An Roinn Caiteachais Phoiblí agus Athchóirithe
Department of Public Expenditure and Reform

Prevention & Early Intervention Series, Focussed Policy Assessment No.1

Immunisation

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Under *A Programme for a Partnership Government*, the Department of Public Expenditure & Reform has established a Prevention and Early Intervention Unit (PEIU). The focus of the PEIU's work is on prevention and early interventions that can improve the life outcomes of children as well as the quality of life of older people dealing within long term conditions such as chronic illness; which the PEIU is locating within the context of population health.

These types of interventions have a strong common-sense appeal; most people are familiar with the idiom that "prevention is better than cure". However, effective prevention and early interventions rely on both knowing what to do (scientific understanding of cause and effect) and being in a position to act (the capacity of the government to intervene).

The PEIU is undertaking a series of Focussed Policy Assessments on key prevention and early interventions supported by public resources. The approach is to describe each intervention by following a common structure:

- Rationale for the intervention;
- Public resources provided to support the delivery of the intervention;
- Outputs and services provided; and
- Achievements of the intervention relative to its stated goal.

As a whole, this series of descriptive reports will provide the evidential base for a thematic consideration of prevention and early interventions in Ireland.

Introduction[1]

In Ireland, routine childhood vaccinations are designed to reduce the incidence of vaccine-preventable disease in children and babies and produce herd immunity. The HSE aims to reach the entirety of each birth cohort as early as possible by providing vaccination on a universal basis in childhood through the *Primary Childhood Immunisation Programme*. This programme comprises vaccinations delivered in general practice in the first years of life with the schedule of vaccines dependent on the child's date of birth. The HSE's goal is to achieve at least 95% cover for all vaccine preventable diseases in the childhood schedule.

In Ireland vaccinations are also delivered through the *School Immunisation Programme*. This programme provides vaccinations to children aged 4-5 years (as the commence primary school) and to those aged 12-13 years (as to commence second level education). The vaccinations delivered through this programme are primarily boosters to the vaccinations provided in the *Primary Childhood Immunisation Programme*. An exception to this is the Human Papillomavirus vaccine (HPV) which is offered to female students in their first years of second level school to protect them against Human Papillomavirus and cervical cancer.

The purpose of this report is to describe the immunisation programmes in terms of rationale, public resources provided, services delivered and results achieved. This is one of a series of descriptive reports that taken together will inform a thematic consideration of prevention and early interventions in Ireland.

Box 1 – Vaccine Preventable Diseases under the Primary Childhood Immunisation Programme and the School Immunisation Programme

Tuberculosis
The Bacillus Calmette–Guérin (BCG) vaccine protects against tuberculosis and is usually offered at birth. However, in Europe there are delays accessing supply of the BCG vaccine and, in Ireland, all stocks expired at the end of April 2015. The Health Service Executive reports that the *National Immunisation Advisory Committee* and the *Health Information and Quality Authority* have both recommended that the BCG vaccine does not now need to be give routinely to all babies in Ireland.

Diphtheria, Tetanus, Pertussis, Haemophilus influenza B, Polio and Hepatitis B
The vaccines for these diseases are offered to infants as part of the 6-in-1 at:

- 2 months of age;
- 4 months of age; and
- 6 months of age.

When young children are 13 months of age they are offered a booster dose of the Haemophilus influenza B (Hib) vaccine.

When children enter primary school (aged 4-5 years) they are offered the 4-in-1 booster to protect against Diphtheria, Tetanus, Pertussis and Polio.

Students in their first years of second level school are offered the TDaP booster vaccine for Tetanus, Diphtheria and Pertussis.

[1] The authors are grateful to their colleagues in the Department of Public Expenditure & Reform for providing comments and colleagues in the Health Protection Surveillance Centre for providing up-to-date data.

Streptococcus pneumoniae
The Pneumococcal Conjugate Vaccine (PCV) protects against Streptococcus pneumoniae and is offered to infants at:

- 2 months of age;
- 6 months of age; and
- 13 months of age.

Meningococcal C
The Meningococcal C vaccine is offered to infants at:

- 6 months; and
- 13 months.

Students in their first years of second level school are offered a booster dose of the Meningococcal C vaccine to protect teenagers up to and including early adulthood.

Meningococcal B
The purpose of the Meningococcal B vaccine is to prevent bacterial infection which can cause Meningitis B and is offered to infants at:

- 2 months;
- 4 months and
- a booster dose is offered at 12 months.

Measles, Mumps and Rubella
The MMR vaccine protects against Measles, Mumps and Rubella and is offered to infants at 12 months of age.

When children enter primary school they are offered a second dose of the MMR vaccine.

Rotavirus[2]
The Rotavirus vaccine protects against the rotavirus which is the most common cause of acute gastroenteritis in Irish paediatric patients and is offered to infants at:

- 2 months; and
- 4 months.

Human Papillomavirus[3]
Female students in their first years of second level school are offered the Human Papillomavirus vaccine (HPV) to protect them against cervical cancer. This is provided in two doses at least six months apart. Females aged 15 years or older at their first dose are administered three doses.

[2] In 2010, the National Centre for Pharmacoeconomics completed the evaluation of the cost-effectiveness of a universal rotavirus vaccination programme in Ireland, on behalf of the National Immunisation Advisory Committee (NIAC). http://www.ncpe.ie/wp-content/uploads/2012/03/Rotavirus-Vaccine-summary.pdf

[3] In 2008, the National Centre for Pharmacoeconomics completed a Health Technology Assessment of the human papillomavirus (HPV) vaccine in Ireland, on behalf of the Health Information and Quality Authority (HIQA). https://www.hiqa.ie/reports-and-publications/health-technology-assessments/hta-hpv-vaccination-girls

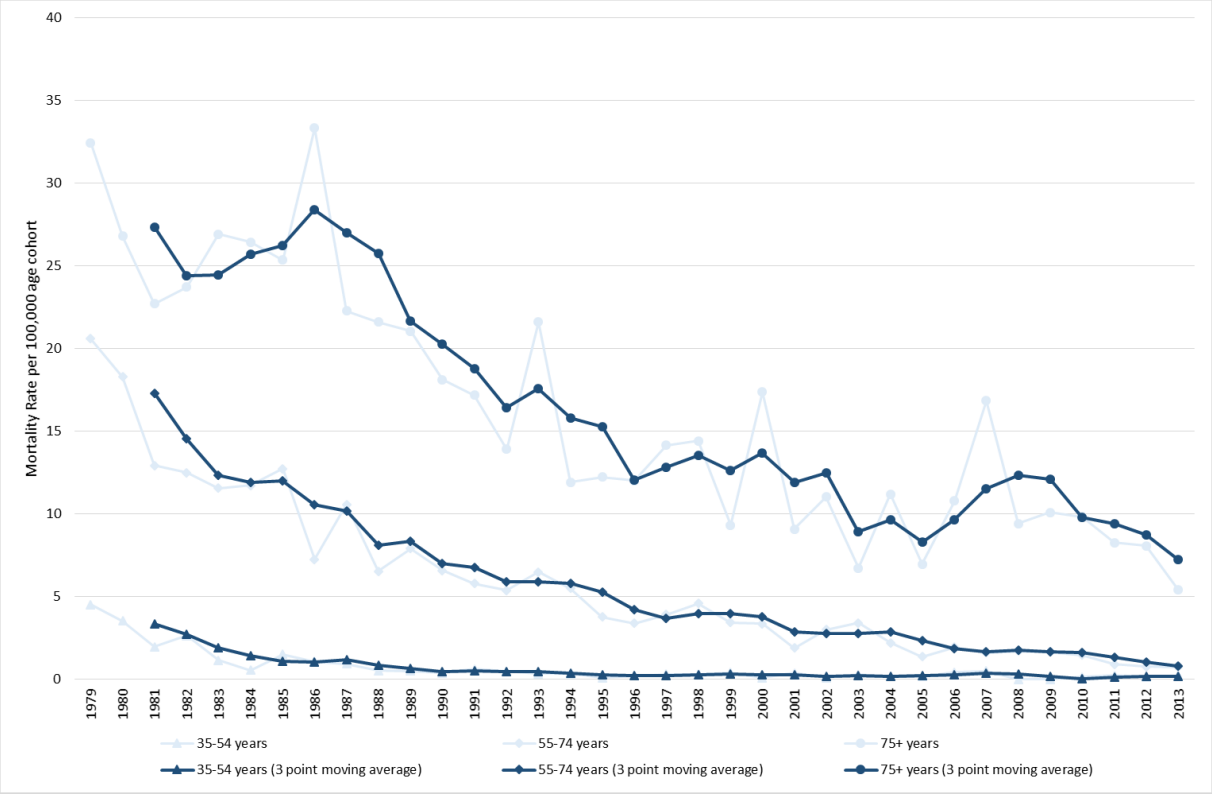
Rationale

In Ireland, the purpose of the immunisation schedule is to produce immunity to potentially life threatening or life limiting diseases and their associated complications.

Tuberculosis

Tuberculosis (TB) is a disease that is caused by a bacterium called Mycobacterium tuberculosis (Mtb). It is transmitted by people infected with pulmonary (lung) TB who release Mycobacterium tuberculosis into the air through coughing, sneezing or spitting. The World Health Organization estimates that in 2013 there were 9 million new cases of TB and 1.5 million deaths. Over 90% of TB cases occur in low and middle income countries that have fragile healthcare infrastructures and constrained resources available. The TB epidemic continues in spite of an available, cost-effective and broadly implemented vaccine for infants – Bacille Calmette-Guerin (BCG). The World Health Organization recommends the vaccination of neonates with BCG, due to its protective effect in infants and young children.[4]

Figure 1 – Mortality Rates associated with Tuberculosis amongst Adults in Ireland, 1979-2013



Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

In Ireland, the BCG vaccine was introduced in 1937. In the years 1979-2017, tuberculosis has been associated with almost 2,360 deaths. The distribution of the number of mortalities associated with tuberculosis is such that 68% occurred between 1979 and 1995. When account is taken of the number of people in each cohort, the average mortality rate associated

[4] See http://www.who.int/immunization/diseases/tuberculosis/en/

with tuberculosis is much higher amongst those aged 75 years and older (16.3 per 100,000 between 1979 and 2013) than it is for any of the other age cohorts (5.9 per 100,000 for those aged 55-74 years and 0.7 per 100,000 for those aged 35-54 years). Amongst the oldest age cohort, the average mortality rate is decreasing in that it was 27.2 per 100,000 in the period 1979-1986 and 13 per 100,000 in the period 1987-2013.[5] (See Figure 1.)

Diphtheria

Diphtheria is an infectious disease caused by the bacterium *Corynebacterium diphtheria*. Diphtheria can cause a thick coating in the nose, throat or airway that can lead to severe breathing problems, heart failure or paralysis. The World Health Organizations reports that vaccination against diphtheria has reduced the mortality and morbidity of diphtheria dramatically. It recommends a 3-dose primary vaccination series followed by a booster dose.[6]

In Ireland, a vaccine against Diphtheria was introduced in the 1930s as part of the 2-in-1 vaccine. In 1948 there were about 500 cases of this disease and some 30 deaths were associated with it. While single cases of diphtheria have been reported in each of 2015 and 2016, for the three decades prior to that there were no notifications. In Ireland, the last death associated with diphtheria occurred in 1967.

Tetanus

Tetanus is a disease that can cause painful muscle spasms, convulsions and difficulty in breathing. It is a non-communicable disease contracted through exposure to the spores of the bacterium, *Clostridium tetani*, that exist in soil and in animal intestinal tracts. As a consequence it can contaminate many surfaces and substances and the ubiquity of the bacterium means that the disease cannot be eradicated. However, tetanus can be prevented through immunisation and the World Health Organization recommends that an individual receives 3 primary doses and 3 booster doses through routine immunisation.[7]

In Ireland, a vaccine against Tetanus was introduced in the 1930s as part of the 2-in-1 vaccine. Tetanus can potentially be fatal. Since 1979, there have been seven deaths associated with tetanus, the most recent occurring in 1989.

Pertussis

Pertussis is a highly contagious disease of the respiratory tract caused by *Bordetella pertussis*, a bacteria that lives in the mouth, nose and throat. The disease spreads easily from person to person, mainly through droplets produced by coughing or sneezing. Pertussis can cause an irritating cough that gradually gets worse and can lead to severe breathing difficulties, pneumonia, fits and brain damage. The disease is most dangerous in infants. The main aim of pertussis vaccination is to reduce the risk of severe pertussis in infancy and the World Health Organization recommends a 3-dose primary series.[8]

In Ireland, a vaccine against Pertussis was introduced in 1952 as part of the 3-in-1 vaccine. In 1950 there were about 5,000 cases of “whooping cough”. In the years between 2010 and

[5] This and subsequent references to mortality by age cohort are based on data published to 2013 on the number of deaths associated with specified morbidity from the WHO Mortality Database. (http://apps.who.int/healthinfo/statistics/mortality/whodpms/)
[6] See http://www.who.int/immunization/diseases/diphtheria/en/
[7] See http://www.who.int/immunization/diseases/tetanus/en/
[8] See http://www.who.int/immunization/diseases/pertussis/en/ and http://www.who.int/wer/2015/wer9035.pdf?ua=1

2017 there were just over 1,640 notified cases of pertussis. Since 1979 pertussis has been associated with 16 deaths in Ireland.

Polio

Polio (poliomyelitis) is a highly infectious viral disease. The poliovirus invades the nervous system. It can cause irreversible paralysis in a matter of hours and there is no cure for polio; only treatment to alleviate the symptoms. Polio can be prevented through immunisation. High levels of vaccination coverage must be maintained to stop transmission and prevent outbreaks occurring. The World Health Organization recommends that all countries using Oral Polio Vaccine (OPV) in the national immunisation programme, should include at least one dose of Inactivated Polio (IPV) in the vaccination schedule.[9]

In Ireland, an Oral Polio Vaccine (OPV) was introduced in 1957 and, in 2001, an Inactivated Polio vaccine (IPV) was added to the immunisation schedule. In 1950 there were about 500 cases of polio. The most recent notified case of polio in Ireland was in 1984.

Rubella

Rubella is a contagious, usually mild, viral disease that can cause rash, fever and swollen glands. However, a Rubella infection just before conception and in early pregnancy may result in miscarriage, foetal death or congenital defects known as congenital rubella syndrome (CRS). Rubella vaccines are available either in monovalent formulation or in combinations with other vaccine viruses, such as with vaccines against measles and mumps (MMR). The World Health Organization recommends that all countries that have not yet introduced rubella vaccine, and are providing two doses of measles vaccine using routine immunisation and/or supplementary immunisation activities should consider the inclusion of a Rubella-containing vaccine in their immunisation programme (e.g. MMR vaccine).[10]

In Ireland, a vaccine against Rubella was introduced in 1971. In 1988, a Measles, Mumps and Rubella vaccine was added to the immunisation schedule. In 1950 there were about 5,000 cases of rubella. In the years between 2010 and 2017 there were 42 notified cases of rubella.

