To recommend or to obligate? – How policies affect measles vaccination rates in the EU

by

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I hope that the readers of this thesis get as curious and thoughtful about the global fight against measles as me and that you enjoy the reading.

Katharina Schmitz

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Abbreviations	Meaning
Czech Rep.	Czech Republic
EEA	European Economic Area
EWRS	Early Warning & Response System
ECDC	European Centre for Disease Prevention and Control
EU	European Union
FInt	Frequency of internet use
MCpM	Measles cases per million inhabitants
UK	United Kingdom of Great Britain and Northern Ireland
VR	Vaccination rate(s)
WHO	World Health Organization

Abstract

The present master thesis detects whether the mandatory character of measles vaccination policies influenced the measles vaccination rates and whether this also impacted the influence of measles outbreaks and internet access on measles vaccination rates in 19 selected EU countries between 2010 and 2016.

Data permitting to evaluate the relations between policies, measles outbreaks, internet use and national measles vaccination rates in the EU between 2010 and 2016 were processed in a statistical analysis.

Keeping the limited statistical power of the sample in mind, the answer to the research question is that on average the mandatory measles vaccination rates among the 19 studied EU countries were higher between 2010 and 2016 in those countries with legally compulsory measles vaccinations. However, for the relationship between measles outbreaks and measles vaccination rates, the measles policy approach of a country appeared to be of small importance. Against theoretical expectation of a negative relationship, the daily internet use of individuals was not related in countries with measles vaccination recommendations and positively related to measles vaccination rates in countries with mandatory measles vaccination policies.

In conclusion it can be said that differences in measles vaccination rates seem to originate less from the differences in measles vaccination policy approaches but rather from the different national political and economic trajectories. It is noticed that mandatory measles vaccination policies were only in place in countries which were under communist, Soviet power influence until few decades ago while the majority of cases of non-mandatory measles vaccination policies are formed by Western EU countries (except from Estonia, Lithuania and Latvia). Increasing measles vaccination rates and percentages in daily internet use just may reflect the situation of those experiencing the improving living standards in these countries, rather than being competing forces in the attempt of achieving measles herd immunity.

Key words: measles vaccination rates, policies, EU countries, internet use, measles outbreaks Health Belief Model

1. Introduction

In autumn 2018, the World Health Organization (WHO, 2018a) reported that the goal to eliminate measles in its five regions by 2020 would be under threat. Measles is a highly contagious, potentially fatal illness that can be prevented via vaccinations initially given in childhood and refreshed in the course of a human's life (ECDC, 2018, p.2). The European Center for Disease Prevention and Control (ECDC) estimates that around 90 % of non-immune people would be infected if being exposed to anyone with measles (ECDC, 2018a).

The overall high immunisation rate coverage in Europe, which has recently been the only effective preventive measure against acquiring measles, may be a positive development into the right direction but might be considered as insufficient when aiming to continuously hinder frequent measles outbreaks in Europe from occurring in the future (ECDC, 2018a). On one of their webpages, the European Union (EU) summarises its actions in the field of vaccination as: "ensuring access to vaccine for all, control all vaccines to ensure highest safety standards, share clear, independent and transparent transformation and to support research to develop new vaccines" (European Commission, 2018) as well as to assist EU countries in coordinating their vaccination policies and programmes. EU vaccination policies are rather setting broad rules and objectives national measles vaccination policies should aim on; such as recommending the development and implementation of national vaccination plans with incentives to improve routine vaccination status checks. However, vaccination policy remains "a competence of national authorities" (European Commission, 2018), consisting of designing, implementing and monitoring measles vaccination policies. Since the EU thus gives leeway to its member states on measles vaccination policy design, variation in the different national policies are expected and shall be revealed in the frame of this research.

The failure of EU member states to eliminate measles has been associated with obstacles that hindered the achievement of herd immunity in countries. The achievement of herd immunity, meaning "population coverage for the second dose of measles-containing vaccine is at least 95 %" (ECDC, 2018e, p.8), is considered as one of the effective tools to prevent measles outbreaks and its complications from occurring.

The overarching goal of this study is to learn why countries in the EU widely have failed to achieve measles herd immunity. Thereby it is focused on the question whether in countries with mandatory measles vaccination policies measles vaccination rates and measles outbreaks as well as measles vaccination rates and daily internet are differently related with each other than in countries that only recommend measles vaccinations.

Nine EU member states are excluded from this study, due to lacking data availability: Austria, Croatia, Cyprus, Finland, Greece, Italy, Luxembourg, Romania and the Republic of Ireland. The 19 EU countries included in this study thus are: Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the United Kingdom (UK).

