The public health impact of vaccination programmes in the Netherlands

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Chapter 6

Financing vaccination programmes in the Netherlands from a macro-economic perspective: a historical analysis

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Financing vaccination programmes in the Netherlands from a macro-economic perspective: a historical analysis
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Abstract

Background

Health economic evaluations are often required before implementation of a vaccination programme. Such evaluations should be viewed in the context of the history of vaccination programmes. Here we aim to provide an overview of the financial history of vaccination programmes in the Netherlands and to reflect government expenditures on these programmes to demographic and macro-economic developments.

Methods

Previously uncatalogued historical expenditures on the Dutch National Immunisation Programme (NIP) and influenza vaccination were obtained from various official reports. All costs were adjusted for inflation using Consumer Price Indices and expressed in Euro of 2016.

Results

Expenditure on the NIP increased from €5 million in 1957 to €93 million in 2014. Since the mid-1980s, expenditure increased nearly five-fold due to the introduction of new vaccines, specifically 7-valent pneumococcal conjugate vaccine. Expenditure reached €5.54 per capita and €533 per birth in 2014. Spending on specific vaccines tended to decline over time. The contribution of the NIP to total healthcare expenditure remained small, ranging between 0.05% and 0.14%. Spending on influenza vaccination increased from €37 million in 1996 to €52 million in 2014, while spending relative to total healthcare expenditure decreased from 0.069% to 0.055%. Together, 0.022% of the Dutch Gross Domestic Product and 0.15% of healthcare expenditure was spent on vaccination programmes in 2014.

Conclusion

While government expenditure on vaccination programmes increased substantially, the contribution to overall healthcare expenditure remained small. The financial evolution of vaccination programmes provides the context for today's decision making.

Introduction

Currently, health economic evaluations of vaccines are a common part of vaccine research. In the Netherlands, the introductions of new vaccines are generally discussed by a special committee of the Health Council of the Netherlands on several criteria before they are considered for inclusion in the National Immunization Programme (NIP). These criteria include the severity of the disease, effectiveness and safety of the vaccine, its acceptability, whether the public health issue is urgent enough, and the cost-effectiveness of the vaccine (Houweling et al., 2010). With the last criterion the economic considerations explicitly come into play.

Cost evaluations were not always part of the decision making process. The merits of Edward Jenner's vaccine against smallpox were measured on its safety and efficacy, not its costs. Similarly, the inclusion of diphtheria, pertussis, tetanus, poliomyelitis, measles, mumps, and rubella, were not evaluated on their cost-effectiveness or cost-saving potential before they were introduced (Black, 2013). In general, considerations on healthcare costs were by far not as prominent as they are nowadays. Also, the first vaccination programmes were introduced in a time with higher infectious disease morbidity and mortality as compared to today, which may have led to an easier decision on implementation of preventive measures. Decision makers focused on whether the disease was severe enough to warrant a vaccination programme and whether the vaccines themselves were efficacious.

The economic aspects of vaccinations have only begun to play an important role in decision making over the past several decades, partially due to the substantial increase in healthcare expenditure in most high income countries (Anderson et al., 2003). In addition, recently introduced vaccines such as the pneumococcal vaccines and the vaccines against human papillomavirus are much more complicated to produce, have a higher price, and their benefits are sometimes less visible than the older vaccines (Hinman et al., 2004; Davis, 2010). For a government with restricted budgets, these developments have led policy makers to focus on health economic analyses of medical and preventive interventions including vaccines (Meltzer, 2008).

Health economic evaluations of a new vaccine that is considered for inclusion in the NIP should be viewed in the context of the vaccination programme as a whole along with its history. Understanding the history of vaccination programmes may help to properly evaluate the benefits and costs of old and new vaccines.

To provide such an understanding, we review the financial history of vaccination programmes in the Netherlands up to the year 2014, with a focus on childhood and influenza vaccinations. Rather than look at the potential future expenditure on new vaccines, we take a look at how much existing vaccination programmes have costed throughout the years from a government perspective. We will briefly discuss the history of the Dutch vaccination programmes and how they were financed, followed by an analysis of the developments in government expenditure on these programmes since implementation. In particular, and to provide further context, we examine whether the expenditure on vaccination programmes have increased relative to other measures such as total healthcare expenditure and Gross Domestic Product (GDP).

Organisation and funding of vaccination programmes

Childhood vaccination programmes

Table 6.1 provides a brief overview of the development of vaccination programmes in the Netherlands. Officially, the Dutch NIP was launched in 1957 with the start of mass vaccinations against poliomyelitis, but already in 1953 mass vaccinations against diphtheria were implemented. Although a toxoid-vaccine against diphtheria was available since the mid-1920s, diphtheria vaccinations in the Netherlands were not widespread before 1953, with only 4% to 13% of the population being vaccinated in the early 1940s (Hoogendoorn, 1954). Vaccinations were generally provided by local private healthcare providers or government bodies and administered by general practitioners to children aged between 4 and 9 years, while most cases of diphtheria occurred in younger children. The potential impact of these vaccinations was thus limited. The vaccines were paid for by parents, private or social health insurances, charities, or other local funding organisations, but there was no coherence between regions or a central coordination of vaccination efforts (Vos and Richardus, 2004a).