Measles

Measles is an acute, serious infection that causes a rash illness, with cough, runny nose, conjunctivitis and high fever. The disease is very infectious and complications are common and, in a small number of cases, can lead to viral and bacterial lung infections (pneumonia) and inflammation of the brain (acute encephalitis). The World Health Organization notes that it remains an important cause of death among young children globally, despite the availability of a safe and effective vaccine. The measles vaccine has been in use since the 1960s. The World Health Organization recommends the standard for all national immunisation programmes should be two doses of measles vaccine, either alone or in combination, such as measles-mumps-rubella (MMR).[11]

In Ireland, a measles vaccine was introduced in 1985. In 1988, a Measles, Mumps and Rubella vaccine was added to the immunisation schedule. In 1950 there were about 15,000

[9] See http://www.who.int/immunization/diseases/poliomyelitis/en/ and http://www.who.int/wer/2016/wer9112.pdf?ua=1
[10] See http://www.who.int/immunization/diseases/rubella/en/
[11] See http://www.who.int/immunization/diseases/measles/en/

cases of measles. In the years between 2010 and 2017 there have been almost 930 notified cases of measles. Since 1979 measles has been associated with 42 deaths in Ireland.

Mumps

Mumps is a contagious virus that can cause swollen neck glands (it primarily affects the salivary glands) and fever that in a small number of cases can lead to viral meningitis and encephalitis. The World Health Organization notes that safe and effective vaccines against mumps have been available since the 1960s. It recommends integrating strategies to control mumps with existing high priority goals of measles and rubella control or elimination and strongly encourages the use of combined MMR vaccine.[12]

In Ireland, a vaccine against mumps was included as part of the Measles, Mumps & Rubella vaccine introduced in 1988. Since the introduction of the vaccine there have been almost 13,660 notified cases of mumps in Ireland. About 85% of these have been reported since 2000.

Haemophilus influenza type b, Streptococcus Pneumoniae and Meningococcus

Haemophilus influenza type b (Hib) is a bacteria responsible for severe pneumonia, meningitis and other invasive diseases almost exclusively in children aged less than 5 years. The World Health Organization notes that vaccines are the only public health tool capable of preventing the majority of serious Hib disease. The World Health Organization recommends that Hib conjugate vaccines are included in all routine infant immunisation programmes.[13]

In Ireland, a vaccine against Haemophilus influenza type b (Hib) was introduced in 1992. Between 1987 and 2017 there have over 750 notified cases of Hib and of these 70% were reported between 1987 and 1992.

Streptococcus pneumoniae is a bacterium that is the cause of a number of common diseases, ranging from serious diseases such as meningitis, septicaemia and pneumonia to milder but commoner infections such as sinusitis and otitis media (an ear infection). The World Health Organization notes that pneumococcal diseases are a common cause of morbidity and mortality worldwide (though rates of disease and death are higher in developing countries than in industrialized countries) and are more common at the extremes of age (i.e, in young children and among the elderly). The World Health Organization recommends the inclusion of pneumococcal conjugate vaccines in childhood immunisation programmes worldwide.[14] It also reports that in those countries that routinely use of pneumococcal conjugate vaccines there has been a dramatic reduction in the incidence of serious diseases due to the organism with virtual disappearance of disease due to serotypes of the organism in the vaccines used.[15]

In Ireland, a pneumococcal conjugate vaccine, PCV7, was first introduced to the immunisation schedule in 2008, and a second such vaccine, PCV13, was introduced in 2010.

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[12] See http://www.who.int/immunization/diseases/mumps/en/
[13] See http://www.who.int/immunization/diseases/hib/en/
[14] While there are over 90 serotypes, only a small minority cause most disease and the available pneumococcal conjugate vaccines (PCV) target the most prevalent of these serotypes.
[15] See http://www.who.int/immunization/diseases/pneumococcal/en/

Neisseria meningitides (meningococcus) is a leading cause of bacterial meningitis and septicaemia. The World Health Organization notes that invasive meningococcal disease has a very high fatality rate (>50% if untreated). There are several polysaccharide and conjugate vaccines available for protection from the most common serogroups of meningococcal disease[16]. The World Health Organization recommends that countries with high (>10 cases per 100,000 population/year) or intermediate (2-10 cases per 100,000 population/year) endemic rates and/or frequent epidemics of invasive meningococcal disease conduct appropriate large scale meningococcal vaccination programmes.[17]

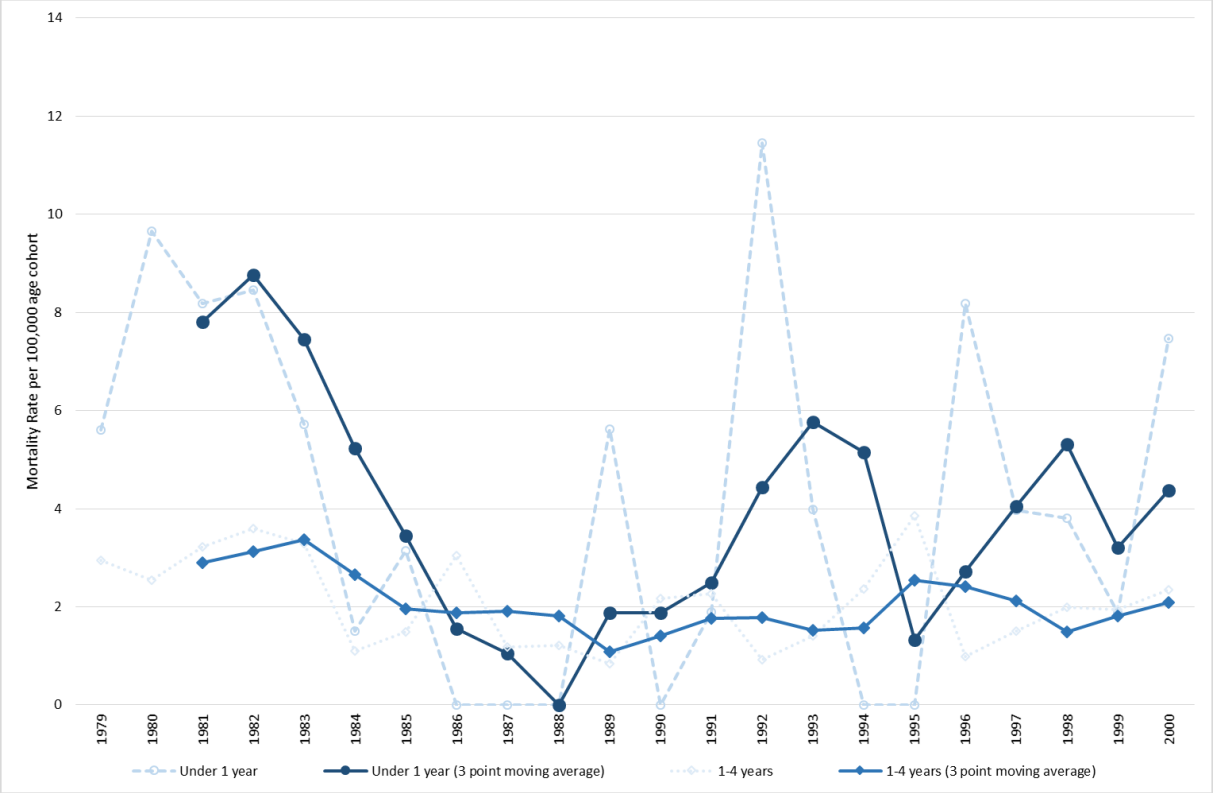
In Ireland, a vaccine against Meningococcal C was introduced to the immunisation schedule in 2000 and a vaccine against Meningococcal B was introduced in 2016.[18] Between 1999 and 2017 there were almost 430 notified cases of Meningococcal C with about 64% of these reported in the years 1999 and 2000.

As such then, *Haemophilus influenza type b*, *streptococcus pneumoniae*[19] and meningococcal diseases can lead to a range of very serious and potentially fatal complications such as meningitis (inflammation of the lining around the brain and spinal cord) and septicaemia (blood poisoning). In Ireland, meningococcal disease has been associated with almost 410 deaths between 1979 and 2017. Of those deaths that occurred between 1979 and 2013, more than half (55%) have been amongst infants (young than 1 year) and young children (aged 4 years or younger).[20]

Figure 2 sets out the mortality rates for both of these cohorts prior to the introduction of the Meningococcal C vaccine in 2000. For the period 1979-2000, the mean mortality rate amongst infants was 4.11 per 100,000 while among young children it was 2.1 per 100,000. It is clear from Figure 2 that there is much greater volatility in the mortality rates amongst infants than was the case amongst young children. In the latter's case, the average mortality rate was 3.12 per 100,000 for the years 1979-1983 before decreasing to 1.66 per 100,000 in 1984-1991 and then increasing slightly to 1.92 per 100,000 in 1992-2000. Within the infant cohort there was much greater variation as the average mortality rate was 7.52 per 100,000 for the years 1979-1983 before decreasing to 1.52 per 100,000 in 1984-1991 (below that for the young children) and then increasing to 4.52 per 100,000 in 1992-2000.

[16] Of the 12 serogroups identified, A, B, C, X, W, and Y are responsible for the majority of disease, but serogroup distribution varies by location and time.
[17] See http://www.who.int/immunization/diseases/meningitis/en/
[18] Since October 2016, the Meningococcal B Vaccination has been offered to babies at two months and four months with a booster dose at 12 months. The purpose of this vaccine is to prevent bacterial infection which can cause Meningitis B.
[19] In 2007, the National Centre for Pharmacoeconomics evaluated the cost-effectiveness of a universal pneumococcal conjugate vaccination programme in Ireland. http://www.ncpe.ie/wp-content/uploads/2012/03/Pneumococcal-Conjugate-Vaccine-summary.pdf
[20] Children aged 5-14 years account for 15% of deaths due to meningococcal disease while those aged 15-24 years account for a further 16%.

Figure 2 – Mortality Rates associated with Meningococcal Infection amongst Infants and Young Children in Ireland, 1979-2000



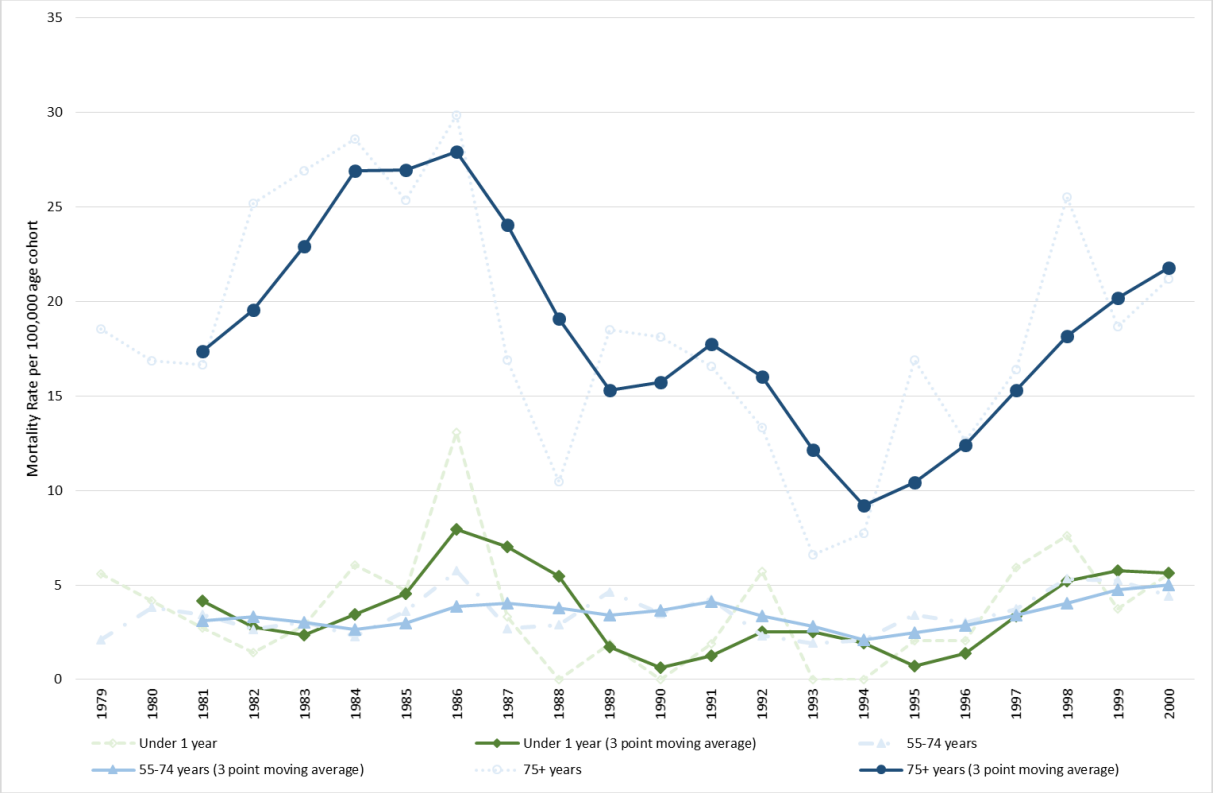
Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Septicaemia is a type of blood poisoning and, since 1979, has been associated with over 2,075 deaths in Ireland. The very young and very old are more especially at risk than other segments of the population. While septicaemia can be caused by a variety of infections and bacteria (e.g. pneumonia, urinary tract infections, kidney infections), it can also be caused by the same bacteria that cause the most common form of bacterial meningitis. Of those deaths associated with Septicaemia, the oldest age cohort (75 years and older) accounts for 61% of deaths with those aged 55-74 years accounting for 29% of deaths; less than 3% of deaths are accounted for by infants.

Figure 3 sets out the mortality rates for infant and older adult cohorts prior to the introduction of the Meningococcal C vaccine in 2000. When the number of people in each cohort is taken into account, the mortality rate for septicaemia amongst the oldest age cohort was 18.5 per 100,000. This is notable greater than the average mortality rates of 3.5 per 100,000 amongst those aged 55-74 years and 3.7 per 100,000 amongst infants.

From Figure 3 it is evident that mortality rates amongst the oldest and youngest age cohorts have followed a broadly similar trend. For the oldest cohort, the average mortality rate was 22.8 per 100,000 for the years 1979-1987 before decreasing to 13.7 per 100,000 in 1988-1997 and then increasing to 21.8 per 100,000 in 1998-2000. Similarly, in the infant cohort the average mortality rate was 4.9 per 100,000 for the years 1979-1987 before decreasing to 1.9 per 100,000 in 1988-1997 and then increasing to 5.6 per 100,000 in 1998-2000. In the other adult cohort, the average mortality rates were more or less unchanged between 1979 and 1997 (3.3 per 100,000 and 3.2 per 100,000) but began to increase in the years 1998-2000 (5 per 100,000).

Figure 3 – Mortality Rates associated with Septicaemia amongst Infants and Older Adults in Ireland, 1979-2000



Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Hepatitis B

Hepatitis B is a viral infection that affects the liver and can cause lifelong infection and lead to cirrhosis, cancer or liver failure.[21] The World Health Organization notes that it is a major global health problem, and the most serious type of viral hepatitis. The virus is highly contagious. It is transmitted through contact with the blood or other body fluids of an infected person and can survive outside the body for at least 7 days (an important occupational hazard for health workers). The World Health Organization recommends that all infants should receive their first dose of Hepatitis B vaccine as soon as possible after birth and that the birth dose should be followed by 2 or 3 doses to complete the primary series.[22]

In Ireland, a vaccine against Hepatitis B was included as part of the 6-in-1 in 2008. Between 1979 and 2013, viral hepatitis has been associated with almost 390 deaths. Of these deaths, almost half occurred amongst those aged 35-54 years, just over a quarter amongst those aged 55-74 years and just over one-tenth amongst those aged 75 years or older.

