True, False |
| va\_hpv\_all\_doses | whether all doses have been received of the HPV vaccine | True, False |
| va\_td\_all\_doses | whether all doses have been received of the tetanus/diphtheria vaccine | True, False |

1. Vaccine coverage 2010-2018

From 2010 onwards, vaccines are allocated to individuals using data from the Annual Report on Immunisation Performance compiled by the Ministry of Health, Malawi for the WHO/UNICEF (WHO/UNICEF Joint Reporting Form on Immunization). These data list the vaccine schedules for every year, with estimates of vaccine coverage by district.

In the simulation, all childhood vaccines are scheduled at birth through the on\_birth function. In this function, the probability of receiving each vaccine is derived from the coverage estimate for that vaccine by district of residence and scheduled to occur at the appropriate time.

As the vaccine schedule (and vaccine type) changes over time, individual events are set up for every vaccine that has been used since 2010, e.g. DTP pre-2013 and DTP\_HepB\_Hib from 2013 onwards. The vaccine bundles (e.g. DTP\_HepB\_Hib, OPV, PCV and Rotavirus delivered at weeks 6 and 10) are delivered under separate events because the probability of a vaccine being administered varied dependent on the available stock.

Many reported vaccine coverage estimates are above 100% due to issues in calculating the denominator (number of eligible children) or the vaccines are given to children outside the eligible age range. In these cases, we assume that coverage is 100%.

Vaccines administered in this time-period are not subject to constraints in the health system (either consumables or health officers) as coverage is known. As they are simulated through individual events and not health system events, consumables are not tracked and the “appointments” required to deliver the vaccines are not logged.

Table . Schedule of vaccines administered through the Expanded Programme on Immunisation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Vaccine type | 1st dose | 2nd dose | 3rd dose | 4th dose |
| Bacille Calmette-Guerin vaccine | Birth |  |  |  |
| Oral polio vaccine or Inactivated polio vaccine | Birth | W6 | W10 | W14 |
| Diphtheria and tetanus toxoid with pertussis, Hib and HepB vaccine | W6 | W10 | W14 |  |
| Pneumococcal conjugate vaccine | W6 | W10 | W14 |  |
| Rotavirus vaccine | W6 | W10 |  |  |
| Measles and rubella vaccine | M9 | M15 |  |  |
| Tetanus and diphtheria toxoid for pregnant women | First ANC visit | Second ANC visit |  |  |

Example, W6 = week 6 of life, M9 = month 9. ANC = antenatal care.

1. Vaccine coverage 2019-onwards

From 2019, vaccine delivery is scheduled through the health system module and is therefore subject to any constraints imposed on consumables or health officer time. These appointments occur at facility level 1a and have a unique appointment footprint (“EPI”) which uses 0.06 minutes of Clinical Officer time, 4 minutes of Nurse time and 1.68 minutes of Pharmacy time on average. All infants are scheduled to receive the full programme of vaccinations on birth and their likelihood of receiving each vaccine depends on the stock availability in that district at the scheduled time. If doses of vaccine are not available, the dose is missed.

The RTS,S vaccine for malaria has been available at a sub-national level since 2017 in the highest-risk malaria districts. To date, we don’t yet have the coverage estimates for the RTS,S vaccine or the effectiveness against clinical disease and so do not include this in the EPI module. Once this data become available, this vaccine will also be administered to eligible children through this module.

Model outputs – pop size 10,000

Chart, line chart

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