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Immunization funding across 28 European countries

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ACCEPTED MANUSCRIPT

Abstract

Introduction:

Disease prevention and improving vaccination coverage in Europe are key elements contributing to resilient health systems and ensuring better health outcomes for all. The aim of this study was to describe the immunization funding landscape across all European Union 28 countries (EU28).

Areas covered

Data collected in a targeted literature review supported descriptive analysis on the different indicators that were looked at: vaccines included in the EU28 national immunization programs (NIP), national immunization funding, immunization funding per capita (2015-2019) and percentage of healthcare budget allocated to immunization.

Expert opinion

Immunization funding represents a small proportion of total healthcare spend in Europe (median 0.3%). In the context of the current COVID-19 pandemic, demographic changes and the potential introduction of new vaccines; the need for adequate financing of immunization programs will be important, to establish resilient immunization systems and provide sustainable protection of the population against vaccine preventable diseases.

Keywords: Europe, national immunization program, vaccination/immunization, vaccination funding, vaccination policies

Article Highlights

- The COVID-19 pandemic has highlighted a need to strengthen health systems and crisis management, and reinforced the urgency for investment in prevention measures, including immunization programs;
- This first targeted literature review of EU28 immunization calendars and immunization budgets has shown that immunization funding has been constant over the last five years with some small upward trends observed within countries, and that Sweden, Germany and the UK funded the highest budgets per capita allocated to immunization;
- The proportion of healthcare spend dedicated to immunization ranged from 0.09% (Malta; Netherlands) to 2.51% (Luxembourg), with a median spend of 0.30%. The majority of countries spent less than 0.5% of their healthcare budgets on immunization;
- A high variability and reliability in terms of the level of publicly available data for vaccination budgets.

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1. Introduction

Vaccination is one of the most effective tools in the prevention of infectious diseases and greatly reduces disability, death and health inequity worldwide [1]. Immunization has led to the eradication of smallpox from the face of the earth, near eradication of polio and each year averts 2-3 million deaths worldwide [2,3]. Direct benefits of immunization include prevention of life-threatening or life-debilitating diseases, but immunization also bears indirect effects such as community protection (herd immunity), reduction in health care utilization and prevention of antimicrobial resistance (Pneumococcal conjugate vaccine [PCV] reduced the prevalence of resistant pneumococcal strains) [4]. Most vaccines are cost-effective with many of the older vaccines considered cost-saving, thus bringing value for money [5]. Finally, vaccination provides substantial value for society, improving health of individuals thus contributing to overall economic growth.

In Europe, vaccination prevents annually 1.6 to 2.1 million influenza cases by influenza immunization, translating into €332 million in averted costs [6]. Despite the benefits of vaccination, budgets attributed to prevention programs and vaccination by European member states remain low as demonstrated by Ethgen *et al.* who reported that less than 0.5% of country GDP is allocated to prevention programs and vaccine expenditures representing less than 0.5% of healthcare spending [7,8]. However, the research of Ethgen *et al.* was restricted to seven European countries, and to our knowledge no study has reported the national vaccination budget for each of the 28 European member states (EU28). The aim of this study was to understand the current immunization funding landscape across the EU28.

2. Materials and Methods

2.1. Literature search

We conducted a targeted review of national government sources, MEDLINE[®], MEDLINE[®] in-process and Embase[®] as well as OECD and WHO databases[9,10]. The primary data source were official government sources and these were complemented with WHO and OECD databases. The bibliographies of publications retrieved in the search of MEDLINE[®] and Embase[®] were reviewed for relevant data sources (**Figure 1**).

The following keywords were considered: 'vaccine', 'immunization', 'budgets', 'expenditure', 'healthcare financing', 'funding' and 'financing'. The geographic scope was restricted to the 28 member states of the European Union which were grouped into four regions: Northern Europe, Western Europe, Eastern Europe, and Southern Europe (**Table 1**). Of note, the study was conducted in 2019 when the UK was still part of the EU. National websites of all EU 28 countries were searched in the local language. The search was limited to the past 10 years (2009-2019). However more complete data were found for the last five years, hence the study presents data for the years 2015-2019.

Data collected by country were: national healthcare budgets, healthcare budget or expenditures dedicated to immunization programs, and vaccines included into national immunization programs (NIP). Population size and gross domestic product (GDP) were collected to support descriptive analysis [11]. EU countries published either Immunization Budget (IB) defined as planned spending or immunization expenditure (IE) referring to actual spending. These data were collected as published by national authorities including reported IB or IE, year of data, and method of calculation by authorities when available. National data sources were considered preferentially when available and WHO sources were selected otherwise. Data were validated by local experts employed by Merck Sharp & Dohme (MSD).

The following parameters were calculated based on the information collected throughout the literature review: vaccine funding per capita over time (2015-2019), percentage of healthcare budget or expenditure allocated to immunization and vaccine funding versus gross domestic product (GDP) per capita for each year data were available. The median was also calculated for the percentage of healthcare budget or expenditure allocated to immunization and median vaccine funding per capita across the EU28. All costs were expressed in euros and currencies

were converted for countries outside the Eurozone. The European Central Bank conversion rates were applied based on the annual average rate for the year data were reported [12].

3. Results

NIPs per country are presented in supplementary materials (**Supplement 1 to Supplement 4**). Data sources for the schedules are presented in Supplement 6. The UK, Ireland and Greece had the highest number of publicly funded vaccines with 17 each. Conversely, Romania had the lowest number of vaccines (n=8) publicly funded. Childhood vaccination against diphtheria, tetanus, poliomyelitis, pertussis, *Haemophilus influenzae* type B, measles, mumps, rubella and pneumococcal diseases in healthy individuals is recommended across all countries, except Estonia who does not include vaccination against pneumococcal disease. Across the EU28, the most frequently introduced vaccines over the last 10 years were vaccines against pneumococcal disease, rotavirus and human papillomavirus (HPV), whether it was implementation of the vaccine in the population or extension of vaccination to other populations such as boys for HPV vaccine.