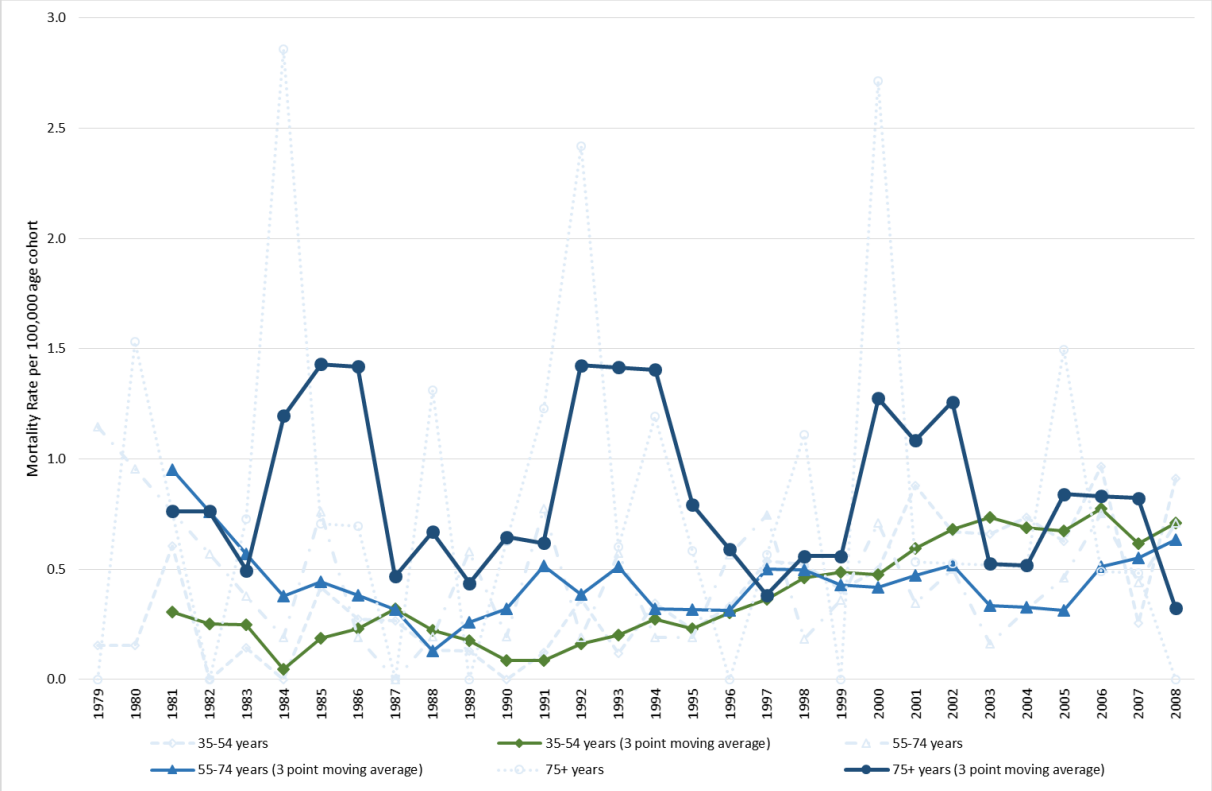
Figure 4 presents the mortality rates amongst adults that are associated with viral hepatitis prior to the inclusion of the Hepatitis B vaccine in the 6-in-1 vaccine in 2008. While the oldest age cohort has an average mortality rate of 0.81 per 100,000, there is a lot of variation from

[21] In 2006, the National Centre for Pharmacoeconomics conducted an economic evaluation of the cost-effectiveness of a universal hepatitis B vaccination programme, for the Health Protection Surveillance Centre/National Immunisation Advisory Committee. http://www.ncpe.ie/wp-content/uploads/2012/03/Universal-Infant-Hepatitis-B-Vaccine-Programme-summary.pdf

[22] See http://www.who.int/immunization/diseases/hepatitisB/en/

year-to-year. By contrast, within the other two cohorts there is less variation around the average mortality rates of 0.47 per 100,000 people aged 55-74 years and 0.38 per 100,000 people aged 35-54 years. However, it is worth noting that the mortality rate amongst the younger of these cohorts would appear to be increasing as the average for the period 1979-1996 was 0.21 per 100,000 and for 1997-2008 it was 0.64 per 100,000.

Figure 4 – Mortality Rates associated with Viral Hepatitis amongst Adults in Ireland, 1979-2008



Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Human Papillomavirus

Infection with Human Papillomavirus (HPV) is the main cause of cervical cancer. The World Health Organization notes that virtually all cervical cancer cases (99%) are linked to genital infection with HPV and it is the most common viral infection of the reproductive tract. The World Health Organization also notes that the available vaccines are highly efficacious in preventing infection with virus types 16 and 18, which are together responsible for approximately 70% of cervical cancer cases globally. The vaccines are also highly efficacious in preventing precancerous cervical lesions caused by these virus types. The World Health Organization recommends that HPV vaccines should be included in national immunisation programmes.[23]

In Ireland, a vaccine against HPV was included as part of the immunisation schedule 2010.[24] The average incidence of cervical cancer in Ireland is 11.5 per 100,000 for 1994-2014. The

[23] See http://www.who.int/immunization/diseases/hpv/en/ and http://apps.who.int/iris/bitstream/10665/255353/1/WER9219.pdf?ua=1

[24] In 2008, the National Centre for Pharmacoeconomics completed a Health Technology Assessment of the human papillomavirus (HPV) vaccine in Ireland, on behalf of the Health Information and Quality

net five year age standardised survival rate suggests an improving trend (from 56.4% in 1994-1998 to 62.3% in 2010-2014).[25] The mortality rate associated with malignant neoplasm of cervix uteri has an average of 3.8 per 100,000 (1979-2014).[26]

Rotavirus

The Rotavirus is the most common cause of acute gastroenteritis in Irish paediatric patients. While it rarely results in severe complications or deaths in previously healthy infants, it can cause a significant disease burden on health services and caregivers.[27] The availability of a vaccine presents an opportunity to reduce the burden of illness associated with the Rotavirus infection (i.e., reduced hospitalisations, A&E attendances and GP visits). In 2009, the World Health Organization (WHO) announced a global recommendation that Rotavirus vaccines be included in national immunisation programmes.[28]

Since 2016, the Rotavirus vaccination was included in the Primary Childhood Immunisation Programme on the grounds of its wider social impact and favourable tender price.[29]

Influenza and Pneumonia

Influenza is an acute contagious respiratory illness caused by infection with an influenza virus. While influenza can occur throughout the year, it usually peaks in winter and can affect people of all ages but it can have more severe consequences in older people or people defined as being at high risk for influenza (e.g. people who suffer from chronic diseases, obesity or diabetes, those with weakened immune systems and pregnant women). While it can cause mild to severe illness, at times it can lead to death. The World Health Organization notes that immunisation is the best intervention to prevent influenza virus infection. An influenza vaccine is made available each year. However, influenza viruses evolve constantly, and twice a year the World Health Organization (WHO) makes recommendations to update the vaccine compositions. The effectiveness of the vaccine varies from year-to-year and depends on whether or not the strains of influenza that are circulating in the population are those the WHO estimated to be the strains that would most likely to be circulating in a given year.[30]

Pneumonia is an infection that causes the alveoli in lungs to become inflamed and filled with fluid. Pneumonia is usually caused by bacteria including those that lead to pertussis, streptococcus pneumoniae and haemophilus influenza type b. People who are very young or very old as well as those with another serious health condition, are more likely to require hospital treatment if they develop pneumonia.

Authority (HIQA). https://www.hiqa.ie/reports-and-publications/health-technology-assessments/hta-hpv-vaccination-girls

[25] Data published by the National Cancer Registry Ireland. https://www.ncri.ie/data *Accessed*: 2 October 2018.

[26] Calculation based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

[27] According to World Health Organization estimates, in 2013, about 215,000 children aged younger than 5 years die each year from vaccine-preventable rotavirus infections; the vast majority of these children live in low-income countries.

[28] See http://www.who.int/immunization/diseases/rotavirus/en/

[29] In 2010, the National Centre for Pharmacoeconomics completed the evaluation of the cost-effectiveness of a universal rotavirus vaccination programme in Ireland, on behalf of the National Immunisation Advisory Committee (NIAC). http://www.ncpe.ie/wp-content/uploads/2012/03/Rotavirus-Vaccine-summary.pdf

[30] See http://www.who.int/immunization/diseases/influenza/en/

Between 1979 and 2013, there have been almost 920 deaths associated with influenza and pneumonia has been associated with almost 66,860 deaths. People in the oldest age cohort account for about 80% of deaths from both of these diseases with those in the 55-74 years of age cohort accounting for 16% of deaths. When account is taken of the number of people in each cohort, the average mortality rate associated with pneumonia is much higher amongst those aged 75 years and older (909.9 per 100,000) than it is for any of the other age cohorts: 56.5 per 100,000 for those aged 55-74 years and 10.4 per 100,000 infants.

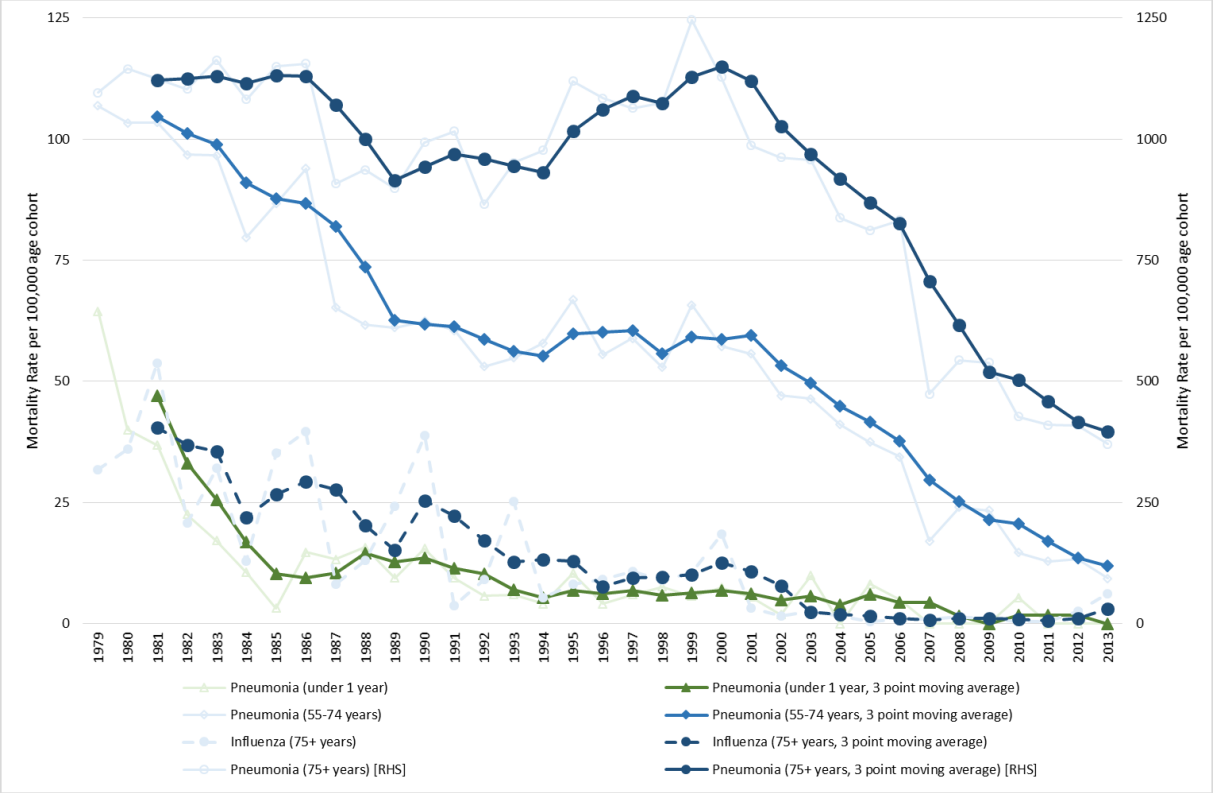
From Figure 5 it is evident that there are a number of notable trends in mortality rates associated with pneumonia. Within the oldest cohort, between 1979 and 2001 the average mortality rate was 1,055.3 per 100,000. (Note the scale for this metric is on the right hand side of Figure 5.) Since then there has been a notable decrease in mortality rates and for the period 2002-2013 the average mortality rate has been 631.2 per 100,000.

Amongst the 54-74 years age cohort the trend has had three basic phases. The first of these from 1979-1989 is associated with decreasing mortality rates during which time the average mortality rate was 86.9 per 100,000. The second phase, 1990-2001, is associated with a levelling off of the mortality rate around an annual average of 58.5 per 100,000. Since the start of the new millennium, the mortality rate has once again started to decrease and has averaged 26.7 per 100,000.

Similarly, there are three basic phases to the mortality rate from pneumonia amongst infants. The first of these from 1979-1984 is associated with decreasing mortality rates during which time the average mortality rate was 31.9 per 100,000. The second phase, 1985-1994, is associated with a levelling off of the mortality rate around an annual average of 9.7 per 100,000. Since then the mortality rate has decreased slowly and has averaged 4.0 per 100,000.

The average mortality rate for influenza for those aged 75 years and older is 13.7 per 100,000 and for all other cohorts it is less than 0.85 per 100,000. For the older age cohort the trend also has three basic phases. The first of these from 1979-1996 is associated with an overall decrease in mortality rates but with notable year-on-year variation around an overall average of 22.6 per 100,000. The second phase, 1997-2003, is associated with less annual variation and a levelling off of the mortality rate around an annual average of 8 per 100,000. Since then the mortality rate trend has exhibited a gradual decrease and has averaged 1.6 per 100,000.

Figure 5 – Mortality Rates associated with Influenza and Pneumonia amongst Infants and Older Adults, 1979-2013



Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Resources

The Department of Health has not yet provided details of expenditure on this programme.

When such details are provided this paper will be updated.

Outputs and Services

In Ireland, routine childhood vaccinations are designed to reduce the incidence of vaccine-preventable disease in children and babies and produce herd immunity. The HSE aims to reach the entirety of each birth cohort as early as possible by providing vaccination on a universal basis in childhood through the *Primary Childhood Immunisation Programme*. This programme comprises vaccinations delivered in general practice in the first years of life with the schedule of vaccines dependent on the child's date of birth. The HSE's goal is to achieve at least 95% cover for all vaccine preventable diseases in the childhood schedule. (As immunisation uptake is one of these programmes' goals it is considered in the next section.)

In Ireland vaccinations are also delivered through the *School Immunisation Programme*. The vaccinations delivered through this programme are primarily boosters to the vaccinations provided in the *Primary Childhood Immunisation Programme*. This programme provides vaccinations to children aged 4-5 years (as they commence primary school) and to those aged 12-13 years (as they commence second level education). An exception to this is the provision of the HPV vaccine to females as they commence second level education.