In the early 1950s the Health Care Inspectorate increased their efforts to get more children vaccinated and at a lower age. To do so, financial support was offered to Child Welfare Centers by providing a reimbursement of 1 Dutch Guilder for each registered vaccination starting in 1951. This was done through a local and government financed fund called the 'Praeventiefonds', which was tasked to provide

financial support to organisations and groups to improve public health and combat disease. In 1953, the government extended its support by providing the vaccines free of charge. Vaccines were produced or bought by the National Institute for Public Health and provided through the Health Care Inspectorate. During this time, vaccines against pertussis and tetanus became available and were provided for free through the same structure. This marks the start of the developments that would eventually lead to the organized vaccination programme we know today.

Providing financial support and consolidating the organisation of vaccination efforts increased vaccination coverage (coverage of the diphtheria vaccine for infants increased from 20% in 1953 to over 50% in 1955 (Van Wijhe et al., 2016)), but it became clear that in order to reach more children, closer collaboration between municipalities and healthcare workers was required. To unite the organisations involved in vaccinations, the first so-called 'entgemeenschap' was launched in 1955. Within this collaborative framework, Child Welfare Centers, local general practitioners, Health Organisations, municipal health services, and local governments worked together to coordinate vaccination efforts (Vos and Richardus, 2004b).

At the same time, it was recognized that a uniform registration system of vaccination was needed to monitor the progress and success of the vaccination campaigns. Since the 19th century a register of smallpox vaccinations was already kept by municipalities and was now extended with the new vaccines. At birth, children received a card on which all vaccinations was registered. With each vaccination (generally administered at Child Welfare Centers or schools), healthcare workers would send a note to the local municipality where the vaccination was recorded.

All efforts of the preceding years came together with the mass vaccination against poliomyelitis in 1957 which sparked an increased public interest in vaccination. A major nationally coordinated vaccination campaign, staged over multiple years, was organised in which all children born since 1945 were invited to be vaccinated against poliomyelitis. This catch-up vaccination programme was executed from 1957 until 1962 and reached more than 2.6 million children. It also marked the launch of the new registration system as well as the start of the expansion of the collaborative framework of 'entgemeenschappen' to the rest of the Netherlands. The mass vaccination campaign against poliomyelitis is therefore seen as the official start of the Dutch NIP (Vos and Richardus, 2004b).

The Praeventiefonds continued to financially support the NIP until 1963, when the Ministry of Social Affairs and Public Health took over the complete funding of the vaccination programme, now containing the vaccines against smallpox and the combined DTP-IPV-vaccine (diphtheria-pertussis-tetanus-inactivated poliomyelitis). Since 1974, funding was provided through the collective and government funded social health insurance (the 'Algemene Wet Bijzondere Ziektekosten'; AWBZ) which covered every Dutch citizen. All subsequent vaccines that were added to the NIP were financed in this way until 2015 when the AWBZ was abolished. In 2018, the childhood vaccination programmes will be incorporated in the Public Health Act. Currently, the NIP is coordinated by the National Institute for Public Health and the Environment (RIVM) which is also responsible for communication on the NIP, and the registration, purchase, storage, and distribution of vaccines.

Influenza vaccination programme

The first successful influenza vaccine was developed in the early 1940s and used by the US military in 1944 and 1945. In the following two decades it became clear that the influenza virus mutates rapidly and that the vaccine needs to be reformulated regularly to match it with the expected strain of influenza, although an occasional mismatch does occur (Hannoun, 2013).

Like the NIP, initially there was no national programme for influenza vaccination in the Netherlands. Vaccinations were distributed by pharmacies and administered by and at general practitioners and targeted towards risk groups. The Health Council of the Netherlands reported each year on which risk groups should be vaccinated. These groups included patients with respiratory or heart problems, patients with diabetes mellitus, patients with HIV, and other groups with medical conditions that impair an adequate immune response. Individuals belonging to the risk groups were invited each year by the general practitioner to receive the influenza vaccine.

In 1991 the vaccination coverage among high risk groups in the general population was estimated at around 28%, while coverage among the risk groups visiting hospitals may have been as high as 56% (Meynaar et al., 1991; Perenboom and Davidse, 1996). Vaccination was ongoing in earlier years but little to no data are available (vaccination coverage was likely around 5% (Beyer and Masurel, 1983)). Reasons for this low vaccination coverage were that part of the target group refused

vaccination because of doubts about efficacy, fear of side-effects, and because they thought it was not necessary. In addition, physicians also had doubts about the efficacy of the vaccine, side effects, the target groups to be vaccinated and how to reach them, and the need to vaccinate. Finally, practical reasons about access and availability may have resulted in lower uptake, as patients were requested to get the vaccine at the general practitioner (Davidse et al., 1994).