3.1. Immunization funding

Table 2 presents detail on the sources for IB or IE by country. In terms of immunization funding no published data from national sources were found for Belgium, Bulgaria, Slovakia, Cyprus, Malta and Greece. Data from WHO Immunization Financing Indicators were then searched for these countries, but information was still missing for Belgium and Greece who therefore were not included in subsequent analyses [13]. The majority of countries published expenditure data (n=17; **Figure 2**). The Netherlands, Ireland, Hungary and Czech Republic provided both budget and expenditure data. In Estonia, Finland, Latvia, Lithuania, Luxemburg and Poland data predominantly relied on vaccine purchases. In 10 of the countries specific detail on the IB or IE was not published. Immunization funding data across Southern Europe countries were scarce: data for Portugal were only retrieved for the year 2019 and reported the combined budget of five of its regions (representing ~95% of its population) [14]. Similarly, data for Spain were only found for the year 2015 and was based on a published source by a non-government organization. **Figure 3a-Figure 3d** provides an overview of the immunization funding per capita from 2015 to 2019. The majority of countries (n=18) across the EU28 spent an annual average of €5 per capita or less over the past 5 years, with the exception of Sweden, Germany, UK,

Ireland, Italy and Luxembourg where annual immunization funding ranged from €7 to €23 per capita.

Figure 4 presents the IB or IE per capita by GDP per capita for each country based on the most recently available data. Highest IB or IE per capita were found for Sweden (€23.0 for 2017), Germany (€18.4 for 2018) and UK (€14.6 for 2017). For the countries with GDP ranging from €20,000–€40,000, immunization funding per capita ranged from ~€1 in Poland to ~€10 in France. The countries with GDP between €40,000 and €60,000 had a range of IB or IE from €5 to €23 per capita in Finland and Sweden respectively. Sweden, Germany and the UK were the outliers spending more per capita on immunization programs in the context of GDP per capita.

The proportion of healthcare spend dedicated to immunization ranged from 0.09% in Malta and the Netherlands to 2.51% in Luxemburg, with a median at 0.30% (**Figure 5**). Seventy-seven percent of the countries (n=20/26) spent less than 0.5% on immunization with only Luxemburg and Latvia spending over 1%. Data and sources for healthcare funding are provided in **Supplement 5 & 6**.

4. Discussion

The aim of our study was to describe the immunization funding landscape across the EU27 plus UK. National data have been found for 22 member states and resources from WHO provided information for 4 additional countries. Data could not be found for Greece and Belgium. Overall, there was a disparity in the public reporting of immunization funding data in terms of methodology and nomenclature (budget or expenditure) and years, thus limiting the comparability between countries. Lack of regular annual publishing of national immunization funding data was observed across southern Europe, possibly because funding in those countries is decided on a regional level (e.g. Spain, and Italy).

Immunization funding has been constant over the last five years with some small upward trends observed within some countries. The majority of countries across the EU28 spent annually on average €5 per capita or less in a five-year time period. In Italy, the upward trend from 2017 could be related to the introduction of Men B and MenACWY vaccines into the NIP in 2017, HPV vaccination of male adolescents and the implementation of rotavirus vaccination in 2018. Additionally, in 2017 after a measles outbreak, Italy increased the number of compulsory vaccines from 4 to 10. In 2016, just 87% of 2-year-old age group in Italy were vaccinated against measles. However, by the middle of 2018 that number had risen to 94% [15]. The

introduction in the Romanian NIP of the PCV vaccine in 2017 may have contributed to the increase in funding compared to 2016. Finally, the low levels of government immunization funding per capita in Poland may be explained in part by out of pocket costs with eight vaccines on the schedule that are recommended but not publicly funded. In addition, Poland also recommended and funded whole cell pertussis vaccine on their NIP, an older vaccine with likely limited budget impact.

Median immunization funding per capita was €4.22 across the 26 countries with published data. Highest and most recent IB or IE per capita were found for Sweden (€23 for 2017), Germany (€18 for 2018) and UK (€14.6 for 2017). The funding data for these countries were the most complete. The UK and Germany also have a higher number of government funded vaccines, 17 and 15, respectively. Although Sweden had an inferior number of government funded vaccines on the schedule (n=12) it had the highest immunization funding per capita. This is likely related to higher vaccine coverage rates (VCR) observed in Sweden with more than 97% of 2-year old children immunized in 2018 [16].

We found that the proportion of healthcare spend dedicated to immunization ranged from 0.09% (Malta and the Netherlands) to 2.51% (Luxemburg), with a median at 0.30%, and that 77% of the countries spent less than 0.5% of their total healthcare budget on immunization. Luxemburg and Latvia had smaller government healthcare budgets per capita, €337 (2019) and €410 (2017) respectively, compared to the Netherlands with €5,875 per capita and a percentage split of IB or IE within healthcare funding of 0.09% (See **Error! Reference source not found.**). The results of this study are similar to the findings of Ethgen *et al.* who reported that no country spent more than 0.5% of its healthcare budget on vaccines among a study group of seven European countries (Germany, England, France, Italy, Spain, Sweden and Portugal) [7,8]. In comparison to other areas of healthcare, immunization funding is small. Cardiovascular disease was associated with a cost per capita of €218 and represented 8% of total healthcare spending in 2017 across Europe [17].