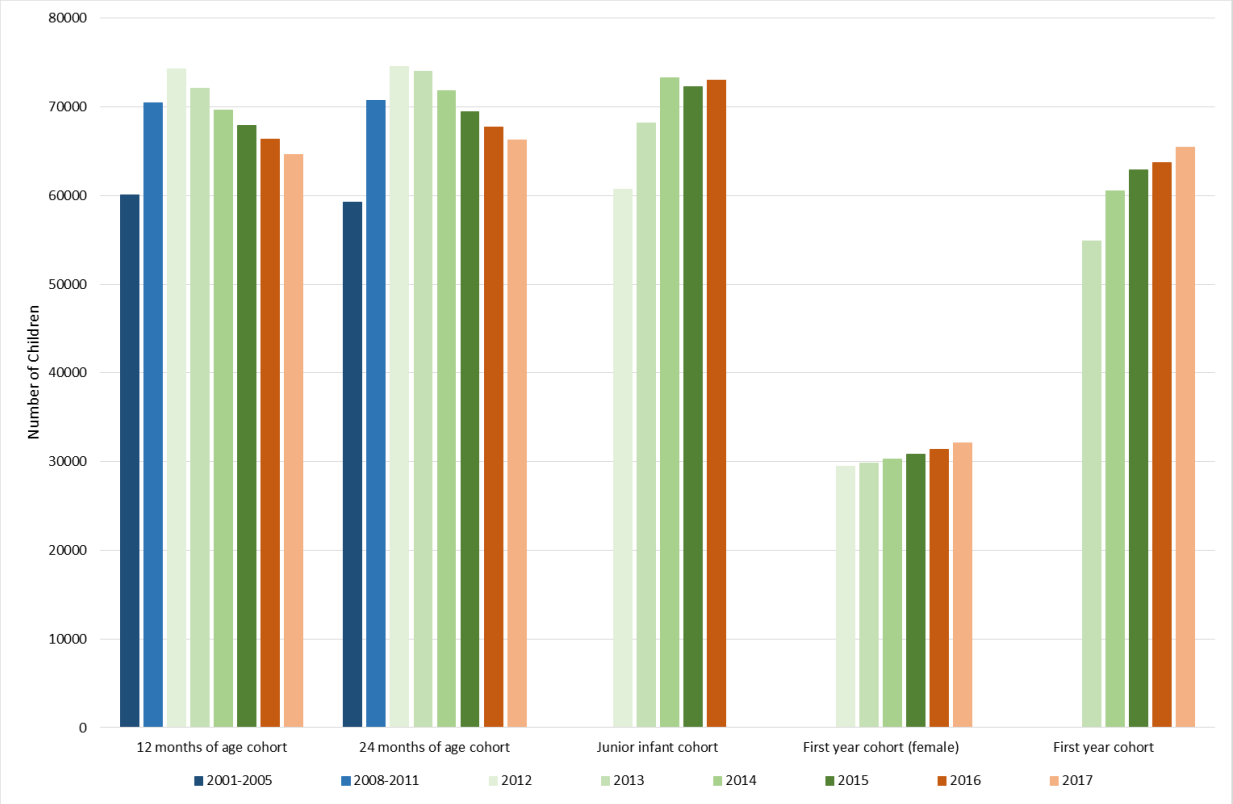
Figure 6 presents estimates of the number of children in each cohort. This provides some measure of the volume of service that the various elements of the health service are required to provide as part of the immunisation programmes.

Over the last decade and a half, the number of infants and young children who were within the scope of the *Primary Childhood Immunisation Programme* has increased but these numbers peaked at around 74,500 in 2012 and have since decreased to about 65,000 in 2017.

Under the *School Immunisation Programme*, the number of junior infants has also increased from around 60,000 in 2012 to about 73,000 in more recent years.

There has also been a notable increase in the number of older children who come within the scope of the *School Immunisation Programme*. The number of females in first year of second level who could avail of the HPV vaccine has increased from 29,500 in 2012 to about 32,000 in 2017. The number of all pupils at this stage of their education who could avail of the vaccines under this programme has increased from just less than 55,000 to almost 65,500.

Figure 6 – Number of Children in Key Immunisation Schedule Cohorts



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. The HPSC notes that cohort sizes vary slightly by vaccine. For ease of presentation an average figure has been presented where appropriate. Data for 2016 and 2017 provided directly by the Health Protection Surveillance Centre.

Influenza vaccination

The Health Service Executive encourages those in at risk groups to be vaccinated against seasonal influenza.[31]

The influenza vaccine is made available through general practitioners and the HSE provides the vaccine free of charge for all those in the at-risk groups. However, those who do not have either a Medical Card or a GP Visit Card will be charged a consultation fee by their doctor.

In addition to providing vaccination to high risk groups, it is also important to offer it to those who work in health care settings. (The levels of uptake amongst this cohort are examined in the next section.) Influenza infection can spread rapidly in health care settings. To address this problem, the HSE offers the influenza vaccine to health care workers. In a note to healthcare workers, the HSE National Immunisation Office[32] notes that:

- Healthcare workers are at increased risk of exposure and hence influenza infection compared to the general adult population;

[31] The at-risk groups include people aged 65 years and over, anyone over six months of age with a long term illness requiring regular medical follow-up such as chronic lung disease, chronic heart disease, diabetes or those with lower immunity due to disease or treatment; pregnant women; and residents of nursing homes and other long stay facilities.

[32] HSE National Immunisation Office. 2017. *Why flu vaccination is important for health care workers (HCWs)*. https://www.hse.ie/eng/health/Immunisation/pubinfo/flu-vaccination/healthcare-workers/why-flu-vaccination-is-important-for-health-care-workers.pdf

- It is estimated that at least 20% of healthcare workers are infected with influenza every year;
- During hospitalisation, patients in general are 5-35 times more likely to acquire influenza if exposed to infected patients or healthcare workers; and
- Institutions with high levels of healthcare worker immunisation in Europe have shown reduced rates of influenza-like illness, hospitalisation and deaths from influenza in the elderly, and a reduction in healthcare worker sick leave.

Goals and Achievements

The aim of vaccination programmes is to first reduce, and then where possible eliminate the incidence of these diseases in the population.

This section begins by focusing on immunisation uptake. If the immunisation programme is to be effective then there needs to be very high coverage across the population to ensure "herd immunity". The share of the population that needs to be immunised to achieve this varies by vaccine. That said, the Health Service Executive notes that the World Health Organization (WHO) has set a target uptake of 95% for primary immunisations to prevent outbreaks of vaccine preventable diseases and as such the uptake rate for the various vaccines is compared against this percentage.[33]

The next sub-section considers what is the central goal of the vaccination programmes, that is, reducing and where possible eliminating the incidence of disease in the population. In particular, there is an examination of the number of reported cases of vaccine preventable diseases. Where data is available a comparison is made of morbidity rates before and after the introduction of specific vaccines.

The final sub-section focuses on the most serious consequence of these diseases, that is, the person dies. This part considers mortality rates for relevant cohorts. Where data is available a comparison is made of mortality rates before and after the introduction of specific vaccines.

Vaccination Programme Uptake Rates

Figures 7 to 10 set out the uptake rates for a variety of vaccines that are part of the Primary Childhood Immunisation Programme and the School Immunisation Programme and compare them against a vaccination uptake rate of 95%. The data presented here refers to the proportion of children who completed the recommended primary childhood immunisation schedule by 12 months and 24 months in the reference year.

Tuberculosis Vaccine

Perhaps the most familiar of the long established vaccines is the BCG vaccine that protects against Tuberculosis. Figure 7 shows the level of uptake for this vaccine. For the years for which data has been published by the Health Surveillance Protection Centre, coverage converges on the 95% level up until 2010 and is generally greater than 90%. Between 2010 and 2015, the level of coverage diverges significantly from the 95% target level of coverage. In part, this is due to issues with how data is reported.[34] (If those HSE areas that present data

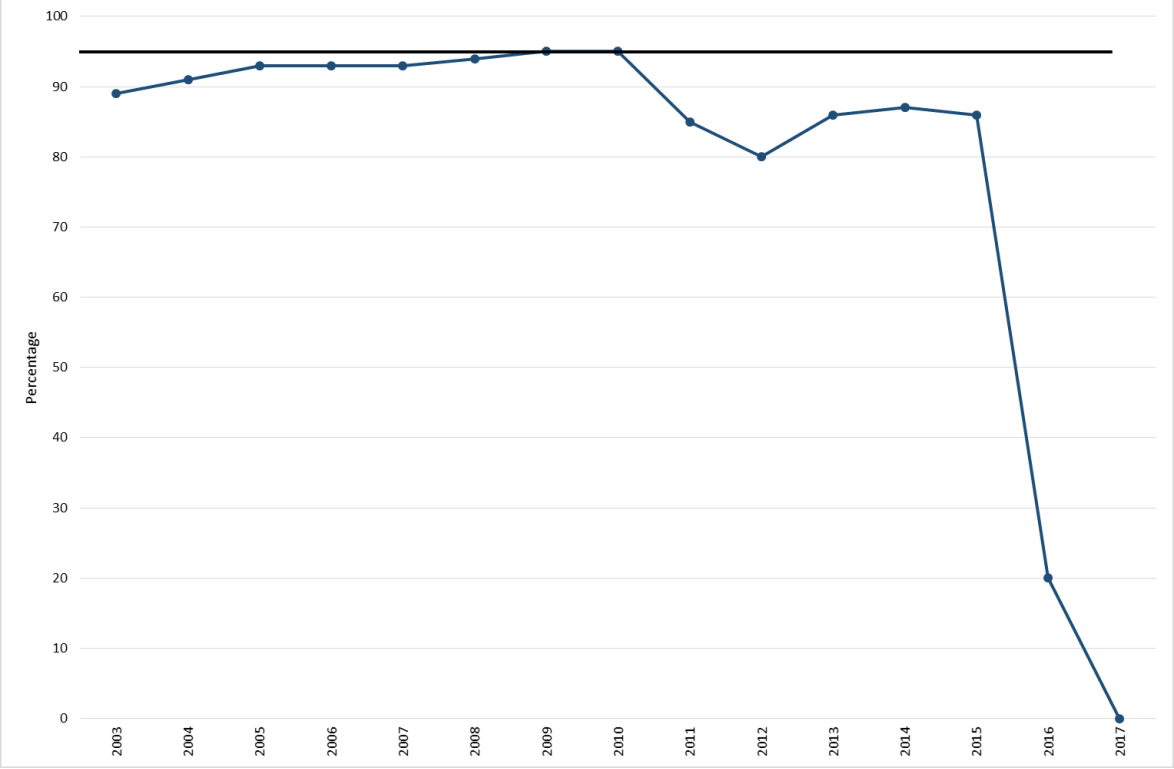
[33] Health Service Executive. 2016. *Guidelines for Vaccinations in General Practice*: 7.

[34] The Health Surveillance Protection Centre (HPSC) notes that BCG uptake data at 12 months has been incomplete since reporting to HPSC began in Quarter 3 2003. The HPSC states that this has

problems were excluded, average coverage in 2012 in the five HSE Areas was 95.8%.) Since end-April 2015, the BCG vaccine stock expired in all areas of Ireland and the HSE continues to experience ongoing delays with the supply of BCG vaccine. This continues to be a Europe wide issue (most European countries do not give BCG vaccine to all babies).

The *National Immunisation Advisory Committee* (NIAC) and the *Health Information and Quality Authority* (HIQA) have both recommended that BCG vaccine does not now need to be given routinely to all babies in Ireland. A decision on BCG policy based on these recommendations will be determined by the Department of Health when BCG vaccine is back in stock.[35]

Figure 8 – Uptake Rates for BCG Vaccine, 2003-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. These annual reports set out a variety of caveats about how the data are reported. Additional data provided directly by the Health Protection Surveillance Centre.

occurred due to differences in implementation of a neonatal BCG programme across the HSE Areas as well as difficulties in providing these data to the HPSC where the programme was implemented. Prior to the establishment of the HSE each former health board determined their own BCG vaccination policy and some areas (Western and parts of the Southern Health Boards) stopped routine neonatal BCG vaccination but provided BCG vaccination for adolescents or high risk groups. The neonatal programme has been routinely implemented for all neonates in most, but not all, HSE areas. While more complete data on neonatal BCG vaccination is available, in most HSE areas, in the HSE North East, where a neonatal programme is implemented, data is not available for reporting, and in the HSE West the neonatal programme is not routinely or comprehensively implemented in all LHOs. Therefore, data provided for the HSE West reflects BCG vaccination for just a small proportion of all babies born in this area. (For instance, see: Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*. 116.)

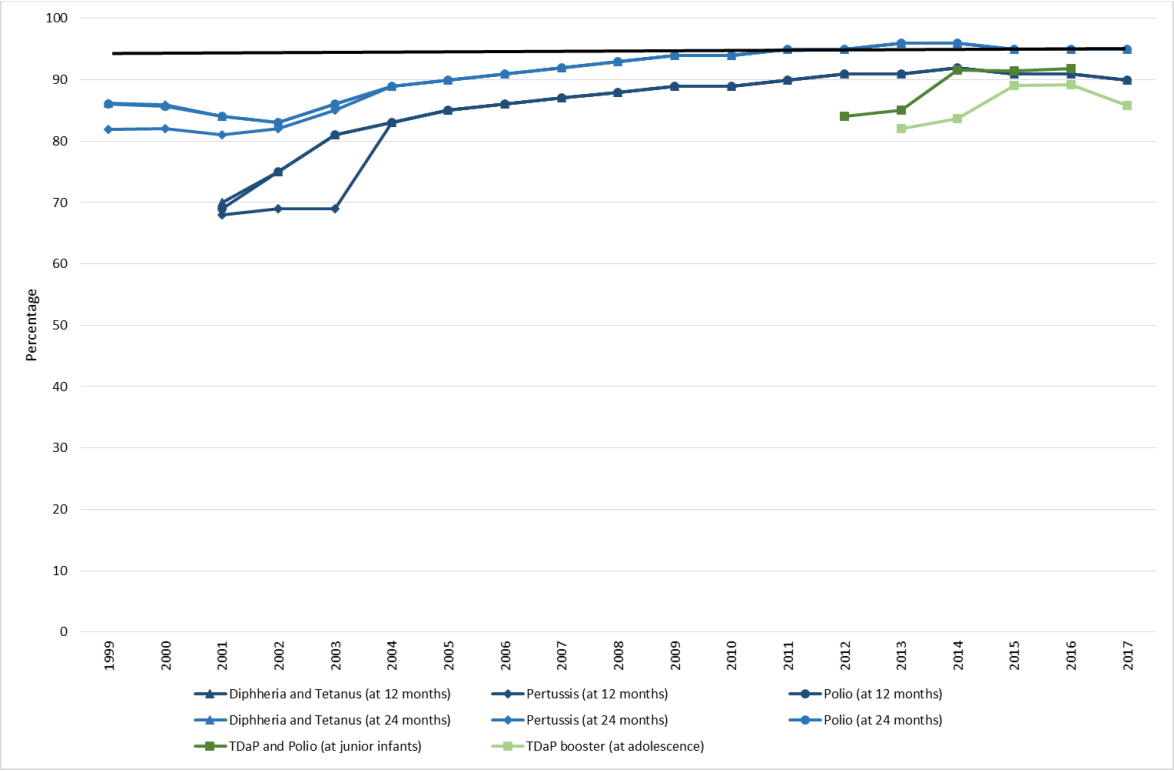
[35] https://www.hse.ie/eng/health/immunisation/news/bcg2018.html

Diphtheria, Tetanus, Pertussis and Polio Vaccines

For the other long-standing vaccines, it is clear from Figure 8 that since 1999 uptake rates have converged on the target rate of 95% coverage. It is worth noting that when this target is achieved it is at the 24 month stage in a child's life. The uptake rates at 12 months have not yet achieved 95% coverage.

The introduction of subsequent booster vaccinations at primary and secondary level school stages is associated with levels of coverage that are greater than 80%. In the first few years after their introduction, the uptake rates for these boosters converged on 90% but in more recent years little further progress has been made toward achieving 95% coverage.