Between 1998 and 2017, strong fluctuations in the number of measles cases in the EU could be observed (Table 1) (Carrillo-Santisteve & Lopalco, 2012, p.50), what may be traced back to variations in measles vaccination rates among EU countries over the examined time period (Table 2), (Carrillo-Santisteve & Lopalco, 2012, p.52). In the EU, Estonia, Hungary, Latvia, Malta, Portugal, Slovenia and Sweden are the countries which both, at least once had reached the herd immunity threshold of 95 % between 1998 and 2016 and never faced annually more than 100 reported measles cases per year. In Austria, Belgium, France, Germany, Greece, Italy and the UK, herd immunity was never reached since the measles vaccination rates stayed below 95 % during the selected time period and in one or several years these countries also faced at least once more than 100 annually reported measles cases. Despite not having reached herd immunity between 1998 and 2017 Cyprus, Denmark, Finland, Luxembourg and Malta nevertheless were not confronted with more than 100 annually reported measles cases. In contrast, Bulgaria, Croatia, the Czech Republic, Lithuania, the Netherlands, Poland, Romania, Slovakia and Spain, despite having reached herd immunity against measles at least for a certain period between 1998 and 2017, still notified more than 100 measles cases per year, underlining the importance of not only reaching but also consolidating herd immunity against measles in the long-term is crucial for measles elimination (Table 1, Table 2, WHO, 218b+2018c). Carrillo-Santisteve and Lopalco (2012) reflect on why the goal of measles elimination has not been achieved in the EU so far.

Table 1. Annual number of reported measles cases

Country	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Austria	95	27	309	117	0	36	68	52	49	448	20	23	9	15	90	n.d.	0	n.d.	1	0
Belgium	367	n.d.	47	70	39	109	576	40	33	98	64	15	26	61	44	n.d.	83	n.d.	n.d.	0
Bulgaria	165	1	0	0	14	1	157	22004	2249	1	1	1	3	0	0	0	8	46	24	80
Croatia	7	4	206	n.d.	0	2	12	7	2	51	0	1	2	54	19	6	8	9	31	648
Cyprus	3	0	0	10	0	1	0	18	0	1	0	0	1	0	0	0	n.d.	0	0	1
Czech Rep.	142	7	9	222	15	22	17	0	5	2	2	7	0	17	30	4	6	9	2	19
Denmark	4	3	9	27	17	2	84	5	6	14	2	27	2	0	0	32	11	14	n.d.	n.d.
Estonia	1	2	4	0	2	4	7	0	0	0	1	27	2	0	0	0	0	9	12	17
Finland	11	4	2	n.d.	2	n.d.	27	5	2	5	0	0	1	0	0	0	1	n.d.	n.d.	1
France	519	79	157	267	272	n.d.	14949	5048	1541	604	39	40	36	4448	n.d.	5185	n.d.	10000	n.d.	n.d.
Germany	929	326	2464	443	1771	166	1607	780	574	917	567	2307	778	121	779	4657	6024	n.d.	n.d.	n.d.
Greece	968	0	1	1	3	3	40	149	2	1	2	n.d.	122	1	n.d.	5	12	56	69	66
Hungary	36	0	0	0	1	2	5	0	1	0	0	1	2	0	0	0	20	1	1	23
Ireland	25	n.d.	4	33	51	107	285	443	164	57	64	87	95	334	584	243	241	n.d.	147	204
Italy	4042	n.d.	159	n.d.	n.d.	376	5189	372	351	1617	321	439	135	599	10982	9385	n.d.	1457	2908	4072
Latvia	0	0	0	36	0	3	1	0	0	3	0	7	2	0	n.d.	n.d.	1	0	0	3
Lithuania	2	22	50	11	35	0	7	2	0	1	0	1	1	1	1	103	7	19	23	18
Luxembourg	4	0	0	n.d.	0	2	6	0	0	1	0	8	n.d.	0	1	n.d.	n.d.	0	n.d.	n.d.
Malta	0	0	2	0	n.d.	n.d.	3	0	1	1	2	1	6	4	4	7	2	2	1	3
Netherlands (the)	16	6	7	140	2632	10	51	15	15	109	10	1	4	11	4	3	n.d.	1019	2368	9
Poland	63	123	n.d.	n.d.	84	71	n.d.	13	115	n.d.	40	120	13	11	48	34	133	77	99	2255
Portugal	34	0	8	n.d.	1	23	2	5	3	1	0	0	7	5	8	8	n.d.	45	50	96
Romania	9076	2435	4	59	1159	6450	4189	193	8	12	353	3196	5043	117	9	14	10	35	240	9547
Slovakia	7	0	1	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	530
Slovenia	8	1	18	52	1	2	22	2	0	0	0	0	0	0	0	0	0	n.d.	1	13
Spain	161	37	115	154	131	1204	3802	302	41	297	267	362	22	26	256	67	n.d.	152	246	446
Sweden	41	3	22	26	51	30	26	6	3	25	1	19	13	5	3	9	5	59	n.d.	n.d.
UK	364	558	91	133	1919	2092	1112	443	1212	1445	1022	764	79	189	460	314	73	104	n.d.	74
Average	610	146	137	82	328	469	1194	1068	228	212	99	276	237	215	533	837	316	596	311	788