Factors such as the process for purchasing of vaccines and incentives for HCPs to vaccinate could be associated with the allocation of funding across countries. A study conducted by Wilsdon *et al.* highlighted that purchasing of vaccines through price based tenders may lead to reduction in choice and value added services such as public awareness campaigns that are important for vaccine uptake [18]. In the UK, GPs receive payment based on achieving certain vaccination rate targets. In Germany there is a separate payment process for vaccinations and unlike other primary care services vaccines are not subject to budget restrictions.

There are several limitations to this study. The first one lies in the high variability and reliability in terms of the level of publicly available data for vaccination budgets. This heterogeneity in data made comparison between countries challenging and only allowed for a descriptive approach. Some countries published budget data and others expenditure. The distribution of budget in terms of vaccine acquisition costs, awareness campaigns, HCP incentives were not fully described for the majority of countries. Therefore, comparing or concluding on a relation on lower budgets and only vaccine purchase costs covered was not possible. Secondly, only overall immunization funding is considered in this study without stratification by vaccine. It could be interesting in further research to establish the distribution of budgets by vaccine and see whether funds were equally distributed or if they were concentrated on a few key areas. Additionally, further analyses would be interesting to determine potential associations between immunization funding per capita and overall vaccine coverage rate or health indicators. Finally, interviews of local experts would be valuable to confirm and further refine our results.

To our knowledge, this is the first study describing the national publishing of vaccine funding across the EU28. The current situation of vaccination in Europe is concerning with a fall in global vaccine coverage rate and compliance due to the recent emergence of anti-vaccine movements and growing mistrust in vaccination. The increase in measles cases is a good example of this lack of confidence [19]. In 2018 17,822 cases of measles were reported by 29 EU/EEA Member States representing an overall notification rate of 34.4 cases per 1,000,000 population, substantially higher than the rates in 2014–2016 (7.1–9.0 per 1,000,000) [20]. This defiance toward vaccination is even more relevant in the light of the COVID-19 pandemic outbreak that severely affected Europe in terms of excess mortality and strain on healthcare systems. Substantial consequences are forecasted for national economies with the EU economy expected to contract by 7% to 10% (estimated fall in GDP) in 2020 [21]. Numerous candidate vaccines are currently being developed, and a survey conducted by Neumann-Böhme *et al.* in seven European countries have already reported a willingness to be vaccinated against COVID-19 estimated between 62% and 80% [22]. Our results demonstrated low levels of investment in NIPs in a context of vaccine hesitancy and should encourage member states to assess the adequate level of funding to protect accordingly their populations.

5. Conclusion

This study is the first to provide an overview of the immunization funding landscape across the EU28. Despite substantial heterogeneity in data, it is estimated that 77% of the European countries spend less than 0.5% of their healthcare budget on immunization. Immunization budgets have been relatively flat over the last five years with only small increases observed. The need for adequate financing of immunization programs will be important to establish effective and resilient immunization systems and provide sustainable protection of the population against vaccine preventable diseases. This is particularly relevant in the light of the social challenges EU currently faces with an aging population, migration and refugees crisis and especially in the context of the COVID-19 pandemic and the potential introduction of new vaccines.

6. Expert opinion

The health impact of vaccination is well established, reducing considerably the burden of numerous diseases worldwide. Most vaccines have demonstrated to be cost-effective, many even cost-saving, thus bringing value for money. Furthermore, vaccination provides substantial value to society, improving long-term health of individuals thus contributing to overall economic growth. Despite the known benefits of vaccination, it has been demonstrated in a study published in 2018 that seven (of the 28) EU member states reported allocating less than 0.5% of their healthcare budget to vaccination. Our study aimed at collecting data for all EU 28 member states (UK included prior to 2019) to provide a current European landscape of vaccines calendars and investment.

As shown in the European Centers for Disease Control (ECDC) vaccine scheduler, vaccination calendars were not homogenous across EU 28 member states, with countries in Northern and Western Europe funding a more complete set of vaccination programs as compared to countries in Eastern Europe [23].

Our research on the level of investment in immunization programs of the 28 EU member states has shown that data available on immunization budget is limited; no data were available for Greece and Belgium from national sources or WHO references; and for Bulgaria, Slovakia, Cyprus and Malta, only WHO data were found. Furthermore, data was heterogeneous in terms of completeness and description of the vaccination budget across the EU 28 countries hindering comparison between countries. For the countries where data were available, immunization

funding has been constant over the last five years with some small upward trends observed in a few countries. Our findings reinforce the need for more granularity of the data being made available to the public on immunization spending

In 26 countries for which data were available, the level of investment in immunization is low compared to investment in other public health issues. Countries are spending a median of 0.3% of healthcare budget whilst in comparison the spending on cardiovascular disease management reached 8% of healthcare budget.

In the context of the current COVID-19 pandemic, vaccination has been at the center of the scientific and governmental efforts to stop the pandemic along with testing and protective measures. EU countries should put prevention measures, specifically immunization programs, as a public health priority and prioritize funding of vaccination to support access to populations as well as ensuring the successful implementation of immunization programs translating into sustainable and high vaccination coverage rates.

The aim of this study was to describe the current landscape of immunization funding in EU28 countries and did not include analysis of factors influencing immunization budget such as country specific policies, population access modalities, or funding pathways. Further research would be required to analyze these factors and understand their impact on the immunization budget. To our knowledge, this is the first study examining the national reporting of vaccine funding across the EU28 countries.