Figure 8 – Uptake Rates for Diphtheria, Tetanus, Pertussis and Polio Vaccines, 1999-2017



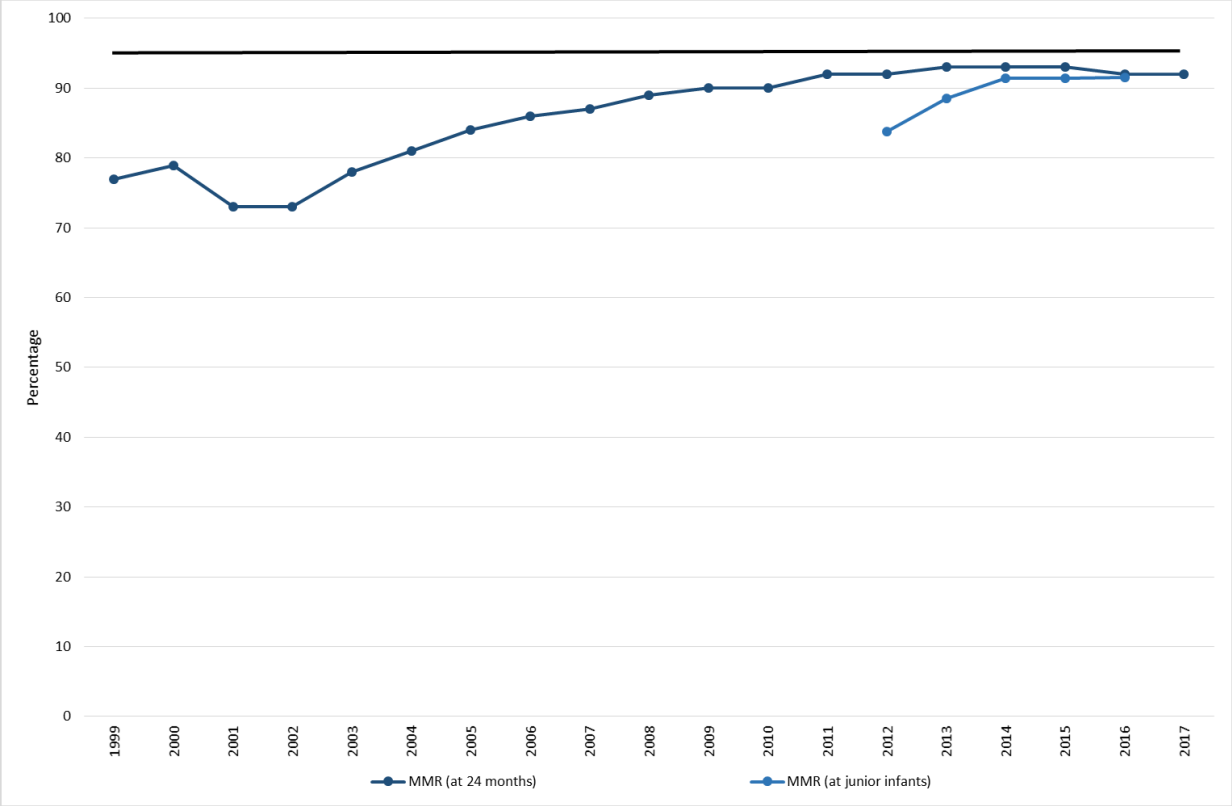
Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. These annual reports set out a variety of caveats about how the data are reported. Additional data provided directly by the Health Protection Surveillance Centre.

Measles, Mumps & Rubella Vaccine

In 1988, the immunisation schedule was updated to include the Measles, Mumps & Rubella (MMR) vaccine. Prior to this a monocomponent vaccine against Rubella was introduced to the schedule in 1971 and, in 1985, a monocomponent was introduced for measles.

From Figure 9 it is evident that in the early years of the last decade, uptake of this vaccination was 15-to-25 percentage points less than the target coverage rate. Since then uptake has converged on (but has yet to achieve) 95% coverage.

Figure 9 – Uptake Rates for Measles, Mumps & Rubella Vaccine, 1999-2017



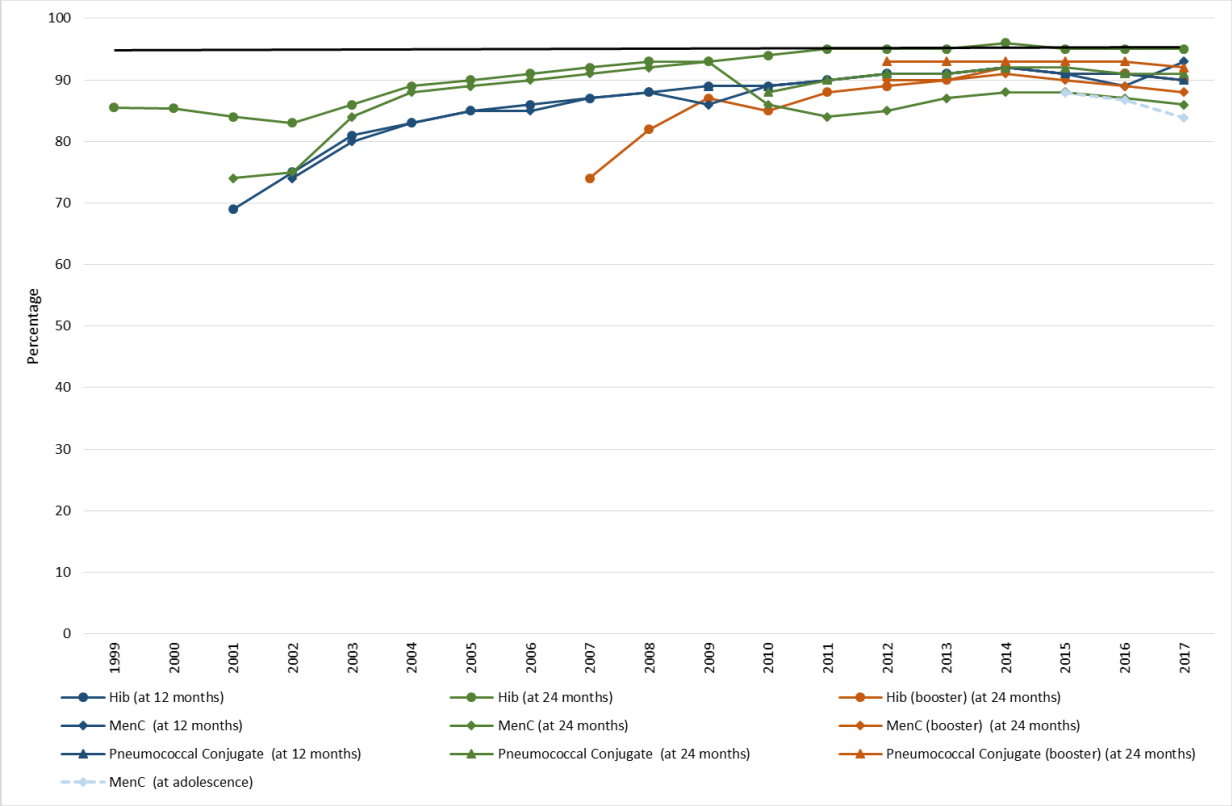
Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. These annual reports set out a variety of caveats about how the data are reported. Additional data provided directly by the Health Protection Surveillance Centre.

Haemophilus Influenzae (Type b), Meningococcal C, and Pneumococcal Conjugate Vaccines

The vaccine against Haemophilus Influenzae (Type b) was introduced to the immunisation schedule in 1992 with the vaccine against Meningococcal C introduced in 2000 and the Pneumococcal Conjugate vaccine in 2008. From Figure 10 it is evident that uptake rates of these vaccines are converging on 95% coverage.

The uptake rates of booster doses of the vaccines are also in and around the 90% level of coverage. The initial period following the introduction of the Hib booster dose is characterised by notable increases in uptake rates (an increase of 13 percentage points over the first two years). In more recent years, coverage associated with booster doses has remained in and around the 90% level, including for the initially provision of the recently introduced Meningococcal C and Pneumococcal Conjugate vaccine boosters. However, it should also be noted that while there was an initial increasing trend in the uptake of Meningococcal C vaccine by 24 months, the uptake rate decreased in 2010 and has remained well below the 95% target rate (averaging 86% between 2010 and 2017). Furthermore, the uptake rate of the Meningococcal C amongst adolescents has decreased each year since it was introduced to the schedule.

Figure 10 – Uptake Rates for Haemophilus Influenzae (Type b), Meningococcal C, and Pneumococcal Conjugate Vaccines, 1999-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. These annual reports set out a variety of caveats about how the data are reported. Additional data provided directly by the Health Protection Surveillance Centre.

Influenza Vaccine

One of the "at risk" groups that the HSE advises should avail of the influenza vaccine are people aged 65 years and older. For 2015, the HSE set out a target that three-quarters of those aged 65 years or older with a Medical Card or a GP Visit Card should avail of this vaccine.[36] The data presented in Figure 11 suggests that the uptake of the influenza vaccination amongst this cohort has fallen short of the stated target.[37] While there was increased volatility in the data between 2008 and 2010[38], in the years prior to 2008 average coverage was 61.8% and in the years subsequent to 2010 it was 57.1%.[39] That said, the uptake rate for the most recent season is substantially greater than this average level.

[36] Health Service Executive. 2014. *National Service Plan 2015*: 26.

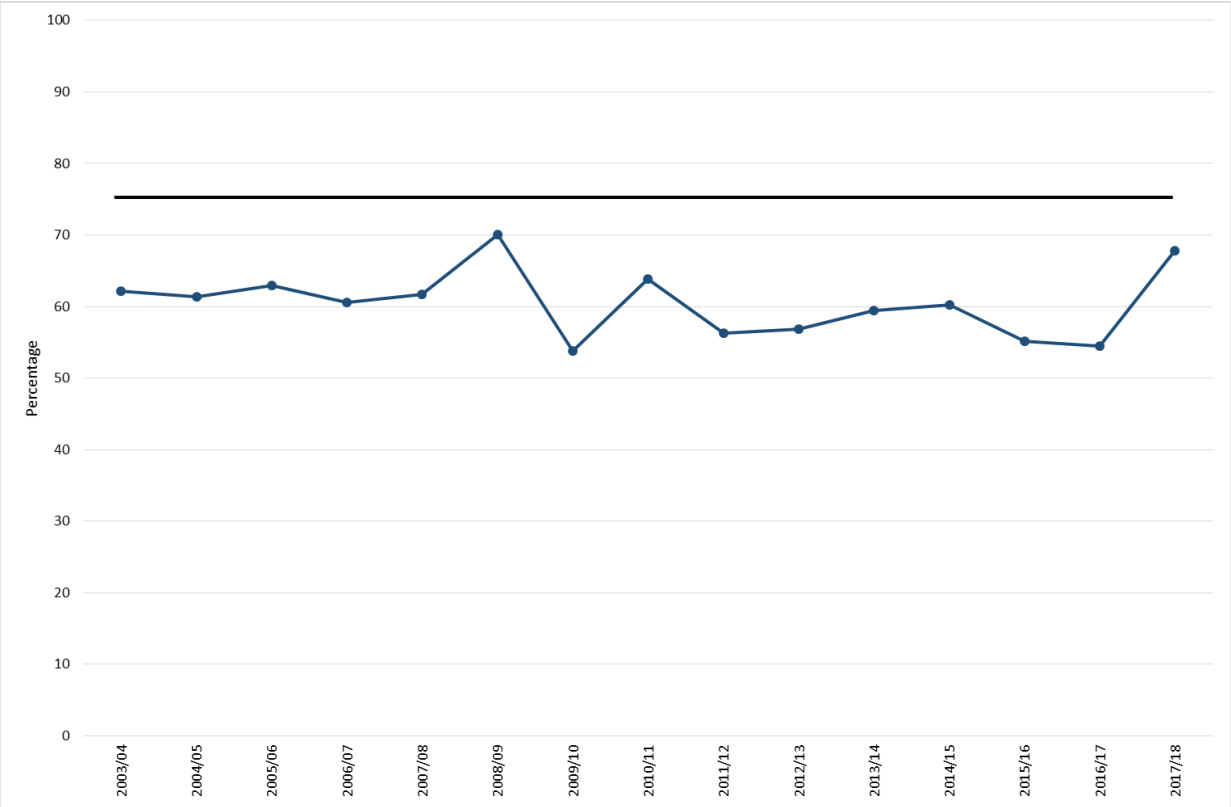
[37] The OECD publishes data on vaccine uptake amongst those aged 65 years and older. The Irish data is provided by the Health Protection Surveillance Centre. There are a number of limitations associated with the influenza vaccine uptake data. It should be noted that all influenza vaccine data relate to paid claims for influenza vaccine reimbursement for medical card holders and GP Visit Card holders aged 65 years old and over attending GP clinics and pharmacies for influenza vaccination. Data from pharmacies were only available from the 2012/2013 influenza season when administration of influenza vaccine by pharmacists commenced. Data reported for 2016/17 season are provisional.

[38] This volatility was primarily due to changes in the number of people vaccinated. In 2008/09 the number of people vaccinated was 14% greater than the number vaccinated the season before. In 2009/10 the number of people vaccinated decreased by 23% over the previous season while in 2010/11 it increased by 23% over the previous season.

[39] The HPSC note that this decrease might be related to the fact that from August 2015 everyone aged 70 or over, ordinarily resident in Ireland, was eligible for free GP care regardless of income; increasing the number of individuals eligible for vaccination. (HPSC. 2016. 'Seasonal flu vaccine

Within this cohort of people, the HSPC notes that participation in the influenza vaccination programme is strongest amongst those aged 75 years and older (60.6%) and it is weakest amongst those aged 65-69 years (45.5%).

Figure 11 – Uptake Rates for Influenza Vaccine among people aged 65 years or older, 2003/04 – 2017/18



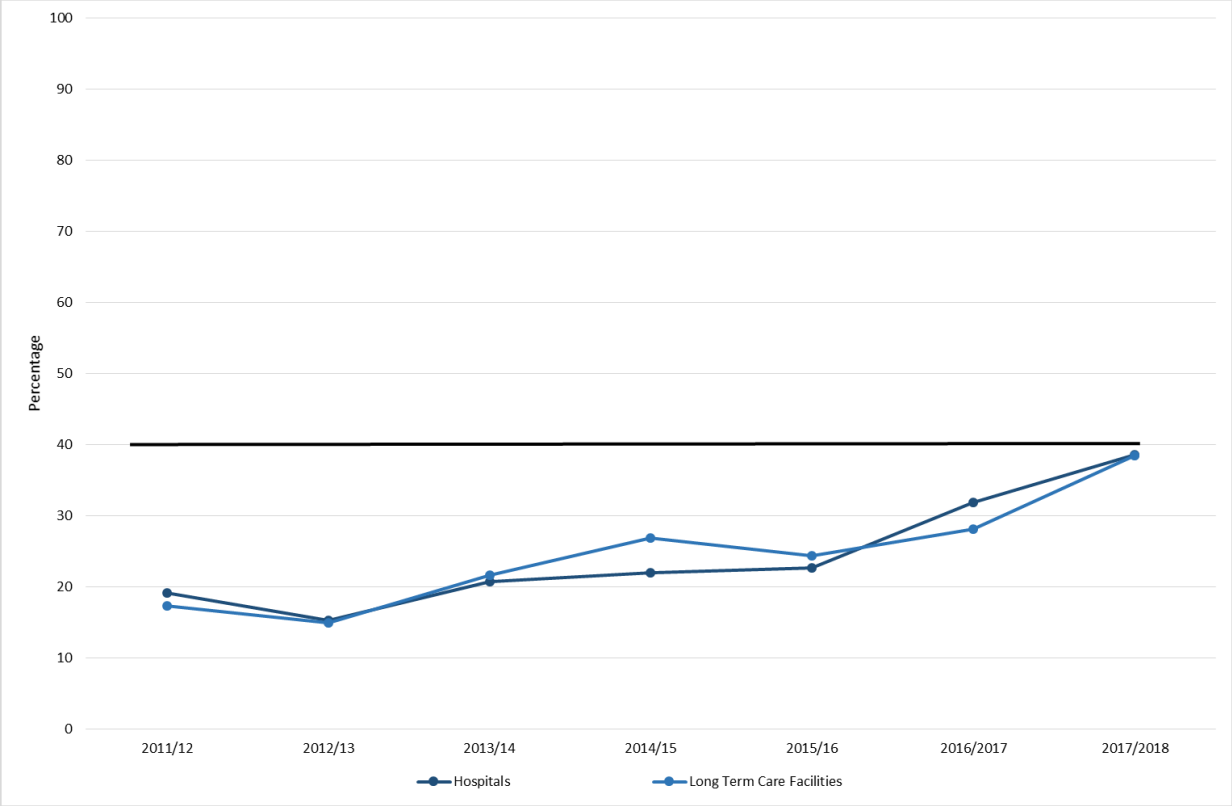
Source: OECD.Stat online database. Additional data provided directly by the Health Protection Surveillance Centre.