In the early 1990s, the government and other organisations decided to actively intervene and increase the coverage of influenza vaccination. This was initially attempted by reaching out to the risk groups through media campaigns. In 1992 and 1993 the Dutch Ministry of Health, Welfare and Sport, as well as other organisations including pharmaceutical companies and the National Organisation of General Practitioners, financed a national campaign, including television commercials, to inform risk-groups on the annual influenza vaccination (Sprenger and Masurel, 1992). The next step was achieved in 1995 when a national vaccination campaign was organised by the National Organisation of General Practitioners. This programme was extended in 1996 to also include everyone over 65 years of age, a strategy which was shown to be favourable in cost-effectiveness research (Postma et al., 1999). Similar to the NIP, the influenza vaccination campaign was to be financed by public funds through government funded social health insurance. Although funded similarly, influenza vaccinations are not part of the NIP but organised as a separate programme. Reason for this separation is that the vaccination needs to be repeated each year and target specific risk groups and the elderly rather than focussing on children in general.

In 1997 the programme became officially known as the National Programme Influenza Prevention and in 2008 the target age was further extended to everyone over 60 years of age in addition to risk-groups. Currently, the programme is coordinated by the RIVM that also buys and distributes the vaccines. In recent years the vaccination coverage has been declining steadily from 71.5% in 2008 to 53.5% in 2016; possibly due to an increase in healthy elderly within the target population who perceive lower risks of influenza and are less willing to vaccinate. (Tacken et al., 2015; Heins et al., 2017).

Table 6.1: Short history of the Dutch National Immunization Programmes.

Year	Vaccine	Target group	Modifications and other remarks on funding and organisation
1799	Smallpox	There was no specific target group at this time.	
1823	Smallpox	School-going children and infants under 1 year of age.	
1951			Start financial support of Child Welfare Centers by the Praeventiefonds.
1953	Diphtheria	Infants under 1 year of age.	Government starts providing vaccines for free.
1954	DTP	Infants under 1 year of age.	Diphtheria combined with tetanus and pertussis in DTP.
1955			Start first 'entgemeenschap'.
1957	Poliomyelitis	Catch-up campaign: everyone born since 1945 (3 doses). Routine vaccination: 3-, 4-, 5- and 11-month-olds (4 doses).	Official start of Dutch NIP.
	DTP	3-, 4-, 5-, 11-month-olds (4 doses)	Catch-up vaccinations for 4 and 9-year-olds.
1959			'Entgemeenschappen' extended over the rest of the Netherlands.
1962	DTP-IPV	3-, 4-, 5-, 11-month-olds (4 doses).	DTP combined with inactivated poliomyelitis vaccine in DTP-IPV.
1963			Complete funding of the NIP provided by the government.
1965	DT-IPV	4- and 9-year-olds.	
1974	Rubella	11-year-old girls.	Smallpox vaccination discontinued. Funding provided through social health insurance.
1976	Measles	14-month-olds.	
1987	MMR	14-month-old and 9-year-old boys and girls.	Measles combined with mumps and rubella in MMR.
1993	*Haemophilus influenza* serotype b (Hib)	3-, 4-, 5-. 11-month-olds (4 doses).	As a separate vaccination. Government and other organisations funded a national campaign to inform risk-groups of influenza vaccination.
1995	Influenza	Risk groups.[1]	Start of nationally organised influenza vaccination for risk-groups.
1996	Influenza	65-year-olds and over.	Influenza vaccination extended to 65-year-olds and over and financed through social health insurance.
1999	DTP-IPV and Hib	Starting age for DTP-IPV and Hib one month earlier, at 2, 3, 4, and 11 months.	

Table 6.1: *Continued.*

Year	Vaccine	Target group	Modifications and other remarks on funding and organisation
2001	Acellular pertussis (aP)	4-year-olds.	As a separate vaccine.
2002	Meningococcal serotype C (MenC)	Catch-up campaign: everyone up to 18 years old. Routine vaccination: 14-month-olds.	
2003	Hepatitis B (HepB)	2-, 3-, 4-, and 11-month-old children with parents from high risk countries and children from mothers who carry hepatitis B-virus (4 doses).	
	DTP-IPV-Hib		Hib combined with DTP-IPV in DTP-IPV-Hib.
2005			Pertussis component in DTP-IPV-Hib for infants replaced with acellular pertussis.
2006	7-valent pneumococcal conjugate vaccine (PCV-7)	2-, 3-, 4-, and 11-month-olds (4 doses).	Coordination of influenza vaccination handed to the RIVM.
	HepB	Directly after birth for children from mothers who carry hepatitis B-virus.	HepB combined with DTP-IPV-Hib for risk groups.
	DTaP-IPV		Acellular pertussis for 4-year-olds now combined in DTaP-IPV.
2007			'Entgemeenschappen' integrated in RIVM.
2008	DTaP-IPV-Hib-HepB	Children with down syndrome.	
	Influenza	60-year-olds and over.	Target age for influenza vaccination lowered to 60 years from 65.
2009	Human papilloma virus (HPV)	Catch-up campaign: everyone born between 1993 and 1996.	
2010	HPV	Start Routine vaccination: 12-year-old girls (3 doses).	
2011	PCV-10		PCV-10 replaces PCV-7.
	DTaP-IPV-Hib-HepB	2-, 3-, 4-, and 11-month-olds.	Now as a combination vaccine for all children.
2013	PCV-10		Change from four to three doses of PCV-10, at 2, 4, and 11 months.
2014	HPV		Change from three to two doses of HPV.
2018	MenACWY	14-month-olds	MenACWY replaces MenC. Catch-up campaign: everyone born between 1-5-2018 and 31-12-2018.