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Declaration of interest

P Faivre, G Bencina, R Drury and S Quilici are employees of Merck Sharpe & Dohme (MSD) a subsidiary of Merck & Co., Inc., Kenilworth, NJ, USA and may own stocks and/or stock options. R Campbell is an employee of Syneos Health. Syneos Health received funding by MSD to conduct this study. P Bonanni received grants for epidemiological and HTA research projects from GSK, MSD, Sanofi Pasteur, Pfizer and Seqirus and fees for taking part in advisory boards on different vaccines from the same companies. G Tesovic received grants for epidemiological and HTA research projects from GSK, MSD, Sanofi Pasteur and Pfizer and fees for taking part in advisory boards on different vaccines from the same companies. N Dauby is an unpaid consultant for MSD on the topic of economic impact of immunization and has received travel grants and invitation to scientific conferences from Pfizer and Janssens. The authors have no other relevant affiliations or financial involvement with any organization or entity with a financial interest in or financial conflict with the subject matter or materials discussed in the manuscript apart from those disclosed.

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* of interest

** of considerable interest

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Reference annotations

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- Reference 20: ECDC. Measles. In: ECDC. Annual epidemiological report for 2018. Stockholm2020.
*of interest: This article presents data on the measles outbreak in Europe and link with low vaccine coverage rates
- Reference 22: Neumann-Bohme S, Varghese NE, Sabat I, et al. Once we have it, will we use it? A European survey on willingness to be vaccinated against COVID-19. Eur J Health Econ. 2020 Sep;21(7):977-982
*of interest: This article discusses a survey reporting willingness to be vaccinated against Covid-19 vaccine in Europe

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Table 1: Geographical scope

Northern Europe		Southern Europe	
Denmark	DEN	Croatia	CRO
Estonia	EST	Cyprus	CYP
Finland	FIN	Greece	GRC
Ireland	IRL	Italy	ITA
Latvia	LVA	Malta	MLT
Lithuania	LTU	Portugal	PRT
Sweden	SWE	Slovenia	SVN
United Kingdom	UK	Spain	SPA
Western Europe		Eastern Europe	
Austria	AUT	Bulgaria	BGR

Belgium	BEL	Czech Republic	CZE
France	FRA	Hungary	HUN
Germany	GER	Poland	POL
Luxembourg	LUX	Romania	ROU
The Netherlands	NLD	Slovakia	SVK

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Table 2: National immunization data availability (published information)

Country	Budget	Expenditure	Source
Austria	No data found	Expenditure on vaccinations	[24]
Belgium	No data found	No data found	NA
Bulgaria	No data found	Government expenditure on vaccines reported by WHO	[13]
Croatia	No data found	Vaccine expenditure from the Croatian Health Insurance Fund	[25]
Cyprus	No data found	Government expenditure on vaccines reported by WHO	[13]
Czech Republic	Planned spend on vaccination and pandemic plan	Expenditure on immunization programs*	[26]
Denmark	Budget for the child vaccination program and influenza vaccine	No data found	[27]
Estonia	Budget for the purchase of vaccines only, in the immunization program under the infectious disease prevention and control act	No data found	[28]
Finland	Budget for the purchase of vaccines	No data found	[29]
France	No data found	Expenditure on organized vaccinations financed by local authorities and the National Fund for Prevention, Education	[30]

Country	Budget	Expenditure	Source
		and health information (INPES)	
Germany	No data found	Vaccination expenditure by the statutory health Insurance fund	[31]
Greece	No data found	No data found	NA
Hungary	Published national were only available for 2019	WHO data were available for the years 2015-2018 and based on the government expenditure on vaccines	[13,32]
Ireland	National Immunization Office budget for years 2018-19	Expenditure on immunization programs for years 2015-17	[33,34]
Italy	Budget for the purchase of vaccines included in the national vaccine plan*	No data found	[35]
Latvia	The budget for the purchase of vaccines and syringes	No data found	[36]
Lithuania	The budget for the purchase of vaccines and syringes in the National Immunoprophylaxis Program	No data found	[37]
Luxembourg	The budget for the acquisition of vaccines and related costs	No data found	[38]
Malta	No data found	Government expenditure on vaccines reported by WHO	[13]
Netherlands	Budget includes the combined cost for	Expenditure includes funding for the implementation of the	[39]

Country	Budget	Expenditure	Source
	disease prevention vaccinations and the National Institute for Health and Environment contribution to vaccinations	national immunization program (costs of vaccines and organization costs and the Vaccine Service and Prevention Programs together). Reflects only the national immunization program and no other programs such as the influenza program*	
Poland	No data found	Expenditure on the purchase of vaccines to carry out compulsory preventive vaccinations	[40]
Portugal	Combined budget for the vaccines acquisition by the 5 regional health administration of the Ministry of Health: Lisbon and the Tagus Valley, Alentejo, Algarve, Centro and North	No data found	[41]
Romania	Budget allocated to the National vaccination program	No data found	[42]
Slovakia	No data found	Government expenditure on vaccines reported by WHO	[13]
Slovenia	No data found	Vaccine expenditure by the sick fund financial plan	[43]
Spain	No data found	Vaccine expenditure, published by non-government organization Deloitte	[44]
Sweden	No data found	Expenditure on immunization programs	[45]
United	No data found	Expenditure on immunization programs	[46]

Country	Budget	Expenditure	Source
Kingdom			

NA = Not Applicable; WHO = World Health Organization

* Expenditure data were more representative of the study objective and considered for the analyses in this study

‡ Budget for 2017 to 2019 represents the incremental budget and was combined to the baseline historical 2015 expenditure to present the total value

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Figures (see attachments)

Figure 1: Literature source hierarchy

Figure 2: Overview immunization budget and expenditure reporting (EU27 plus UK)

Note: Refer to Table 2 for more detail

Figure 3a Northern Europe, Figure 3b Western Europe, Figure 3c Eastern Europe, Figure 3d Southern Europe: Immunization funding per capita over the five year period (2015-2019; €)