In order to achieve some understanding of the uptake of the influenza vaccination amongst health care workers, the Health Protection Surveillance Centre has, since 2011-12, collected data on seasonal influenza vaccination coverage from hospitals and long term care facilities. The Health Protection Surveillance Centre makes contact with 58 known hospitals and 229 HSE funded long term care facilities. The participation rates have varied year-to-year with between 60% and 86% of hospitals returning completed forms and between 30% and 60% of long term care facilities doing so.

Over the last number of years, the average uptake of the influenza vaccination amongst health care workers in both hospitals and long term care facilities has increased. However, up until the most recent season, the uptake rates in both settings were notably less than the HSE's vaccination target of 40%. (See Figure 12.)

uptake in persons aged 65 years and older.' *Epi-Insight*. Vol. 17 (10).) Up until the 2015/16 the average increase in the number of eligible persons was 2%. In 2015/16 the number of eligible persons was 10% greater than that in 2014/15.

Figure 12 – Uptake Rates for Influenza Vaccine among Health Care Workers, 2011/12 – 2017/18



Source: Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*: 131. Additional data provided directly by the Health Protection Surveillance Centre.

Number of Notified Cases of Vaccine Preventable Diseases

The Health Protection Surveillance Centre publishes details of the number of notified cases of vaccine preventable diseases.[40] This section examines the number of notifications for the period 1982-2017.

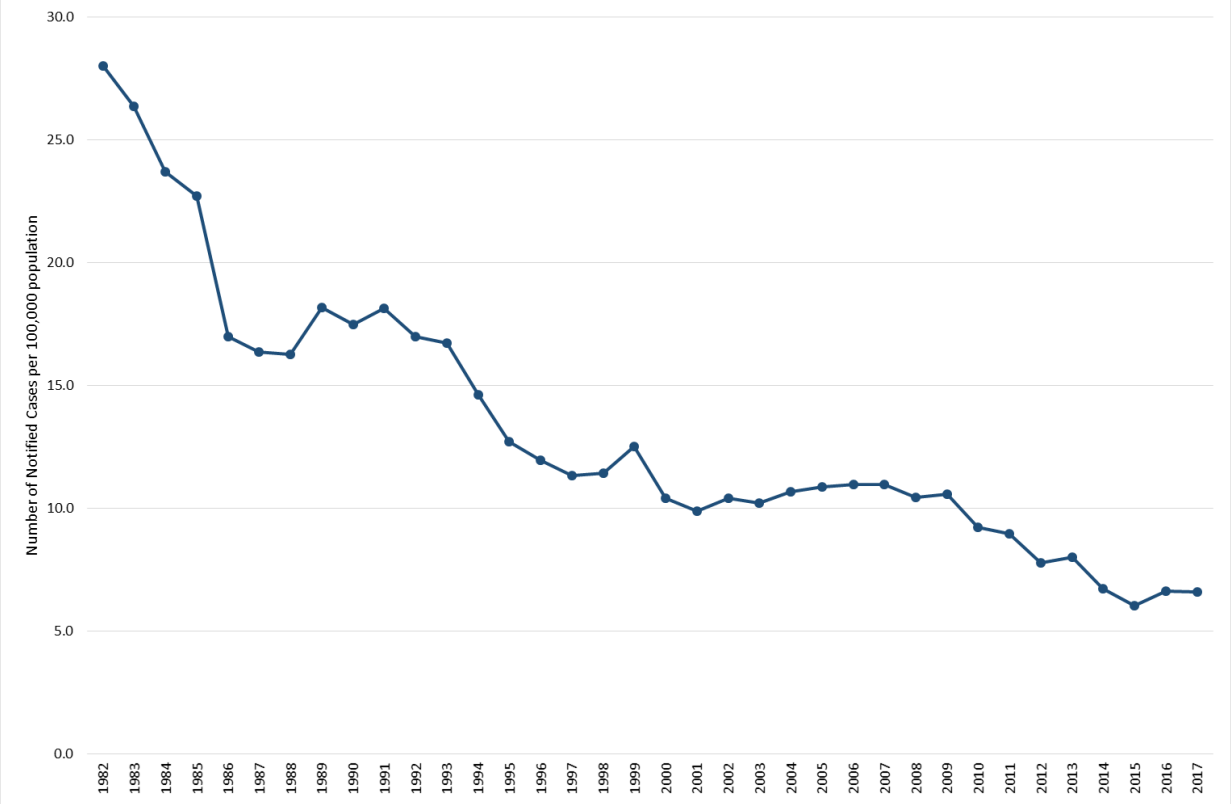
Tuberculosis

A vaccine against Tuberculosis has been on the immunisation schedule in Ireland since 1937. The data published by the Health Protection Surveillance Centre shows that since 1982 there have been almost 18,270 notified cases of Tuberculosis. The distribution of notified cases is such that 32% of these were reported in the 1980s, with 28% reported in the 1990s, 24% in the 2000s and 15% in more recent years.

[40] The data presented here is "reported number of cases". It should be noted that subsequent to this, reported cases are classified as "possible", "probable" and "confirmed". A "possible" case is usually a case with the clinical criteria as described in the case definition without epidemiological or laboratory evidence of the disease in question. The definition of a possible case has high sensitivity and low specificity. It allows for detection of most cases but some false positives cases will be included into this category. A "probable" case is usually a case with clinical criteria and an epidemiological link as described in the case definition. Laboratory tests for probable cases are specified only for some diseases. A "confirmed" case should be laboratory confirmed and may fulfil the clinical criteria or not as described in the case definition. The definition of a confirmed case is highly specific and less sensitive; therefore most of the collected cases will be true cases although some will be missed.

When the size of the population is taken into account the average number of notified cases has decreased from 21.1 per 100,000 population in the 1980s to 14.4 per 100,000 in the 1990s, 10.5 per 100,000 in the 2000s and 7.5 per 100,000 in more recent years. (See Figure 13.)

Figure 13 – Number of Notified Cases of Tuberculosis, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report*, *Annual Epidemiological Report* and *TB Surveillance in Ireland Report*. Additional data provided directly by the Health Protection Surveillance Centre.

Diphtheria and Tetanus

Vaccines against Diphtheria and Tetanus have been available in Ireland since the 1930s. Between 1982 and 2017, there have been two notified cases of Diphtheria (one case in each of 2015 and 2016) and 17 notified cases of Tetanus (with almost half of these occurring between 2000 and 2009).

Polio

A Polio vaccine was introduced in 1957. Since 1982 there have been 2 notified cases of polio; the most recent of these being reported in 1984.

Pertussis

Another long standing vaccine in use in Ireland is that for Pertussis; it was introduced in the early 1950s. Prior to its introduction the number of cases of Pertussis ranged between three and five thousand a year. While the number of cases remained high in the decade or so following the vaccines introduction, by the 1960s the number of notified Pertussis cases was trending below 1,000 cases a year.[41] In the mid-1970s there was a scare regarding the

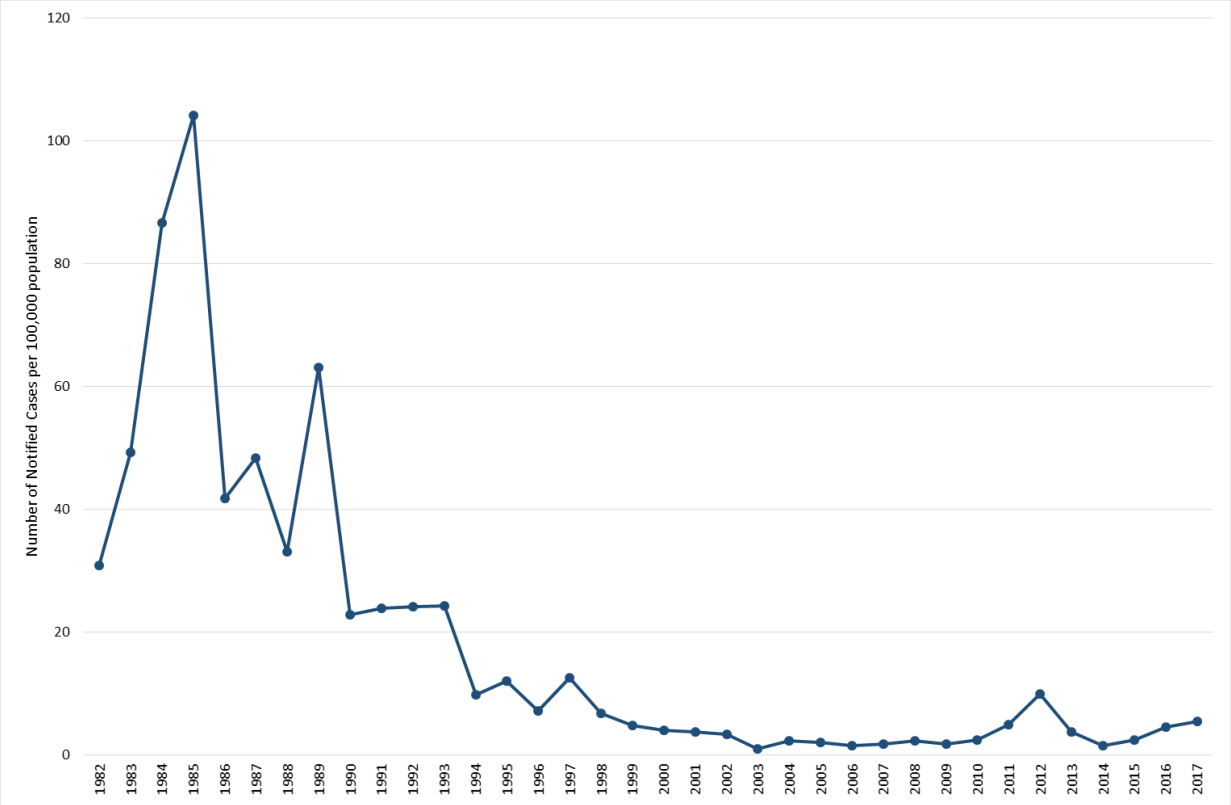
[41] See Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*: 32.

vaccine and a possible association with encephalopathy and the uptake of the vaccine decreased.[42]

Since 1982 there have been over 24,050 notified cases of Pertussis. The distribution of notified cases is such that almost 67% were reported in the 1980s with 22% reported in the 1990s.

When the size of the population is taken into account the average number of notified cases has decreased from 57.2 per 100,000 population in the 1980s to 14.9 per 100,000 in the 1990s and 2.4 per 100,000 in the 2000s. In the years 2010-2017 the average number of notified cases increased to 4.4 per 100,000. It is also worth noting that protection against pertussis declines over time (it usually lasts around a decade) and herd immunity can be quickly lost. (See Figure 14.)

Figure 14 – Number of Notified Cases of Pertussis, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. Additional data provided directly by the Health Protection Surveillance Centre.

Rubella

The data published by the Health Protection Surveillance Centre shows that since 1982 there have been almost 10,540 notified cases of Rubella. The distribution of notified cases is such that 77% of these were reported in the 1980s with almost 20% reported in the 1990s.

When the size of the population is taken into account the average number of notified cases has decreased from 28.8 per 100,000 population in the 1980s to 5.5 per 100,000 in the 1990s, 1 per 100,000 in the 2000s and 0.1 per 100,000 in more recent years. (See Figure 15.)

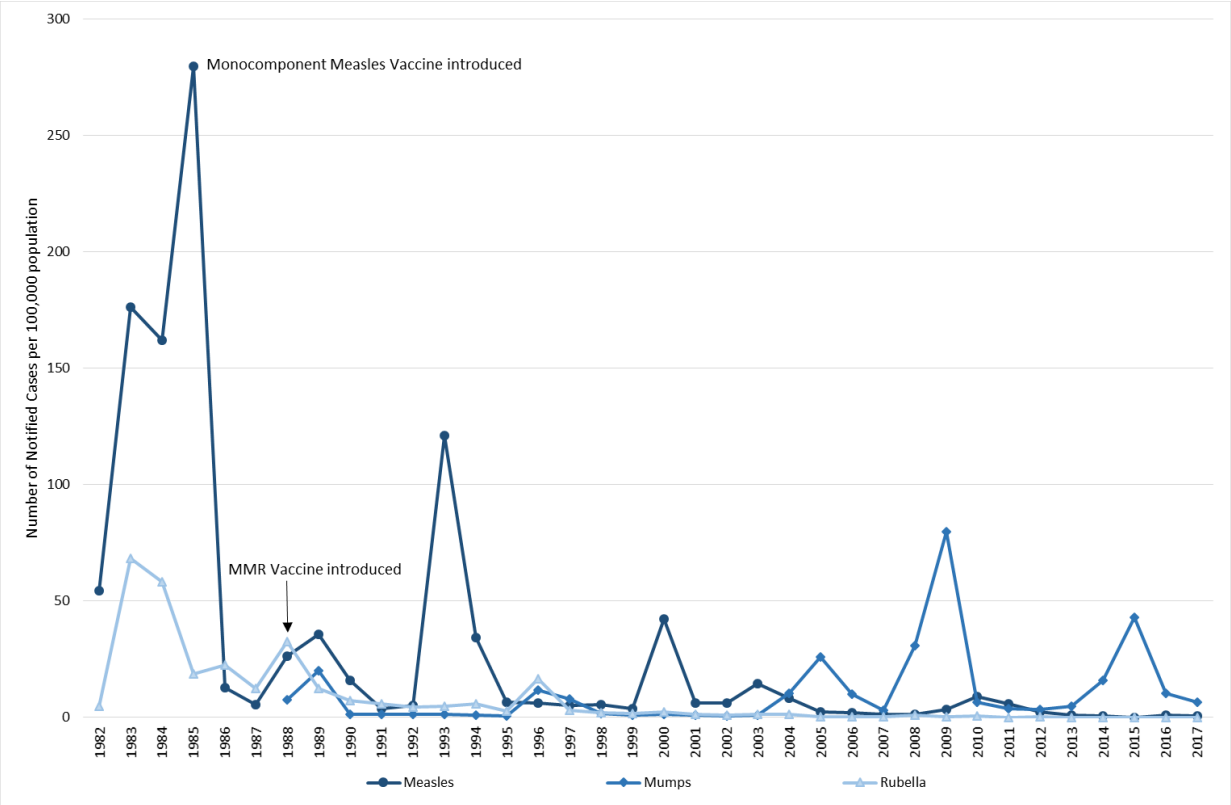
[42] See Health Protection Surveillance Centre. 2013. *Annual Report 2012*: 26.