RIVM: National Institute for Public Health and the Environment. NIP: National Immunisation Programme.
Vaccine key: aP, acellular-pertussis; DTP, diphtheria-tetanus-pertussis; IPV, inactivated poliomyelitis vaccine; Hib, *Haemophilus influenza* serotype b; HepB, hepatitis B; MenC, meningococcal serotype C; MenACWY, meningococcal serotype A, C, W, and Y; MMR, measles-mumps-rubella; PCV, pneumococcal conjugate vaccine; HPV, human papillomavirus.
[1] Risk groups for influenza vaccinations were defined by the Health Council of the Netherlands.

Price development of vaccination programmes

Data and methods

We obtained previously uncatalogued historical expenditure data on the NIP from 1951 up to 2014, from various official reports ranging from annual reports of the Praeventiefonds, the Dutch Ministry of Health, Welfare and Sport, and Sports and her predecessors, and other official publications. For the periods 1973–1976 and 1978–1981 no data were available. We also obtained the expenditure on influenza vaccinations from 1996 up to 2014. These expenses reflect the government expenditure on the NIP and influenza vaccination, and include vaccine costs, costs of administration, personnel costs, and overhead costs, but may not contain all costs associated with vaccination programmes, such as catch-up campaigns. For most periods these costs were not separately specified. Expenditure on specific vaccinations in the NIP from 1995 to 2013 were obtained from databases of the Dutch Health Authority. Data prior to 1987, from 1991–1994, and for 2001 were unavailable. For influenza vaccination, no specific expenditures were available for the period 2004–2008 and cost for this period were based on available subsidies as reported in the 'Staatscourant' (the official Dutch Government Gazette).

We obtained the number of births, population size, as well as overall healthcare expenditure from Statistics Netherlands (Statistics Netherlands (CBS), 2017b,c). For the overall healthcare expenditure, no data were available prior to 1972. Gross Domestic Product was obtained from the Netherlands Bureau for Economic Policy Analysis (Netherlands Bureau for Economic Policy Analysis (CPB), 2017).

We adjusted the development of expenditures of the Dutch NIP, influenza vaccination, GPD, and overall healthcare costs for inflation using the Consumer Price Index (CPI) published by Statistics Netherlands (Statistics Netherlands (CBS), 2017a). By adjusting for the general price development of a basket of consumer goods and services, the movements in the expenditures on the NIP are the combined result of changes in the volumes and the specific price movements of vaccinations only. The expenditures were expressed in prices of 2016 (in Euro) and data prior to 2002 were converted to Euro from Dutch Guilders where €1 = 2.20371 Dutch Guilder. We expressed the expenditure on the NIP and influenza vaccination programme relative to demographic (population and births) and macro-economic changes (total healthcare expenditure and GDP).