Source:(WHO, 2018c)

Table 2. *Annually reported estimates of measles-containing vaccine (2nd dose) coverage (in %)*

Country/Year	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998
Austria	84	89	n.d.	87	n.d.	n.d.	n.d.	n.d.	64	62	56	61	91	47	46	39	34	35	n.d.	n.d.
Belgium	85	85	85	85	85	85	83	83	83	81	78	78	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Bulgaria	92	88	87	89	94	94	94	96	93	94	94	93	92	91	89	79	85	83	97	n.d.
Croatia	95	96	96	97	97	97	98	98	n.d.	98	98	98	98	98	98	98	98	n.d.	n.d.	n.d.
Cyprus	n.d.	n.d.	n.d.	n.d.	n.d.	0	n.d.	88	88	89	93	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Czech Rep.	90	93	99	96	99	99	98	98	98	98	98	98	97	97	97	98	97	97	n.d.	n.d.
Denmark	88	85	80	84	86	87	86	85	85	n.d.	88	91	91	88	88	92	87	n.d.	n.d.	n.d.
Estonia	91	92	92	93	92	94	95	95	96	97	97	98	98	97	96	94	84	89	n.d.	n.d.
Finland	92	85	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
France	80	80	79	77	75	72	67	61	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Germany	93	93	93	93	92	92	92	90	89	88	83	77	66	51	53	27	n.d.	n.d.	n.d.	n.d.
Greece	n.d.	n.d.	n.d	n.d.	83	83	77	n.d.	77	77	77	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Hungary	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	99	n.d.	n.d.
Italy	86	n.d.	83	83	84	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Latvia	89	89	92	89	92	92	92	93	92	94	98	99	99	98	99	96	95	90	n.d.	n.d.
Lithuania	92	92	92	92	92	93	94	95	94	96	96	94	95	93	93	95	96	97	n.d.	n.d.
Luxembourg	86	86	86	86	86	86	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Malta	83	86	91	94	88	91	85	97	85	83	77	86	60	n.d.	2	n.d.	n.d.	n.d.	n.d.	n.d.
Netherlands (the)	90	91	92	93	92	93	93	92	93	93	93	93	93	98	98	96	96	96	96	96
Poland	93	93	94	95	93	95	95	94	95	97	98	99	90	96	97	97	96	96	96	n.d.
Portugal	95	95	95	96	96	96	96	95	95	95	95	95	n.d.	n.d.	n.d.	n.d.	n.d.	49	n.d.	n.d.
Romania	75	76	0	n.d.	88	n.d.	91	93	n.d.	95	96	96	96	97	97	97	97	97	96	n.d.
Slovakia	97	97	98	98	99	99	99	99	99	99	99	99	98	98	99	99	99	99	n.d.	n.d.
Slovenia	94	93	96	94	95	96	96	96	98	99	98	99	n.d.	n.d.	n.d.	n.d.	98	n.d.	98	n.d.
Spain	93	95	95	93	91	90	91	92	90	94	95	94	92	91	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
Sweden	95	95	95	95	95	95	95	94	95	94	n.d.	95	95	95	n.d.	n.d.	94	94	n.d.	n.d.
UK	88	89	89	89	88	87	85	84	79	75	74	75	75	76	77	74	75	76	n.d.	n.d.
Average	90	90	91	91	91	92	91	92	90	91	90	91	90	89	83	85	89	80	97	96

Source: (WHO, 2018b)

Carrillo-Santisteve and Lopalco (2012) report that from 1998 onwards there had been a significant decline in measles outbreaks in Europe, "thanks largely to good vaccination coverage achieved through the routine immunisation and two-dose vaccination policies of most European countries" (Carrillo-Santisteve & Lopalco, 2012, p.50). However, this trend reversed in 2010 what may be due to Europe experiencing a "vaccine paradox" (Carrillo-Santisteve & Lopalco, 2012, p.52). A vaccine paradox refers to the case in which "effective and safe vaccine [and] vaccination coverage increases […] result[ing] in a dramatic decrease in the incidence of diseases, followed by a decrease in the perceived risk of the disease and its complications [so that] (…) the disease is no longer remembered as dangerous […]" (Carrillo-Santisteve & Lopalco, 2012, p.52). Similar observations could just be made in the EU:

According to the ECDC, between 31 August 2017 and 1 September 2018, in total nearly 13 550 cases of measles were reported in EU countries (ECDC, 2018c). Even if the number of measles cases varied among EU countries, ranging from several countries with more than thousand cases to countries with less than ten cases during the last twelve months, there have been people in every EU country who have been infected with measles during the last year and as shown in Figure 1, the countries with high numbers of measles cases (red and orange) are spread all over Europe (ECDC, 2018d).