AUT= Austria ; BEL= Belgium ; BGR= Bulgaria ; CRO= Croatia ; CYP= Cyprus ; CZE= Czech Republic ; DEN= Denmark ; EST= Estonia ; FIN= Finland ; FRA= France ; GER= Germany ; GRC= Greece ; HUN= Hungary ; IRL= Ireland ; ITA= Italy ; LTU= Lithuania ; LUX= Luxembourg ; LVA= Latvia ; MLT= Malta ; POL= Poland ; PRT= Portugal ; ROU= Romania ; SPA= Spain ; SVN= Slovenia ; SWE= Sweden ; UK= United Kingdom

¥Ireland: Expenditure data applied for 2015-2017 and budget data for 2018 and 2019

*UK: Before the currency conversion from GBP to EUR in 2015 immunization funding was the lowest, followed by 2017. The lower rate in Euros for 2016 and 2017 are likely due to the impact of a weaker GBP/EUR exchange rate

□ Hungary: Expenditure data 2015-2018 and budget data for 2019

No data retrieved for Belgium or Greece

Figure 4: Immunization funding per capita versus GDP per capita (€/year)

AUT= Austria ; BEL= Belgium ; BGR= Bulgaria ; CRO= Croatia ; CYP= Cyprus ; CZE= Czech Republic ; DEN= Denmark ; EST= Estonia ; FIN= Finland ; FRA= France ; GER= Germany ; GRC= Greece ; HUN= Hungary ; IRL= Ireland ; ITA= Italy ; LTU= Lithuania ; LUX= Luxembourg ; LVA= Latvia ; MLT= Malta ; POL= Poland ; PRT= Portugal ; ROU= Romania ; SPA= Spain ; SVN= Slovenia ; SWE= Sweden ; UK= United Kingdom

Figure 5: Proportion of healthcare budget dedicated to immunization budget or expenditure

AUT= Austria ; BEL= Belgium ; BGR= Bulgaria ; CRO= Croatia ; CYP= Cyprus ; CZE= Czech Republic ; DEN= Denmark ; EST= Estonia ; FIN= Finland ; FRA= France ; GER= Germany ; GRC= Greece ; HUN= Hungary ; IRL= Ireland ; ITA= Italy ; LTU= Lithuania ; LUX= Luxembourg

*; LVA= Latvia ; MLT= Malta ; POL= Poland ; PRT= Portugal ; ROU= Romania ; SPA= Spain ;
SVN= Slovenia ; SWE= Sweden ; UK= United Kingdom*

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Supplementary materials

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Supplement 1: Vaccine schedule (Northern Europe)

See Attached Image .tif file

Abbreviations – DTaP: Diphtheria and tetanus toxoids and acellular pertussis vaccine; IPV: Inactivated Poliovirus Vaccine; Hib: Haemophilus influenzae type b; HepB: Hepatitis B Vaccine; PCV: Pneumococcal Conjugate Vaccine; MenB: Meningococcal B vaccine; Rota: Rotavirus Vaccine; MenC: Meningococcal C Vaccine; MMR: Measles, Mumps & Rubella Vaccine; LAIV: Live, Attenuated Influenza Vaccine; HPV: Human Papillomavirus; Td: Tetanus & diphtheria Vaccine; MenACWY: Meningococcal Conjugate Vaccine; PPV: Pneumococcal Polysaccharide Vaccine; IIV: Inactivated Influenza Vaccine; ZOS: Herpes zoster; BCG: Bacille Calmette-Guérin Vaccine; dT: Diphtheria and tetanus vaccine; VAR: Varicella Vaccine; Tdap: Tetanus, low-dose diphtheria and low-dose acellular pertussis vaccine; TBE: Tick-borne encephalitis

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Supplement 2: Vaccine schedule (Western Europe)

See Attached Image .tif file

Abbreviations – DTaP: Diphtheria and tetanus toxoids and acellular pertussis vaccine; IPV: Inactivated Poliovirus Vaccine; Hib: Haemophilus influenzae type b; HepB: Hepatitis B Vaccine; PCV: Pneumococcal Conjugate Vaccine; MenB: Meningococcal B vaccine; Rota: Rotavirus Vaccine; MenC: Meningococcal C Vaccine; MMR: Measles, Mumps & Rubella Vaccine; LAIV: Live, Attenuated Influenza Vaccine; HPV: Human Papillomavirus; Td: Tetanus & diphtheria Vaccine; MenACWY: Meningococcal Conjugate Vaccine; PPV: Pneumococcal Polysaccharide Vaccine; IIV: Inactivated Influenza Vaccine; ZOS: Herpes Zoster; BCG: Bacille Calmette-Guérin Vaccine; dT: Diphtheria and tetanus vaccine; VAR: Varicella Vaccine; Tdap: Tetanus, low-dose diphtheria and low-dose acellular pertussis vaccine; TBE: Tick-borne encephalitis

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Supplement 3: Vaccine schedule (Eastern Europe)

See Attached Image .tif file

Abbreviations – DTaP: Diphtheria and tetanus toxoids and acellular pertussis vaccine; IPV: Inactivated Poliovirus Vaccine; Hib: Haemophilus influenzae type b; HepB: Hepatitis B Vaccine; PCV: Pneumococcal Conjugate Vaccine; MenB: Meningococcal B vaccine; Rota: Rotavirus Vaccine; MenC: Meningococcal C Vaccine; MMR: Measles, Mumps & Rubella Vaccine; LAIV: Live, Attenuated Influenza Vaccine; HPV: Human Papillomavirus; Td: Tetanus & diphtheria Vaccine; MenACWY: Meningococcal Conjugate Vaccine; PPV: Pneumococcal Polysaccharide Vaccine; IIV: Inactivated Influenza Vaccine; ZOS: Herpes zoster; BCG: Bacille Calmette-Guérin Vaccine; dT: Diphtheria and tetanus vaccine; VAR: Varicella Vaccine; Tdap: Tetanus, low-dose diphtheria and low-dose acellular pertussis vaccine; TBE: Tick-borne encephalitis