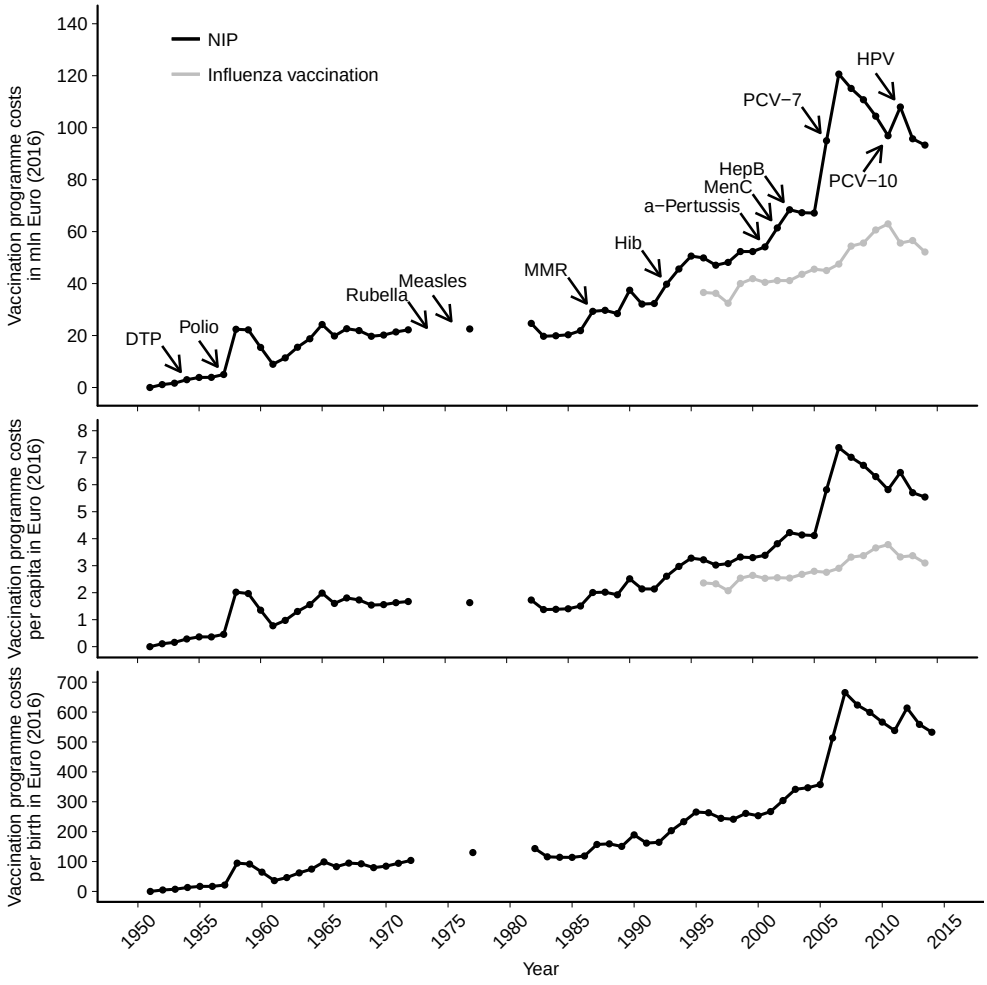

Figure 6.1: Government expenditure on the Dutch National Immunisation Programme (NIP) and influenza vaccination programme, 1951–2014, the Netherlands. Black lines indicate expenditure on the NIP, grey lines indicate the expenditure on the influenza vaccination programme. Arrows indicate when new vaccines are included in the Dutch NIP. All costs are expressed in Euro of 2016 adjusted for inflation using Consumer Price Indexes. All prices express government expenditure according to various official reports. Data for the periods 1973–1976 and 1978–1981 were unavailable. Vaccines key: DTP-IPV, diphtheria-tetanus-pertussis-inactivated poliomyelitis; rubella, only for 11-year-old girls up to 1987; MMR, measles-mumps-rubella, for both boys and girls of 14 months and 9 years of age; Hib, *Haemophilus influenza* serotype b; a-Pertussis, acellular-pertussis; MenC, meningococcal C; HepB, hepatitis B; PCV-7, 7-valent pneumococcal conjugate vaccine; PCV-10 10-valent pneumococcal conjugate vaccine; HPV, human papillomavirus.

Results

Figure 6.1 shows the total, per birth, and per capita expenditure on the Dutch NIP and influenza vaccination programme. In general, the expenditure on the NIP increased gradually over time from €5 million (mln) in 1957 to €93 mln in 2014. Government expenditure increased in particular since the end of the 1980s. The increase in costs is mainly due to the addition of new vaccines such as the measles-mumps-rubella (MMR) vaccine in 1987, the vaccine against *Haemophilus influenza* in 1993, acellular pertussis in 2001, meningococcal C in 2002, and hepatitis B for risk groups in 2003. The expenditure on the NIP increased again in 2006 with the inclusion of the pneumococcal conjugate vaccine (PCV); from €67 mln in 2005 to €120 mln in 2007. The per capita and per birth expenditure on the NIP followed a similar trend, increasing from €0.46 to €5.54 per capita and €21 to €533 per birth between 1957 and 2014. At its peak in 2007 the NIP costed €7.37 per capita and €665 per birth. Since 2007, the costs of the vaccination programme have been declining. Similar to the NIP, the expenditure on the influenza vaccination programme increased, from €37 mln in 1996 to €52 mln in 2014. In total, the government spent €145 mln (€8.65 per capita) on the NIP and influenza vaccination programme in 2014.

A breakdown of the costs of the NIP by vaccine is shown in Figure 6.2. While the total expenditure on vaccinations increased substantially when a new vaccine was introduced, the costs of a specific vaccine seemed to decline over time. For example, expenditure on the MMR vaccine declined from €6.9 mln in 1987 to €2.6 mln in 2013. Reformulations of vaccines (such as combining DTP-IPV-Hib with the hepatitis B vaccine) did not substantially impact total expenditure. The main cause of the increase in costs in 2007 was the inclusion of the PCV-7 vaccine. In 2012, the expenditure on PCV declined dramatically due to better pricing for the PCV-10 vaccine.