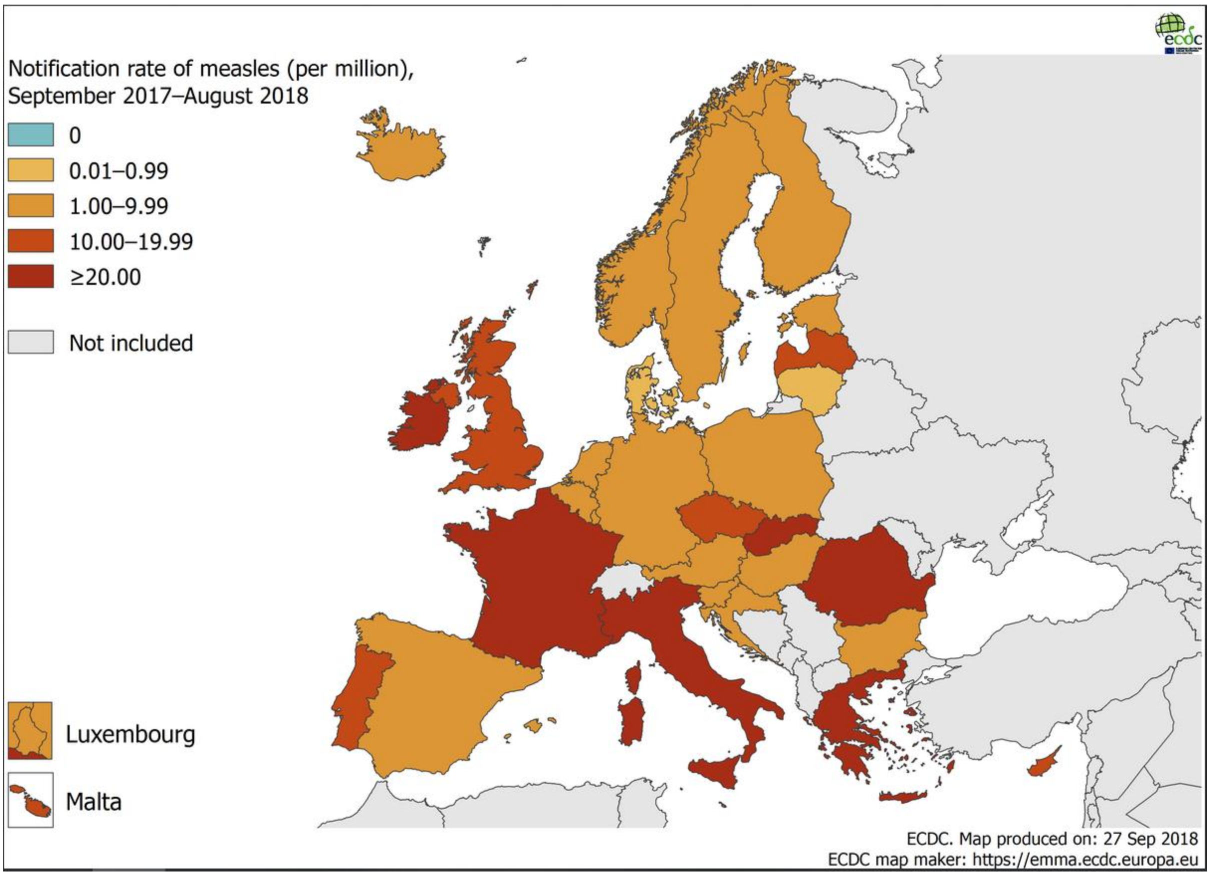


Figure1: Measles notification rate per million by country, EU/EAA, 1 September 2017-31 August 2018, (ECDC, 2018d)

The ECDC notified rates of measles per one million inhabitants between September 2017 and 2018 for each EU country (Figure 1) and came up with the following results (ECDC, 2018d):

- Countries with more than 20 measles cases per one million inhabitants between September 2017 and August 2018: Greece (294.5 cases per one million inhabitants), Romania (89.9), Slovakia (81.5), Italy (44.9), France (41.7)
- Countries with ten to 19.99 measles cases per one million inhabitants between September 2017 and August 2018: Cyprus (17.6), the Czech Republic (15.9), the UK (15.3), Portugal (12.7), Latvia (11.3), Malta (10.9)
- Countries with one to ten measles cases per one million inhabitants between September 2017 and August 2018: Austria (8.9), Belgium (8), Estonia (7.6), Luxembourg (6.8), Germany (6.5), Croatia (5.1), Sweden (5.0), Spain (4.8), Slovenia (4.4.), Poland (3.1), Hungary (1.5), the Netherlands (1.5), Finland (1.3), Bulgaria (1.1)
- Countries with less than one case per one million inhabitants between September 2017 and August 2018: Denmark (0.7), Lithuania (0.7) (ECDC, 2018d).

Eight countries reported in total 37 deaths attributable to measles in 2017, of which 26 occurred in Romania, four in Italy, two in Greece and one each in Bulgaria, France, Germany, Portugal and Spain (ECDC, 2018e, p.9).