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Supplement 4: Vaccine schedule (Southern Europe)

See Attached .tif file

Abbreviations – DTaP: Diphtheria and tetanus toxoids and acellular pertussis vaccine; IPV: Inactivated Poliovirus Vaccine; Hib: Haemophilus influenzae type b; HepB: Hepatitis B Vaccine; PCV: Pneumococcal Conjugate Vaccine; MenB: Meningococcal B vaccine; Rota: Rotavirus Vaccine; MenC: Meningococcal C Vaccine; MMR: Measles, Mumps & Rubella Vaccine; LAIV: Live, Attenuated Influenza Vaccine; HPV: Human Papillomavirus; Td: Tetanus & diphtheria Vaccine; MenACWY: Meningococcal Conjugate Vaccine; PPV: Pneumococcal Polysaccharide Vaccine; IIV: Inactivated Influenza Vaccine; ZOS: Herpes zoster; BCG: Bacille Calmette-Guérin Vaccine; dT: Diphtheria and tetanus vaccine; VAR: Varicella Vaccine; Tdap: Tetanus, low-dose diphtheria and low-dose acellular pertussis vaccine; TBE: Tick-borne encephalitis

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Supplement 5: Government healthcare funding per capita

See attached file

Note: See Supplement 6 for government healthcare funding sources

AUT= Austria ; BEL= Belgium ; BGR= Bulgaria ; CRO= Croatia ; CYP= Cyprus ; CZE= Czech Republic ; DEN= Denmark ; EST= Estonia ; FIN= Finland ; FRA= France ; GER= Germany ; GRC= Greece ; HUN= Hungary ; IRL= Ireland ; ITA= Italy ; LTU= Lithuania ; LUX= Luxembourg ; LVA= Latvia ; MLT= Malta ; POL= Poland ; PRT= Portugal ; ROU= Romania ; SPA= Spain ; SVN= Slovenia ; SWE= Sweden ; UK= United Kingdom

Supplement 6: Healthcare budgets and vaccine schedule data sources

Country	Healthcare budget or expenditure	Vaccination calendar
Austria	Jahrbuch der Gesundheitsstatistik 2017 [47]	ECDC Vaccine Scheduler [23]
Belgium	Not considered for the analysis as no immunization funding data found	ECDC Vaccine Scheduler [23]
Bulgaria	WHO Health Expenditure [48]	Национална информационна кампания „Ваксинко“. 2017. Mandatory immunisation calendar [49] ECDC Vaccine Scheduler [23]
Croatia	Croatian Health Insurance Fund [25]	Calendar of Continuous Vaccination in the Republic of Croatia in 2019 [50]

Country	Healthcare budget or expenditure	Vaccination calendar
		ECDC Vaccine Scheduler [23]
Cyprus	WHO Health Expenditure [48]	ECDC Vaccine Scheduler [23]
Czech Republic	Cesky Statisticky Urad. Výsledky zdravotnických účtů ČR v letech 2010 až 2017. [26]	Dětský očkovací kalendář hrazeného očkování v ČR platný k 1. 9. 2019 [Online]. [51] ECDC Vaccine Scheduler [23]
Denmark	Statistikbanken [52]	Statens Serum Institut (SSI). 2019. The Danish child vaccination program [Online]. [53] ECDC Vaccine Scheduler [23]
Estonia	Rahandusministeerium [54]	Vaktsineeri. National immunisation program [55] ECDC Vaccine Scheduler [23]
Finland	Valtion talousarvioesitykset. [29]	Terveyden ja hyvinvoinnin laitos (THL). 2019. Vaccination program for children and adults [Online]. [56] ECDC Vaccine Scheduler [23]

Country	Healthcare budget or expenditure	Vaccination calendar
France	Ministère des Solidarités et de la Santé. Les dépenses de santé [30]	Ministère des Solidarités et de la Santé. 2019. <i>Le calendrier vaccinal</i> [Online]. [57] ECDC Vaccine Scheduler [23]
Germany	GBE-Bund [58]	Robert Koch Institute. 2019. <i>Impfkalender der Ständigen Impfkommission</i> [59] ECDC Vaccine Scheduler [23]
Greece	Not considered for the analysis as no immunization funding data found	National Child and Adolescent Vaccination Program 2017 [60] ECDC Vaccine Scheduler [23]
Hungary	TÖRVÉNYJAVASLAT MAGYARORSZÁG 2019. ÉVI KÖZPONTI KÖLTSÉGVETÉSÉRŐL [32]	A Nemzeti Népegészségügyi Központ módszertani levele a 2019. évi védőoltásokról [61] ECDC Vaccine Scheduler [23]
Ireland	Central Statistics Office [33]	HSE Immunisation Schedule 2019 [62] ECDC Vaccine Scheduler [23]
Italy	Gazzetta Ufficiale 2019 [63]	Il calendario vaccinale del Piano Nazionale di Prevenzione Vaccinale 2017-

Country	Healthcare budget or expenditure	Vaccination calendar
		2019 [64]
		ECDC Vaccine Scheduler [23]
Latvia	Veslibas ministrija. State-funded healthcare. [36]	Latvijas Vēstnesis. 2019. Amendments to the Cabinet of Ministers Regulations No. 330 " Vaccination Rules " [65]
		ECDC Vaccine Scheduler [23]
Lithuania	Ministry of Health of The Republic of Lithuania [66]	Valstybinė Ligonių Kasa. 2018. Calendar of childhood preventive vaccinations [Online]. [67]
		ECDC Vaccine Scheduler [23]
Luxemburg	Ministere de la Sante [68]	Ministère de la Santé. 2019. Calendrier des vaccinations [Online] [69]
		ECDC Vaccine Scheduler [23]
Malta	WHO Health Expenditure [48]	Health.gov.mt. 2019. National Immunisation Schedule [70]
		ECDC Vaccine Scheduler [23]
Netherlands	Centraal Bureau voor de Statistiek [71]	Rijksinstituut voor Volksgezondheden Milieu (RVM) - Ministerie van Volksgezondheid Welzijn en