Figure 6.3 shows the expenditure on the NIP and influenza vaccinations as proportions of the GDP and healthcare expenditure. Overall, expenditure relative to GDP and healthcare expenditure increased as more mass vaccination programmes were implemented in the Netherlands. The proportion of healthcare expenditure spent on the NIP ranged between 0.05% and 0.14%. Similar to the overall developments in vaccination expenditure, the proportionate expenditure on the NIP increased up to

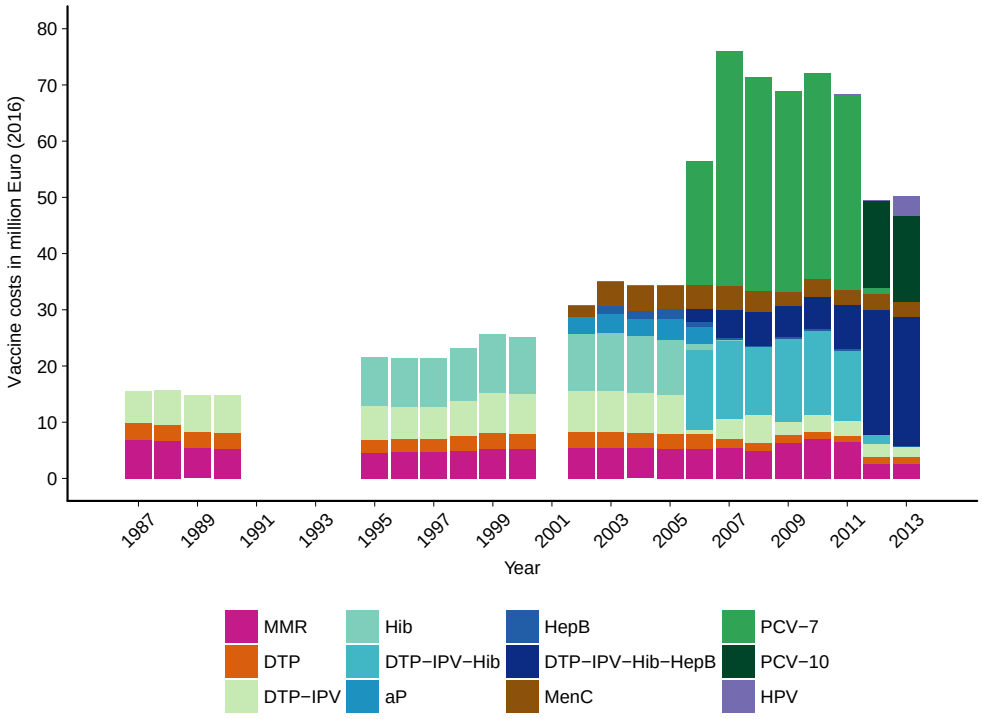

Figure 6.2: Breakdown of costs by vaccine from 1987 to 2013. All costs are expressed in Euro of 2016 adjusted for inflation using Consumer Price Indexes. Data prior to 1987, from 1991–1994, and for 2001 were unavailable. Due to differences in data sources, the timing of costs specified here may not correspond exactly to those in Figure 6.1 or changes in the programme listed in Table 6.1. HPV vaccination was officially launched in 2010 for 12-year-old girls but until 2012 the HPV programme was funded directly by Dutch Ministry of Health, Welfare and Sport and expenditures were confidential. Vaccines key: aP, acellular-pertussis; DTP, diphtheria-tetanus-pertussis; IPV, inactivated poliomyelitis; Hib, *Haemophilus influenza* serotype b; HepB, hepatitis B; MenC, meningococcal C; MMR, measles-mumps-rubella; PCV-7, 7-valent pneumococcal conjugate vaccine; PCV-10 10-valent pneumococcal conjugate vaccine; HPV, human papillomavirus.

2007, after which a steady decline was observed. Meanwhile, relative healthcare expenditure on influenza vaccination showed a decrease from 0.069% in 1996 to 0.055% in 2014. In total, 0.022% of GDP and 0.15% of healthcare expenditure was spent on vaccination programmes in 2014.