It is noticed that the highest proportions of measles patients in the EU and the European Economic Area (EAA) countries in 2017 was formed by those who were unvaccinated (i.e. having neither received the first nor the second dose of measles containing vaccine), (Figure 2, ECDC, 2018e).

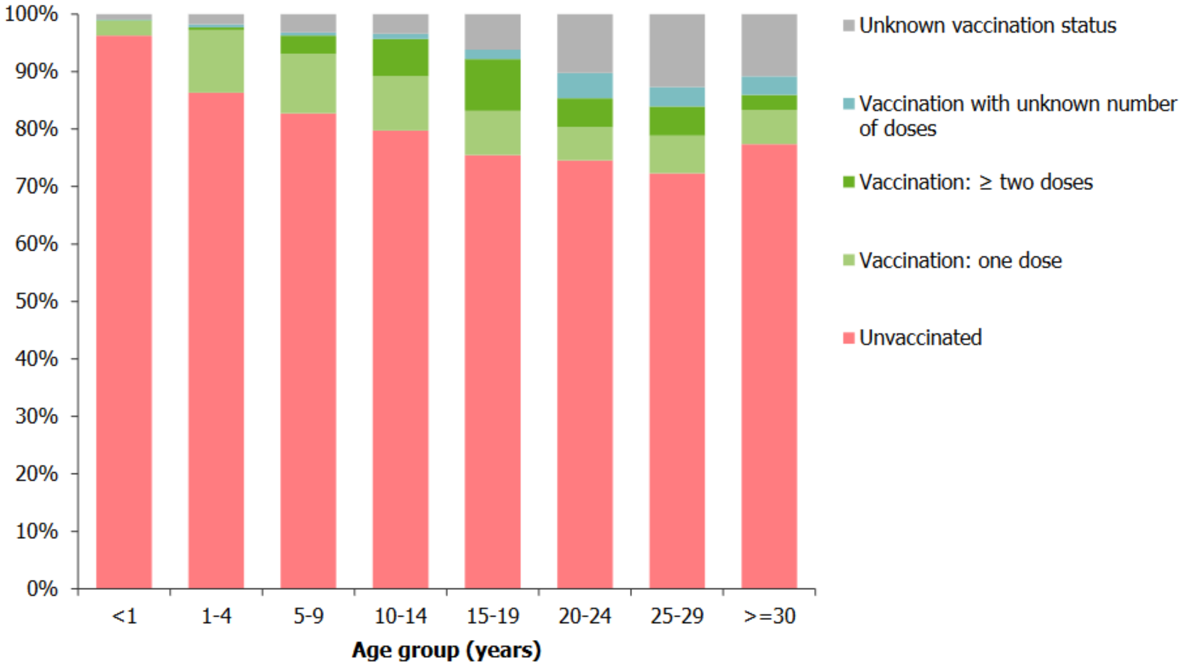


Figure 2: Distribution of measles cases by vaccination status and age group, EU/EEA, 2017, (ECDC, 2018e, p.9)

Figure 2 shows the distribution of measles cases by vaccination status and age group in the EU/EEA, meaning the EU member states and additionally Norway and Iceland since no data excluding the EEA countries could be found on this subject. However, since the vaccination rates in 2016 in Iceland (91 % for the first measles vaccination dose, 95 % for the second measles vaccination dose) and Norway (96 % for the first measles vaccination dose, 91 % for the second measles vaccination dose) were relatively high, their impact on the bar chart in Figure 4 may be negligible for the time being (ECDC, 2018e, p.21).

In total, the vaccination status of 13 753 measles cases registered in EU/EEA countries in 2017 was known (ECDC, 2018e, p.8). 87 % of all cases were unvaccinated, 8 % had received one dose of measles-containing vaccine while 3 % had received two or more doses and 2 % were vaccinated but the number of doses was unknown. Cases with unknown vaccination status occurred especially in the age-group 25-29 years (ECDC, 2018e, p.8).

The ECDC (2018e, p.8) concludes that the proportion of unvaccinated measles patients in the EU/EEA in 2017 was high across all age groups, "but highest among children below one year of age" (96 %). Children below one year are too young for having received the first measles-containing vaccines and thus are especially vulnerable to complications of measles. Best protection from measles for those younger than one year therefore is herd immunity, achieved when "population coverage for the second dose of measles-containing vaccine is at least 95 %" (ECDC, 2018e, p.8).

Overall, in 2016, only 12 of the 27 EU countries have reached the set vaccination target for eliminating measles (95 %) for the first dose of measles-containing vaccine (Hungary and Luxembourg (99 %), Czech Republic and Portugal (98 %), Germany, Greece, Spain and Sweden (97 %), Poland and Belgium (96 %), Austria and Slovakia (95 %)). Six EU countries out of 27 countries (Ireland did not report on the vaccination rate of the second dose) have reached the targeted value (95 %) for the second dose of measles-containing vaccine in 2016 (Hungary (99 %), Slovakia (97 %), Croatia (96 %), Portugal, Spain and Sweden (95 %)) (ECDC, 2018e, pp.1+21-22).