Country	Healthcare budget or expenditure	Vaccination calendar
		Sport. 2019. Vaccinatieschema [72] ECDC Vaccine Scheduler [23]
Poland	STAN POLITYKI.PL [73]	Szczepienia. 2019. Historic Vaccination Programs [74] ECDC Vaccine Scheduler [23]
Portugal	Ministry of Health [75]	Direção-Geral da Saúde (DGS). 2017. PNV 2017: Esquema vacinal recomendado [Online] [76] ECDC Vaccine Scheduler [23]
Romania	Budget Law no 5/2020 published in the Official Gazette no 2/ 6.01.2020. [77]	Desprevaccin. 2019. Calendar Vaccinare [Online].[78] ECDC Vaccine Scheduler [23]
Slovakia	WHO Health Expenditure [48]	Úrad Verejného Zdravotníctva Slovenskej Republiky. 2019. <i>Ockovací Kalender</i> [Online]. [79] ECDC Vaccine Scheduler [23]
Slovenia	Zavod za zdravstveno zavarovanje Slovenije. Finančni načrt za leto 2019. [80]	Nacionalni inštitut za javno zdravje. 2019. Vaccination calendar for preschool and school children in Slovenia [Online]. [81] Nacionalni inštitut za javno zdravje. Navodila za izvajanje

Country	Healthcare budget or expenditure	Vaccination calendar
		Programa cepljenja in zaščite z zdravili za leto 2019. [82] ECDC Vaccine Scheduler [23]
Spain	Ministerio de Sanidad, Servicios Sociales e Igualdad. Sistema de Cuentas de Salud. Principales resultados [83]	Ministerio de Sanidad. 2019. Calendario de vacunación a lo largo de toda la vida [Online]. [84] ECDC Vaccine Scheduler [23]
Sweden	SCB, Statistiska Centralbyran [85]	Folkhälsomyndigheten. 2019. Vaccination programmes [Online]. [86] ECDC Vaccine Scheduler [23]
United Kingdom	Office of National Statistics [46]	GOV.UK. 2019. Complete routine immunisation schedule [Online]. [87] ECDC Vaccine Scheduler [23]

ECDC =European Centre for Disease Prevention and Control; WHO=World Health Organization;