Measles

The Health Protection Surveillance Centre data shows that since 1982 there have been over 38,330 notified cases of Measles. The distribution of notified cases is such that 62% of these were reported in the short period prior to the introduction of the vaccine (1982 and 1985). The number of cases notified in the 1990s accounted for almost 20% of this total while 9% were reported in the 2000s with 2% reported in the years since 2010.

In terms of population size, the average number of notified cases of Measles decreased from 168.2 per 100,000 in 1982-1985 to less than 21 per 100,000 in 1986-1999 to 8.8 per 100,000 in the 2000s and 2.5 per 100,000 in more recent years. (See Figure 15.)

Figure 15 – Number of Notified Cases of Measles, Mumps and Rubella, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. Additional data provided directly by the Health Protection Surveillance Centre.

Mumps

By way of contrast, the number of notified cases of Mumps has increased in more recent decades. In total, since 1988, there have been almost 13,660 notified cases of Mumps. The distribution of notified cases is such that only 15% of these were reported in the first decade or so following the introduction of the MMR vaccine (1988-1999). However, since then the number of notified cases of Mumps increased with 53% of the total being reported in 2000-2009 and 32% reported in 2010-2017.

When population size is taken into account it is clear that the number of notified cases decreased in the period following the introduction of the MMR vaccine (from an average of 13.9 per 100,000 for 1988-89 to 2.9 per 100,000 in 1990-99). Ireland then experienced a

notable increase in the number of notified cases as the average per 100,000 population reached 16.4 in the 2000s before decreasing to 11.8 in more recent years.[43]

Bacterial Meningitis, Meningococcal Disease, Haemophilus Influenzae and Streptococcus Pneumoniae

Invasive meningococcal disease is the most common form of bacterial meningitis in Ireland. In the year prior to the introduction of the Meningococcal C vaccine in 2000, notified cases of meningococcal disease accounted for 536 of the 587 cases of bacterial meningitis (91%). Of those 536 cases, a quarter were associated with Meningococcal C with 54% associated with Meningococcal B.

Up until the introduction of the Meningococcal C vaccine there was an increasing trend in the number of notified cases of bacterial meningitis. Subsequent to that time there has been a clear decreasing trend. (See Figure 16.) Since 1999 there have been almost 430 notified cases of Meningococcal C. The distribution of notified cases is such that 64% of these have been reported in 1999-2000. When population size is taken into account the average number of notified cases decreased from 3.6 per 100,000 in 1999-2000 to 0.2 per 100,000 in 2001-2017.

In 2016, the immunisation schedule was updated to include a Meningococcal B vaccine. Prior to the introduction of this vaccine, there have been almost 2,620 notified cases (1999-2017); or an average of 3.3 per 100,000 population. It is clear from Figure 16 that the rate of notified cases of Meningococcal B has been decreasing since 2000.

A vaccine against Haemophilus Influenzae Type B was added to the immunisation schedule in 1992. Based on the data published by the Health Protection Surveillance Centre, since 1987 there have been just over 750 notified cases of Haemophilus Influenzae Type B and the distribution of the number of notified cases is such that 70% of these have been recorded in the years prior to the introduction of the vaccine. Of the remaining cases, 14% were reported for the years 1993-1999, 14% in the 2000s and 2% in the years 2010-2017. When population size is taken into account there were, on average, 2.5 notified cases per 100,000 population in the years prior to the introduction of the vaccine but since then this has decreased to 0.4 per 100,000 in 1993-1999, to 0.3 per 100,000 in 2000-2009 and to 0.0 per 100,000 in 2010-2017.

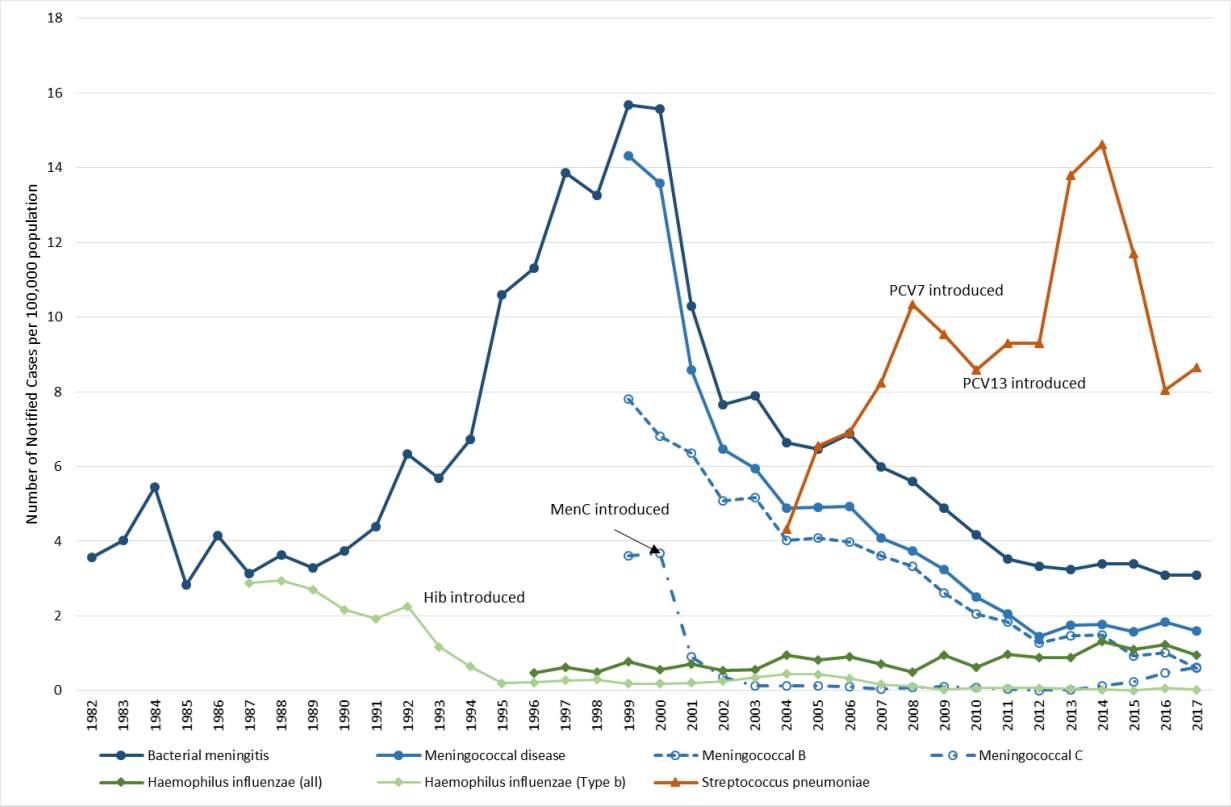
Two variations of the Pneumococcal Conjugate vaccine (PCV7 in 2008 and PCV13 in 2013) have been introduced to protect against Streptococcus Pneumoniae. The Health Protection Surveillance Centre reports that there has been a decline in invasive pneumococcal disease (IPD) in all age groups due to serotypes covered by PCV7. This indicates the indirect (herd immunity) effect the vaccine has conferred on the population. However, there has been an increase in the incidence of IPD due to non-PCV7 serotypes in the population.[44] This pattern is evident in Figure 16. Data published by the Health Protection Surveillance Centre shows that there have been almost 5,900 notified cases of Streptococcus Pneumoniae and the average number has increased from 7.3 per 100,000 in 2004-2008 to 10.4 per 100,000 in 2009-2017.

In addition to PCVs, in Ireland, those aged 65 years and older (and those over 2 years with long term medical conditions) can avail of the Pneumococcal Polysaccharide vaccine (PPV23)

[43] For discussion see Health Protection Surveillance Centre. 2015. 'Mumps outbreak in Ireland 2014-2015'. *Epi-Insight*. Vol.16 (8).
[44] See Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*: 32-33.

which protects against 23 types of pneumococcal disease including those most likely to cause severe disease.

Figure 16 – Number of Notified Cases of Bacterial Meningitis, Meningococcal Disease, Haemophilus Influenzae and Streptococcus Pneumoniae, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. Additional data provided directly by the Health Protection Surveillance Centre.

Hepatitis B

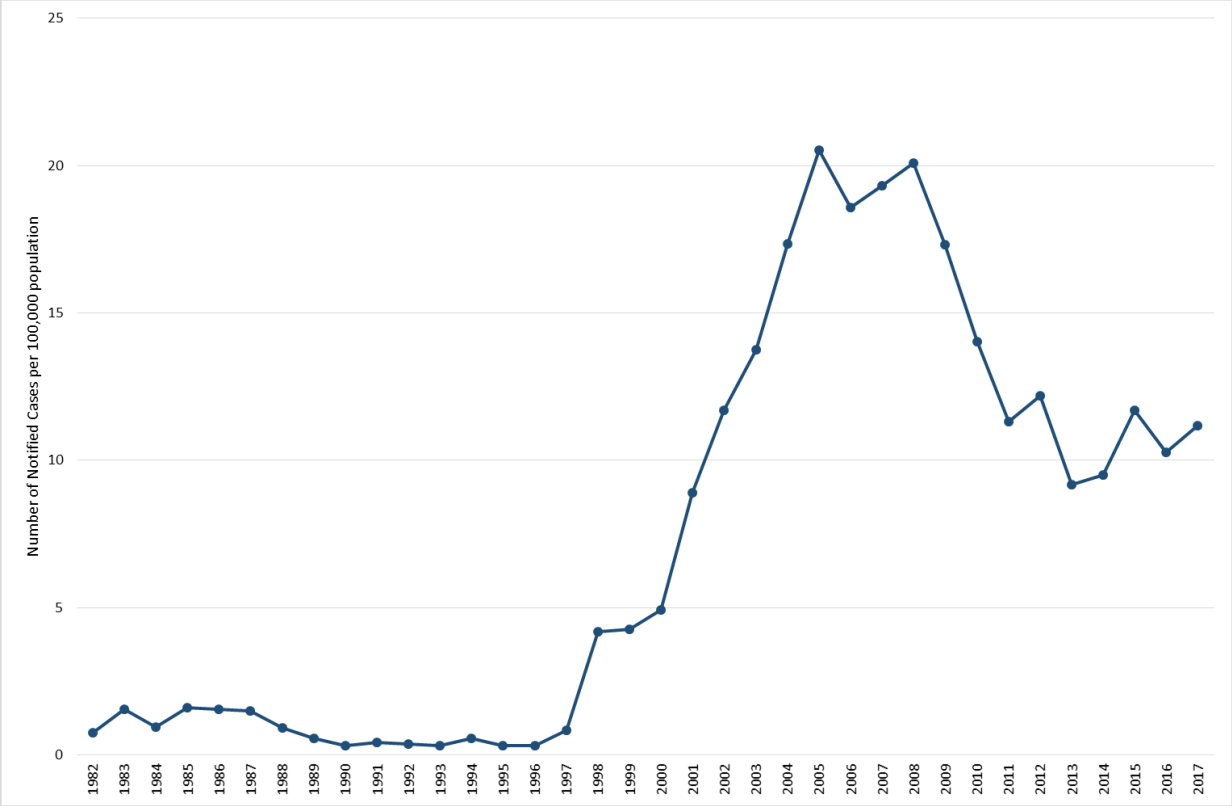
In 2008, a Hepatitis B vaccine was included as part of the now 6-in-1 vaccine given to infants. A significant proportion of the population is not vaccinated against this disease. Since 1982, the Health Protection Surveillance Centre reports that there have been over 11,320 notified cases of Hepatitis B. The vast majority of these cases have been reported since 2000, with 57% being reported in the 2000s and 37% reported in the years 2010-2017.

The number of notified cases of Hepatitis B peaked at around 20 per 100,000 population in 2008 and, during the 2000s, there was an average of 15.2 per 100,000 population. Since then the number of notified cases has decreased and has averaged 11.2 per 100,000 in the years 2010-2017. These rates are greater than those that were observed in the 1980s (1.2 per 100,000) and in the 1990s (1.2 per 100,000). (See Figure 17)

The Health Protection Surveillance Centre observes that the prevalence of hepatitis B in the general population in Ireland is low (less than 1%) and that most cases fall into defined risk groups (i.e., people with multiple sexual partners, sexual or household contacts of known cases, injecting drug users and people who were born in countries with intermediate (2- 7%) or high (>8%) hepatitis B endemicity).[45]

[45] See Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*: 86.

Figure 17 – Number of Notified Cases of Hepatitis B, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. Additional data provided directly by the Health Protection Surveillance Centre.

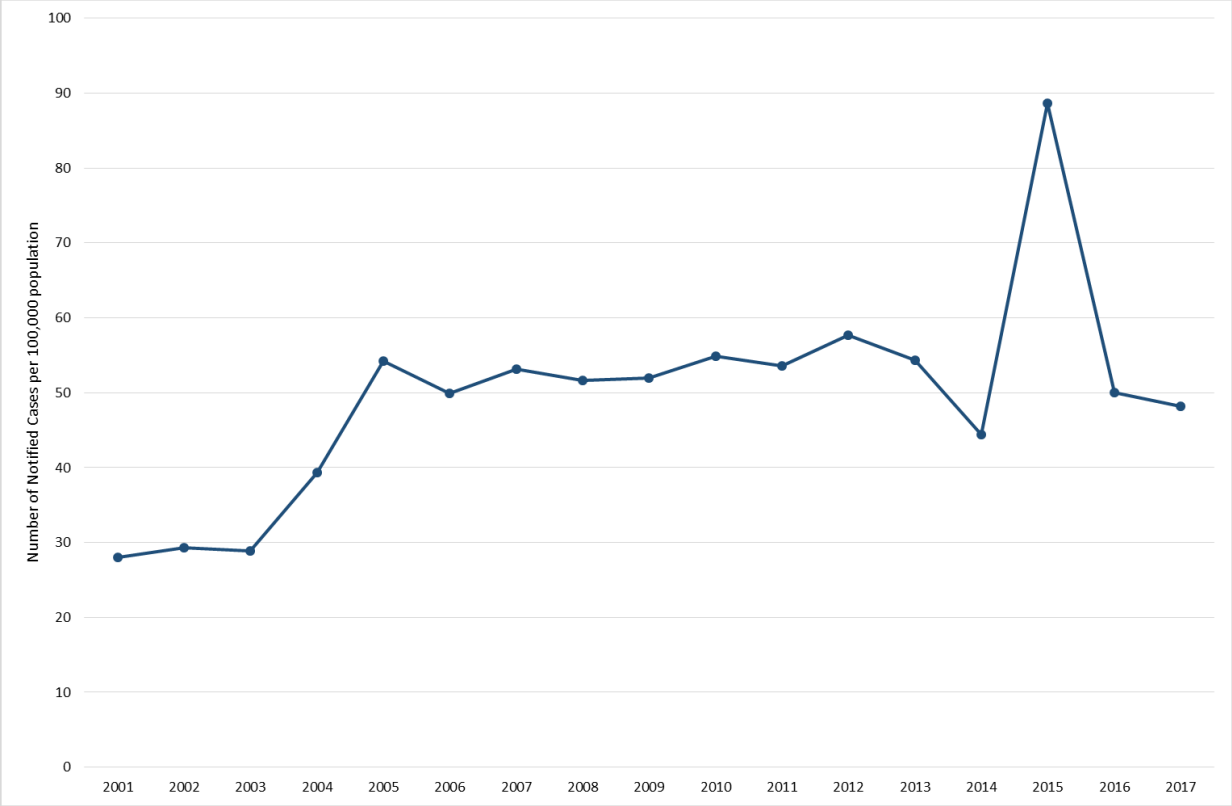
Rotavirus

In 2016, a vaccine against the Rotavirus was added to the immunisation schedule. This virus is the most common cause of paediatric gastrointestinal infection and causes sporadic, seasonal and occasionally severe gastroenteritis of infants and young children.