The just mentioned recent numbers on measles outbreaks and immunisation rates below the elimination target set in EU countries show that there is a social need to take further efforts in order to combat measles. Actors in health care and policy makers on all governmental levels are required to think about how measles immunisation rates could be kept high or even be increased and to "ensure that the reasons for low and decreasing vaccine uptake in EU member states are fully understood [and addressed with] tailor-made solutions for each [country-specific] situation" (EASAC & FEAM, 2018). "One-size-fits all solutions for vaccines across the EU may lead to a continuous increase in measles and other diseases that affect public health" (EASAC & FEAM, 2018).

It has been observed that measles outbreaks in one country often had ultimately resulted from measles being imported from another country (ECDC, 2018a). Therefore measles immunisation has not only been on the agenda of national governments all over the world but also raised discussions on the EU level and within international organizations (WHO, 2018 & European Commission, 2017). In these contexts it is wondered how to circumvent obstacles which may hamper the efficient and effective implementation of vaccination policies. For instance, if measles had not occurred for a while or if media or healthcare providers have reported on possible secondary effects assumed to be caused by measles vaccines, people may tend to neglect to refresh their vaccines or will deliberately decide against them and their children being vaccinated, leading to dropping vaccination rates which may endanger herd immunity (ECDC, 2018b). Successfully tackling such policy challenges in order to maintain and to increase measles immunisation rates all over Europe may contribute to the creation of public value in the sense that more people could be protected in the future to suffer from measles or even from dying on complications caused by measles (European Commission, 2017).

On the occasion of a measles outbreak in Disneyland of the United States in 2015, Yang et al. (2016) published an editorial comment in which they argue that the decreasing measles vaccination rates in European countries in the recent past would be associated with a growing number of anti-vaccine advocates who have managed to increase public vaccine distrust, not also in Europe but also in the US and Australia although multiple research had shown that measles vaccinations are save. Yang et al. (2016, pp.319+320) recommends to EU countries which so far had just expressed measles vaccination recommendations to think about the introduction of mandatory measles vaccines. This master thesis shall reveal whether EU countries with mandatory measles vaccines between 2010 and 2016 achieved higher vaccination rates than EU countries in which measles vaccinations are not legally binding.

Antona et al. (2013, p.362), when studying measles elimination efforts and the 2008-2011 measles outbreaks in France, observed that “vaccine coverage improved over time (…) during [measles] outbreaks”, after having had a persistent suboptimal vaccine coverage in toddlers and insufficient catch-up vaccination in older age groups in previous years what might have been two principal causes for the measles outbreaks starting in 2008. The present master thesis aims to check with the data at hand whether in the 19 selected countries, measles outbreaks between 2010 and 2016 formed key events that can be related to an increase in measles vaccination rates.

Beyond this, this research is dedicated to the relationship between the development of internet use of people and the measles vaccination rate of a country for assessing whether drops in measles vaccination rates in EU countries are observed simultaneously with an increased internet use. Future research could build up on this proxy and further elaborate the relation between non-compliance to vaccination policies and online anti-vaccination campaigns as suggested by Evrony & Caplan (2017). In January 2017, Evrony & Caplan (2017) counted 3 809 likes an anti-vaccination group had received by the global Facebook community, although the website of this anti-vaccination movement, according to Evrony &Caplan (2017, p.1475), failed to offer scientific arguments about the pros and cons of measles vaccinations by only presenting the potential, partly scientifically disproven risks of measles vaccines while leaving out the dangers of a measles infection. In the 19 EU countries included in the study of this master thesis, the proportion of people daily using the internet continuously grew between 2010 and 2016. One part of the present research is dedicated to analyse whether the increased internet use which make it more likely that people come across anti-vaccination propaganda might have contributed to dropping measles vaccination rates in the 19 selected EU countries.

Compiling a summarized report on the second doses of measles vaccination rates between 2010 and 2016 and an illustration which policy instruments existed in the examined EU countries at this time permits to check whether countries with mandatory measles vaccinations achieved higher immunisation rates than countries where measles vaccinations are recommended but not mandatory, (Yang, Bhoobun, Itani, & Jacobsen K.H al., 2016).

The research process of this paper will be guided by the research questions and subquestions formulated in the next section.

1.1 Research question and subquestions

With the aim to get a better idea about which instruments have been included in policies of the EU and 19 selected member states (i.e. Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the UK) addressing measles vaccines and how they might relate to measles vaccination rates in the EU between 2010 and 2016, this master research shall provide answers to the following research question:

> **To what extent did the mandatory character of measles vaccination policies influence the measles vaccination rates and did this also impact the influence of measles outbreaks and internet access on measles vaccination rates in EU countries between 2010 and 2016?**

In order to answer this policy-related evaluative research question, seven subquestions have been defined which give direction on what aspects this research is focusing on:

Subquestion 1: What were the measles vaccination rates in the selected EU countries between 2010 and 2016? (Descriptive)

Subquestion 2: Which policy instruments addressed measles vaccination rates in the selected EU countries between 2010 and 2016? (Descriptive)

Subquestion 3: What was the relationship between policy instruments and measles vaccination rates in the selected EU countries between 2010 and 2016? (Explanatory)

Subquestion 4: What was the relationship between the number of measles cases and the measles vaccination rates in the selected EU countries between 2010 and 2016? (Explanatory)

Subquestion 4a: Did the relationships between the number of measles cases and the measles vaccination rates in EU countries with policies prescribing mandatory measles vaccinations differ from the relationship between measles cases and the measles vaccination rates in EU countries with non-compulsory measles vaccination policies?