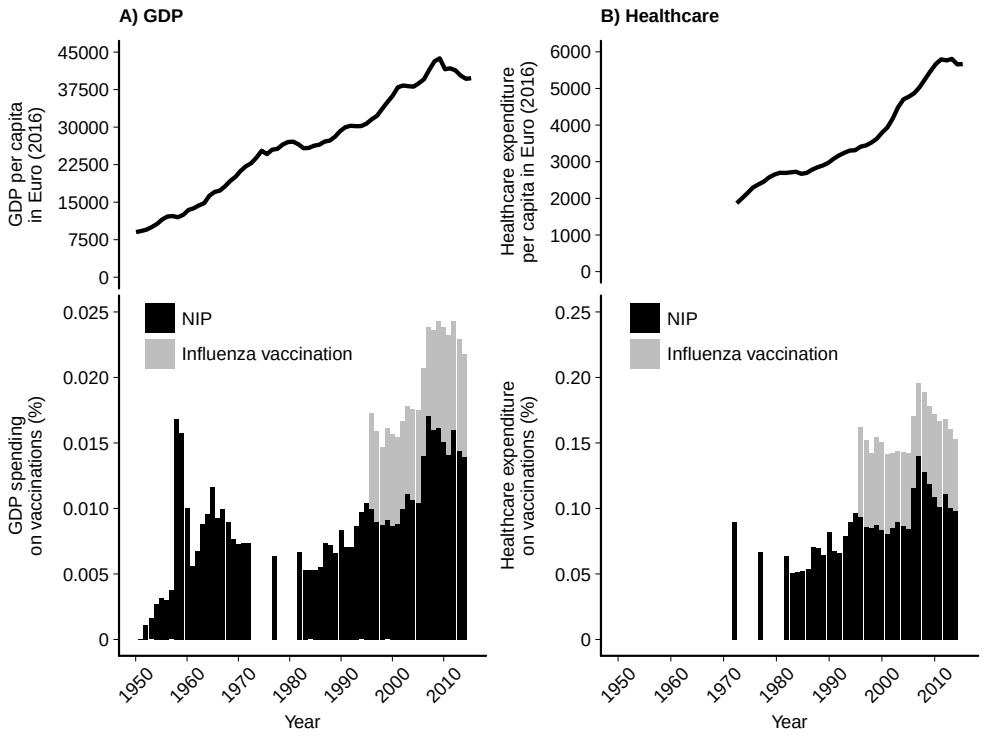

Figure 6.3: Government expenditure on vaccination programmes relative to macro-economic developments. Government expenditure relative to (A) Gross Domestic Product (GDP) for 1951–2014; and (B) relative to total healthcare expenditure for 1972–2014. Top panels show the per capita GDP and total healthcare expenditure, bottom panels show percentages expended on the National Immunisation Programme (NIP) and the influenza vaccination programme. All costs are expressed in prices of 2016 adjusted for inflation using Consumer Price Indexes. Data on cost of the NIP for the periods 1973–1976 and 1978–1981 were unavailable; no data were available on healthcare expenditure from 1951–1971.

Discussion

Vaccines are often hailed as one of the most effective public health methods in preventing infectious diseases. As the cost of new vaccines increase and in time where policy makers are confronted with limited resources and budget constraints, a historic perspective and good understanding of the evolution of the expenditure on vaccination programmes may help give context to today's decision making problems. Here we explored the organizational and financial history of vaccination programmes in the Netherlands.

The expenditure on the Dutch National Immunisation Programme has increased substantially over time, with a near five-fold increase since the mid-1980s and a near doubling since the early 2000s. We found that, both absolute and relative expenditure spiked whenever a new vaccine was introduced, but that expenditures tend to stabilise or decline when a vaccination programme covered the same vaccines.

There are two main reasons for the increase in vaccination expenditure on the long term. First, the number of included vaccines has increased. Nowadays, the Dutch NIP includes vaccines against 12 infectious diseases. Second, new vaccines are introduced at progressively higher prices. The current low costs of vaccines included in the early days of the Dutch NIP sharply contrast the new generation of vaccines which have much higher price tags. These vaccines are more complex to manufacture and thus cost more in the early years of implementation.

Over time the costs of each specific vaccination, including the more recent vaccinations, declined. The expenditure on the MMR-vaccination for example declined by more than 60% between 1987 and 2014. This was partially due to tendering for better prices and a decline in the number of births. That expenditure on specific vaccinations declines over time is likely to be true for the newer vaccines as well as evidenced by the decline in expenditure on PCV after 2011. Vaccination against PCV-7 started in 2006 and dramatically increased the expenditure on the NIP. However, with the shift to PCV-10 in 2011, which was much cheaper, prices dropped considerably.

Contrary to the childhood vaccination programmes, the expenditure on the national influenza vaccinations has not seen a drastic increase since 1996. However, as

more universal influenza vaccines are being developed (Berlanda Scorza et al., 2016) and the elderly population is poised to increase in the coming decades due to the ageing population, an increase in the expenditure on influenza vaccinations is to be expected.

Although the total government expenditure on vaccination programmes has increased substantially, overall the impact on total healthcare expenditure is very small. An earlier analysis showed that spending on vaccinations in 2003 was €8.96 per capita (1.17% of total spending on prevention in the Netherlands); compared to €6.77 in our study (De Bekker-Grob et al., 2007). Although the approaches differ and included expenditure on screening, they broadly corroborate our results. Compared to other European countries, the Netherlands spends relatively little of its healthcare budget on vaccination programmes, accounting for only 0.15% in 2014, and this has been decreasing since 2007. In an analysis of seven other European countries spending on vaccine procurement in 2014 ranged from 0.25% (Spain) of healthcare budget to 0.47% (Germany) (Ethgen et al., 2016). In part this difference is due to differences in the vaccines included (the Netherlands is slow to implement new vaccines) and in differences in financing of healthcare between European countries, and thus differences in total healthcare spending. In 2014, the Netherlands ranked 15th in the world rankings of highest expenditure on healthcare as percentage of GDP (9th on rankings per capita), spending 10.9% of its GDP on healthcare; Germany ranked 10th with 11.3% while Spain ranked 40th (World Health Organization (WHO), 2017).