Since 2001, the Health Protection Surveillance Centre reports that there have been over 37,320 notified cases of Rotavirus. The reporting requirements may in part be a factor in the trend evident in Figure 18 (44% were reported in the 2000s and 56% were reported since 2010).[46] The trend suggests that initially the number of notified cases was around 28.7 per 100,000 (in 2001-2003) but that it has since increased and now ranges between 49.9 and 57.6 cases per 100,000; with notable exceptions in 2014 (44.4 per 100,000) and 2015 (88.7 per 100,000).

[46] Prior to 2004, rotavirus cases were notified under the "Gastroenteritis in children under two years" disease category. From 2004 to 2010, rotavirus was notifiable in all age groups under the "Acute Infectious Gastroenteritis" (AIG) disease category. It became notifiable as a disease in its own right under the Infectious Diseases (Amendment) Regulations 2011 (S.I. No. 452 of 2011). (Health Protection Surveillance Centre. 2016. *Annual Epidemiological Report 2015*: 70.)

Figure 18 – Number of Notified Cases of Rotavirus, 1982-2017



Source: Health Protection Surveillance Centre. Various. *Annual Report* and *Annual Epidemiological Report*. Additional data provided directly by the Health Protection Surveillance Centre.

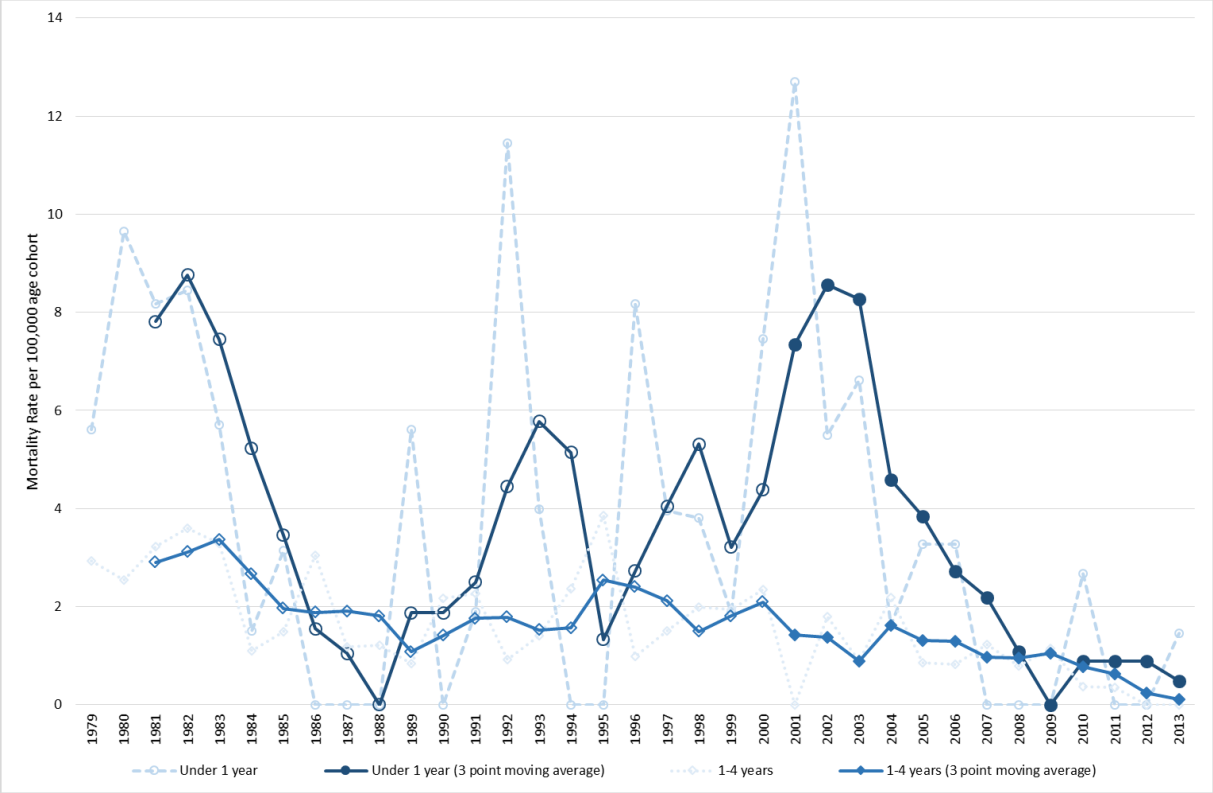
Mortality Rates

Many of the vaccine preventable diseases can have serious consequences that are either life limiting or fatal. As noted earlier, Haemophilus Influenza Type b, Streptococcus Pneumoniae and Meningococcal diseases can lead to a range of very serious and potentially fatal complications such as meningitis (inflammation of the lining around the brain and spinal cord) and septicaemia (blood poisoning). Figures 19 and 20 set out the mortality rates for meningococcal disease (the combination of meningitis and septicaemia) and septicaemia for the period prior to the introduction of the Meningococcal C vaccine in 2000 and the period subsequent to its introduction.

Meningococcal Disease

From Figure 19 it is evident that since 2000 there has been a decrease in the mortality rate associated with meningococcal disease amongst infants and a continuing decrease in the mortality rate amongst young children. In the years prior to the introduction of this vaccine (1979-2000), the average mortality rate was 4.1 per 100,000 infants and 2.1 per 100,000 young children. Following the introduction of the vaccine the average mortality rate for the period 2001-2013 was 2.9 per 100,000 infants and 0.8 per 100,000 young children. When both of these periods are compared, there has been a statistically significant reduction in the average mortality rates amongst young children (at the 1% level of significance one-tailed test). It should be noted that if the periods compared are adjusted slightly (i.e. 1979-2001 and 2002-2013), there would also be a statistically significant reduction in the average mortality rates amongst infants (at the 5% level of significance one-tailed test).

Figure 19 – Mortality Rates associated with Meningococcal Infection amongst Infants and Young Children, 1979-2013



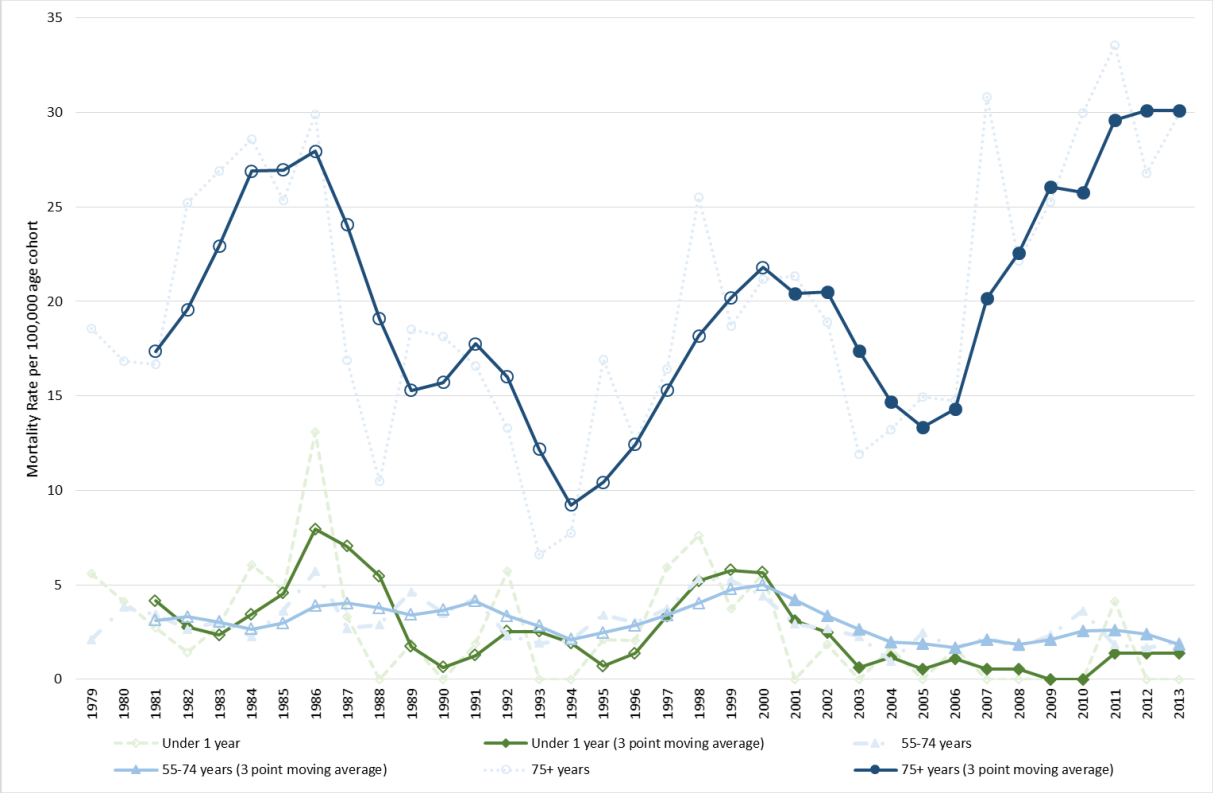
Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Septicaemia

The very young and very old are more at risk from septicaemia that other cohorts in the population. From Figure 20 it is evident that since 2000 there has been a decrease in the mortality rate associated with septicaemia amongst infants. In the years prior to the introduction of the Meningococcal C vaccine (1979-2000), the average mortality rate was 3.7 per 100,000 infants. Following the introduction of the vaccine the average mortality rate for the period 2001-2013 was 0.7 per 100,000 infants. When both of these periods are compared, there has been a statistically significant reduction in the average mortality rates amongst infants (at the 1% level of significance one-tailed test).

However, Figure 20 highlights two different trends amongst adults. For people aged 75 years or older, there has been a statistically significant increase in the average mortality rate associated with septicaemia; from 18.5 per 100,000 people in 1979-2000 to 22.6 per 100,000 people aged 75 years or older in 2001-2013 (at the 5% level of significance one-tailed test). Within the cohort of those aged 55-74 years, there has been a statistically significant reduction in the average mortality rates associated with septicaemia (at the 1% level of significance one-tailed test); from 3.5 per 100,000 in 1979-2000 to 2.2 per 100,000 people aged 55-74 in 2001-2013.

Figure 20 – Mortality Rates associated with Septicaemia amongst Infants and Older Adults, 1979-2013



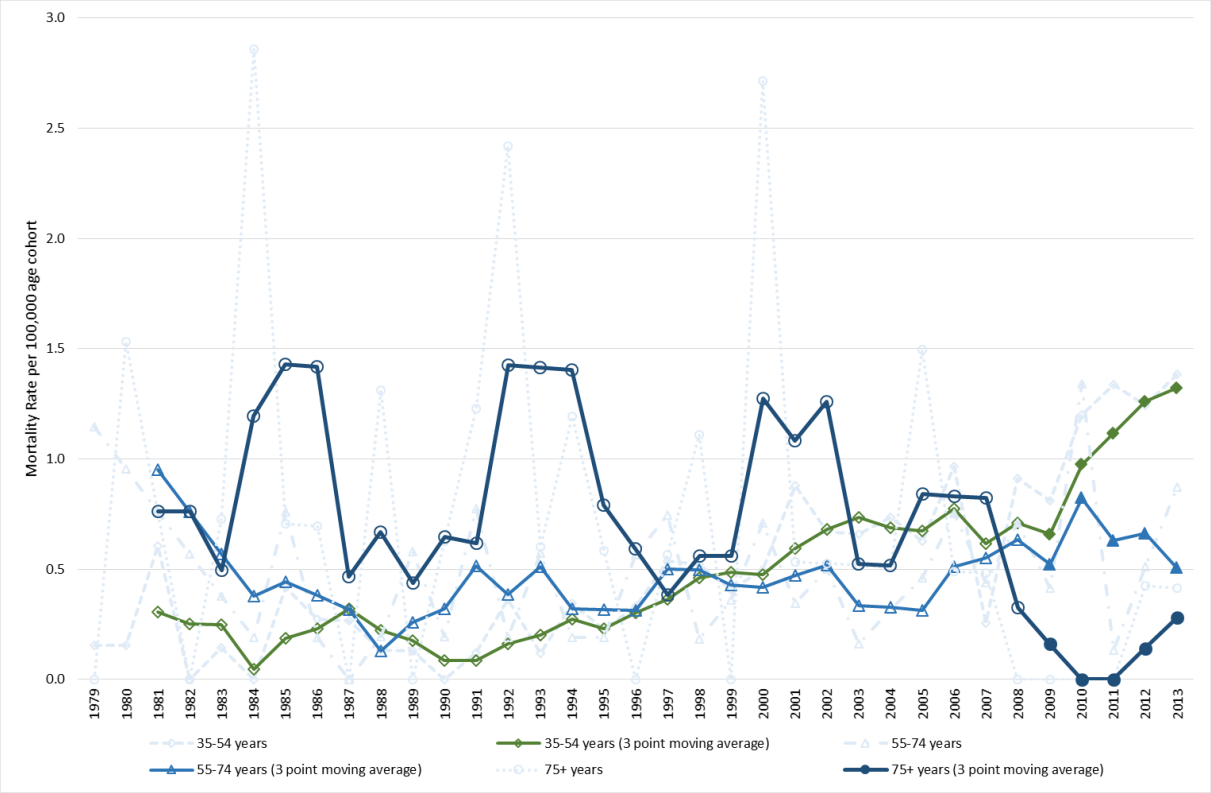
Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Hepatitis B

Hepatitis B is a viral infection that affects the liver and can cause lifelong infection, potentially leading to cirrhosis, cancer or liver failure. Figure 21 presents the mortality rates associated with viral hepatitis both prior and subsequent to the inclusion of the Hepatitis B vaccine in the 6-in-1 vaccine in 2008. (As this vaccine is given to infants and has only been on offer for about a decade, there is a significant proportion of the population that has not been vaccinated against this disease.)

As noted earlier, about 85% of deaths associated with viral hepatitis have occurred amongst those aged 35 years or older. There are a number of trends that should be noted. Amongst those aged 75 years or older there has been a statistically significant reduction in the average mortality rate associated with viral hepatitis (at the 5% level of significance one-tailed test): from 0.8 per 100,000 for the period 1979-2008 to 0.2 per 100,000 for the years 2009-2013. However, amongst those aged 35-54 years there has been a statistically significant increase in the average mortality rate (at the 1% level of significance one-tailed test): from 0.4 per 100,000 for the years 1979-2008 to 1.2 per 100,000 in 2009-2013. (Amongst those aged 55-74 years that average mortality rate associated with Hepatitis B has increased from 0.5 per 100,000 to 0.6 per 100,000 but this difference is not statistically significant at either the 5% or 1% level of significance.)

Figure 21 – Mortality Rates associated with Viral Hepatitis amongst Adults, 1979-2013



Source: Author calculations based on data number of deaths associated with specified morbidity from the WHO Mortality Database (http://apps.who.int/healthinfo/statistics/mortality/whodpms/) and standardised by Central Statistics Office population estimates for each year by age cohorts.

Quality Assurance Process

To ensure accuracy and methodological rigour, the authors engaged in a quality assurance process that involved Department of Public Expenditure & Reform line management and a Quality Assurance Group. Additional data was provided by colleagues in the Health Protection Surveillance Centre.