Subquestion 5: What was the relationship between the proportion of people daily using the internet and measles vaccination rates in the selected EU countries between 2010 and 2016?

Subquestion 5a: Did the relationships between the proportion of people daily using the internet and measles vaccination rates in EU countries with mandatory measles vaccination policies differ from those in EU countries with non-compulsory measles vaccination policies between 2010 and 2016?

1.2 Scientific relevance

This paper forms a comparison of 19 EU countries, reporting national trends of measles vaccination rates and outbreaks between 2010 and 2016 and studying the differences between the national measles vaccination policies of these countries at that time.

The study is a macro-analysis that reports aggregate outcomes EU countries were confronted with between 2010 and 2016. These outcomes were generated by the decisions taken by individuals, expected to be reflected in a country's measles vaccination rate and assumed to be related to events such as measles outbreaks and measles vaccination policy design as well as people's internet use.

The studies previously mentioned in the introduction were isolated studies on individual countries. These studies discussed whether mandatory measles vaccination policies are an adequate tool to foster the achievement of herd immunity, whether measles outbreaks gave occasion for more people to get vaccinated against measles during outbreaks and wondered what role the increasing use of internet has played for individuals' measles vaccination behaviour. The present master thesis combines theories and data from 19 countries and assesses whether previously tested theories are valid for these 19 selected countries over a longer time period of six years.

1.3 Social relevance

This research will generate results that can help governance to design adequate policies. It reveals whether policies that legally prescribe mandatory measles vaccinations have been effective tools to get people vaccinated against measles and to hinder a population's measles vaccination behaviour from being negatively influenced by sources that strengthen measles vaccine hesitancy such as online anti-vaccine movements who, with the increased frequency of people daily using the internet during the studied period, are able to circulate vaccine sceptical information faster than ever before.

2. Theory

The theory presents the Health Belief Model, applies it to the concepts relevant to this research and derives hypotheses on how these concepts are expected to be related with each other. The concept "measles policy" is expected to interact with the other concepts what leads to two different versions of how the concepts of this research can be related. That is why the hypotheses are formulated at the end of the theory chapter after having introduced all concepts and as a summary of assumptions made while applying the Health Belief Model to the given research topic. Furthermore, the two different scenarios are displayed in a subsequent section as a causal model.

2.1 The Health Belief Model

To answer the research question, the Health Belief Model is used. The Health Belief Model, developed in 1966, has been one of the first Social Cognition Models. Social Cognition Models are produced by theoretical work setting down attitudes and certain beliefs of behaviour in order to get a better understanding of individuals' health-related choices (Jones, Smith, Llewellyn, 2014, p.253).

The Health Belief Model consists of five constructs which are expected to contribute to the individuals' likelihood of following medical advice on taking preventive action, carrying medication or using medication at appropriate time. These five constructs are: perceived susceptibility, perceived severity, cues to action, perceived benefits of preventive action and perceived barriers to preventive action (Figure 3) (Jones, Smith, Llewellyn, 2014, p.254).

Perceived susceptibility is the extent to which persons perceive to be at risk of suffering from a disease and is coupled with perceived severity which refers to the extent to which an illness is considered as serious in terms of physical and emotional consequences. Together, those two constructs are forming individual perceptions in the Health Belief Model (Figure 3) (Jones, Smith, Llewellyn, 2014, p.254).

Cues to action include all means which impact the individuals' perceptions on whether a disease is a threat or not, ranging from mass media campaigns, advice from others such as from support groups, reminders from drug manufacturers and clinics, newspaper or magazine articles or personal experiences with the illnesses in one's own social environment. Apart from the means listed under cues of action, also demographic (age, sex, ethnicity), social psychological (personality, social class, peer and reference group pressure) and structural variables (knowledge about a disease and its treatment, previous contact with disease and treatment experiences) are regarded as modifying factors in the Health Belief Model (Figure 3), (Jones, Smith, Llewellyn, 2014, p.254).

Perceived benefits and perceived barriers are allocated under the likelihood of action. While perceived benefits of preventive actions, such as believing in the efficacy of treatment and prevention as well as familial and physicians being in favour of a treatment or preventative action, theoretically increase the likelihood of action, perceived barriers to preventive action are assumed to reduce the likelihood of an action to occur. Phenomena forming perceived barriers to preventative action can be an individual's perceived pressure of having to do the same things as other people of one's age and social group to avoid to be treated in a derogative way or any other inconvenience that could be associated with a medical action such as its difficult use, its costs or potential side effects (Figure 3), (Jones, Smith, Llewellyn, 2014, p.254).