The costs reported here may not include all costs that are related to vaccination. It is often unclear what is actually included in the reported government expenditure on vaccination programmes. For example the reported numbers may not include expenses related to catch-up campaigns. For example, the meningococcal catch-up campaign is estimated to have costed at least €76 mln (Welte et al., 2004). Although substantial, these are one-time expenses. In addition, while vaccines are generally considered as safe, they might cause adverse reactions, such as swellings at the injection site. These side-effects may result in healthcare utilization and thus vaccine-related healthcare costs. These costs were not taken into account here. Nevertheless, the government expenditure on vaccination programmes we reported here gives an indication of the order of magnitude on how much these programmes have costed and how the expenditures have developed over time.

While we have provided an overview of the development in government expenditure on the NIP, these expenditures should be considered in view of the benefits. Vaccination programmes are often considered amongst one of the most effective public health interventions and highly effective in preventing infectious disease morbidity and mortality (Van Wijhe et al., 2016; Roush and Murphy, 2007; Van Panhuis et al., 2013; Centers for Disease Control and Prevention (CDC), 1999; Hinman et al., 2011). By preventing disease and mortality, vaccines also avert medical cost incurred due to treatment of those diseases, costs associated with productivity loss by parents tending to stricken children, as well as other costs due to long-term sequelae. As these costs associated with disease can be substantially higher than the costs of vaccination, many vaccines are cost saving (Chabot et al., 2004; Zhou et al., 2014). Some studies have suggested that the benefits of vaccination programmes extend to other areas such as lifetime income, increasing overall well-being, better school attendance of children due to increased health, and as a consequence of these other benefits gains in productivity and longevity (Bloom, 2011; Rappuoli, 2014; Bloom, 2015). Evidence for such broader impacts remain unclear however (Jit et al., 2015).

For the near future, vaccination costs will increase further due to the implementation of new vaccines or extending the target group of already implemented vaccines. The Dutch Ministry of Health, Welfare and Sport recently decided that in 2018 the meningococcal vaccination against serotype C will be replaced with the vaccine against serotypes A, C, W, and Y. Moreover, the Health Council of the Netherlands recommended vaccination against rotavirus for newborns with high-risk conditions (mainly pre-term infants, infants with a low birth weight, or infants with birth defects). Interestingly, they also stated that vaccination of all children against rotavirus would only be recommended when the cost-effectiveness was beneficial, i.e. the vaccine price was low enough (Health Council of the Netherlands, 2017a). In the near future, the Health Council of the Netherlands is expected advise on a new vaccine against herpes zoster for the elderly. In addition, new target-groups of existing vaccines are under consideration, such as maternal pertussis vaccination (positive recommendation by the Health Council of the Netherlands in 2015), pneumococcal vaccination for elderly, HPV vaccination for boys, combined hepatitis A and B vaccination for children, and influenza vaccination for children (Health Council of the Netherlands, 2017b).

The success of a vaccination programmes is inherently tied to the willingness of policy makers to finance the purchase and delivery of vaccines, the monitoring of their effects in terms of coverage, adverse events, and the occurrence of the target diseases (Hinman et al., 2004; Verweij and Houweling, 2014). Because vaccination programmes are implemented on a large scale, targeting entire birth cohorts, it is easy to perceive them as costly endeavours. Using a historical perspective, we have shown that vaccination programmes only constitute a small portion of the government spending on healthcare and their total costs, although increasing, are relatively low. However, inclusion of a new vaccine might result in an increase in expenditure. Such jumps in expenditure should always be substantiated by additional health gains. Moreover, the expenditure on these vaccines should always be viewed in context with the history of vaccination programmes as a whole; evaluations of the costs and effects of old and new vaccines should not be done in isolation. Understanding the evolution of vaccination programmes both in an organization and financial perspective may help put context to the budgetary impact of future vaccines.

Our historical perspective on the financial developments of vaccination programmes shows that while vaccination programmes have become more expensive, they have a relatively low impact on overall healthcare expenditure. Nevertheless, recent vaccines are progressively more expensive, which may put strain on the willingness of policy makers to finance these programmes. The financial evolution of vaccination programmes provides the context for today's decision making.

Contributors
MvW obtained, extracted, and analysed the data, searched the scientific literature, and wrote the first draft of the manuscript. MvW, PTB, HJJ, HV, JW, and MJP designed the study and revised the manuscript. MvW, MJP, and JW conceived the project.

Declaration of interests
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