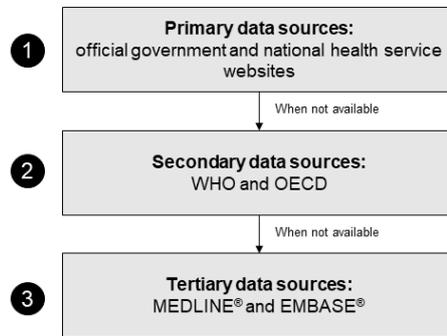


Fig 1

ACCEPTED MANUSCRIPT

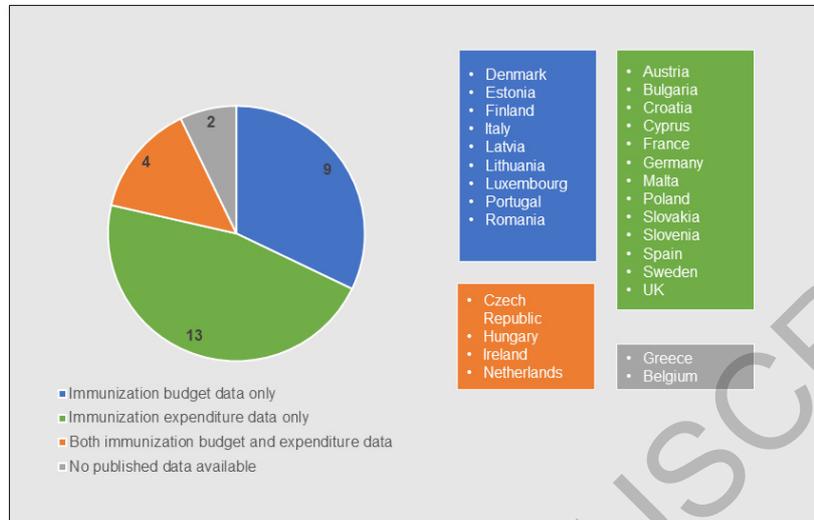


Fig 2

ACCEPTED MANUSCRIPT

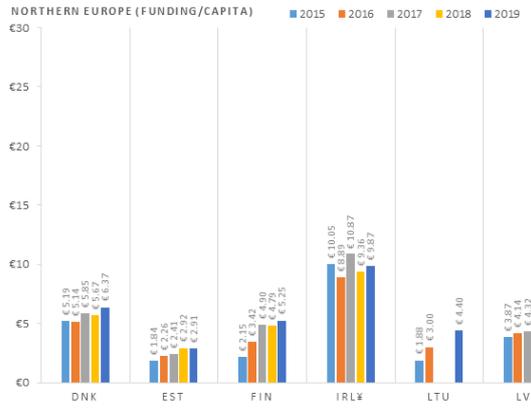


Figure 3a

ACCEPTED MANUSCRIPT

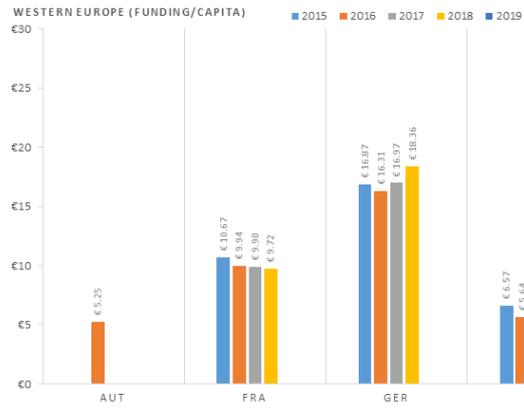


Figure 3b

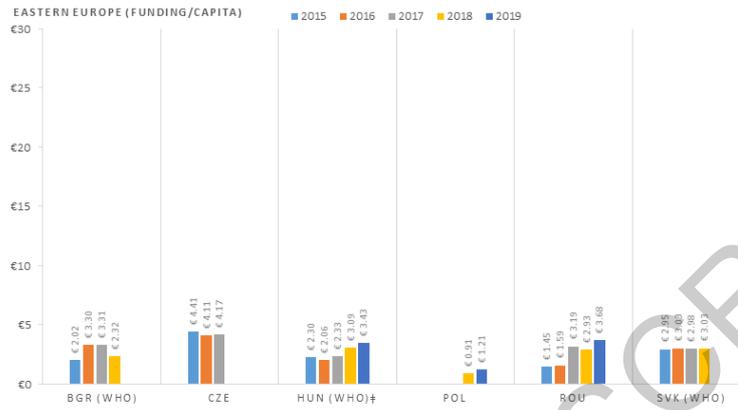


Figure 3c

ACCEPTED MANUSCRIPT

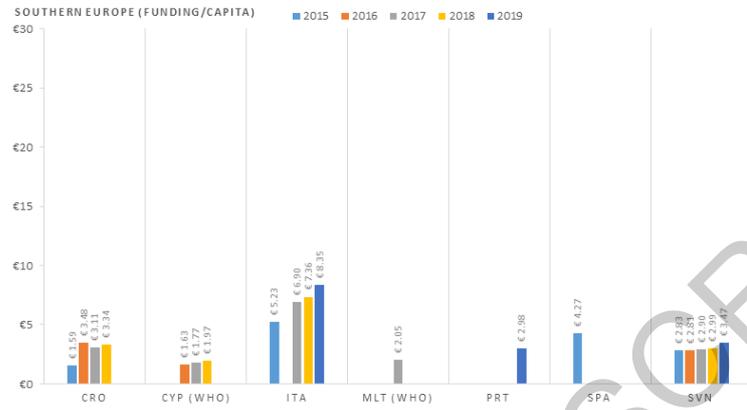
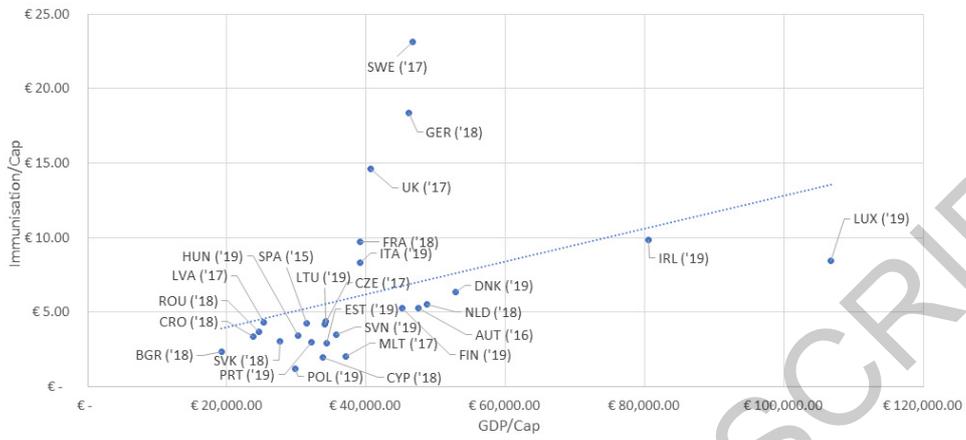


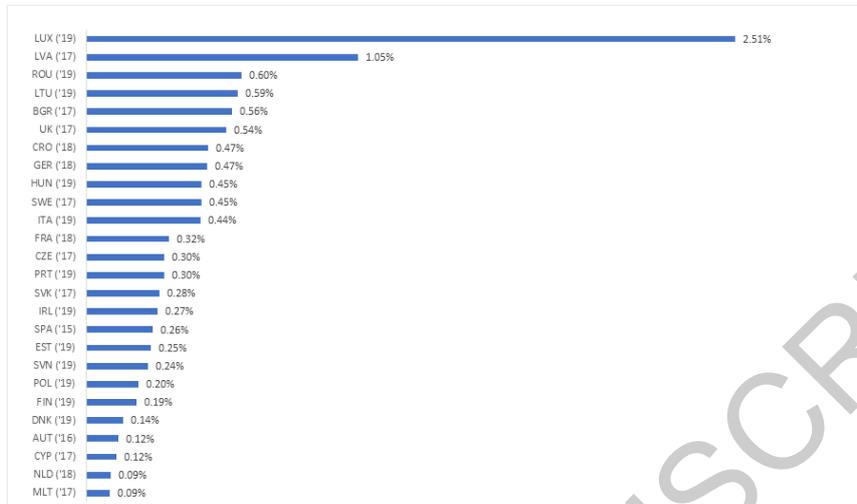
Figure 3d

ACCEPTED MANUSCRIPT



New Figure 4

ACCEPTED MANUSCRIPT



New Figure 5

ACCEPTED MANUSCRIPT