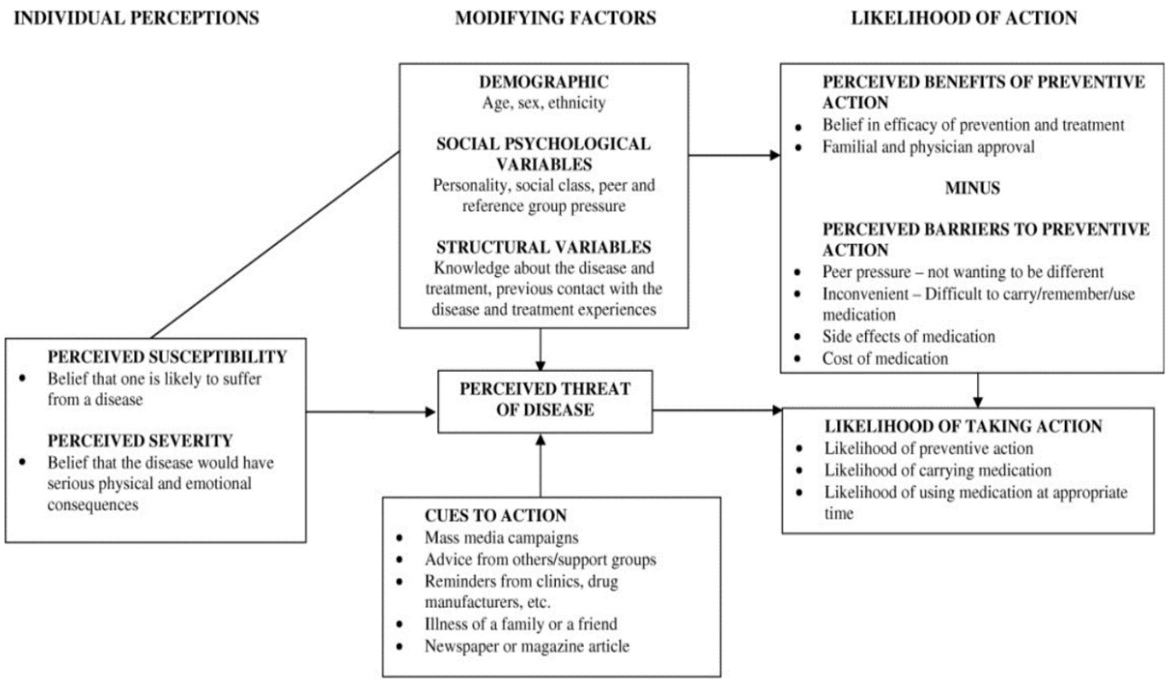


Figure 3: The Health Belief Model, (Jones, Smith, Llewellyn, 2014, p.255)

2.2 The Health Belief Model applied to measles vaccinations

In regard to the selected research setting of this master thesis, focusing of the success of measles vaccinations in 19 EU countries between 2010 and 2016, the Health Belief Model suggests that immunisation compliance is based on perceptions of disease severity, disease risk, vaccine efficacy, vaccine safety and barriers to immunisation of a public (Zimmermann, Giebink, Bosch Street & Janosky, 1995, p.271).

In the 1950s, Rosenstock, Derryberry and Carriager conducted systematic reviews of the existing literature for the U.S. Public Health Service to explore why parents had failed to vaccinate their children against polio. In the frame of this research which was published in Public Health reports, four psychosocial domains impacting parental decision-making to vaccinate their child are identified: 1) the parents' assessment of their child's risk of getting a vaccine-preventable disease (susceptibility), 2) parents' assessment of whether an illness forms a sufficient health concern to warrant vaccination (seriousness), 3) parent's perception that vaccinating their child reduces the chance of their child to be infected by the illness at some point and the feeling that the vaccine is safe (efficacy and safety), 4) concerns and influences encouraging or discouraging the decision of vaccinating one's child against a disease (social pressure and convenience). These four factors turned into the basis for the Health Belief Model (Humiston, Macuse, Zhao, Dorell, Howes & Hibbs, Smith, 2011, p.136).

The next paragraphs explain how the Health Belief Model can be applied to the variables selected for the purpose of this research. For the purpose of this research it is not paid equal attention to each of the five constructs of the Health Belief Model but in particular to the components on “perceived threat of a disease” to which the variable “measles outbreaks” is allocated, “cues to action”, represented by the variable “measles vaccination policies”, “perceived benefits of and barriers to preventive action, to which the variable “individuals’ daily internet use” is allocated to, as well as on “likelihood of taking actions”, reflected in a country’s measles vaccination rate, as explained in the next sections (Figure 4).

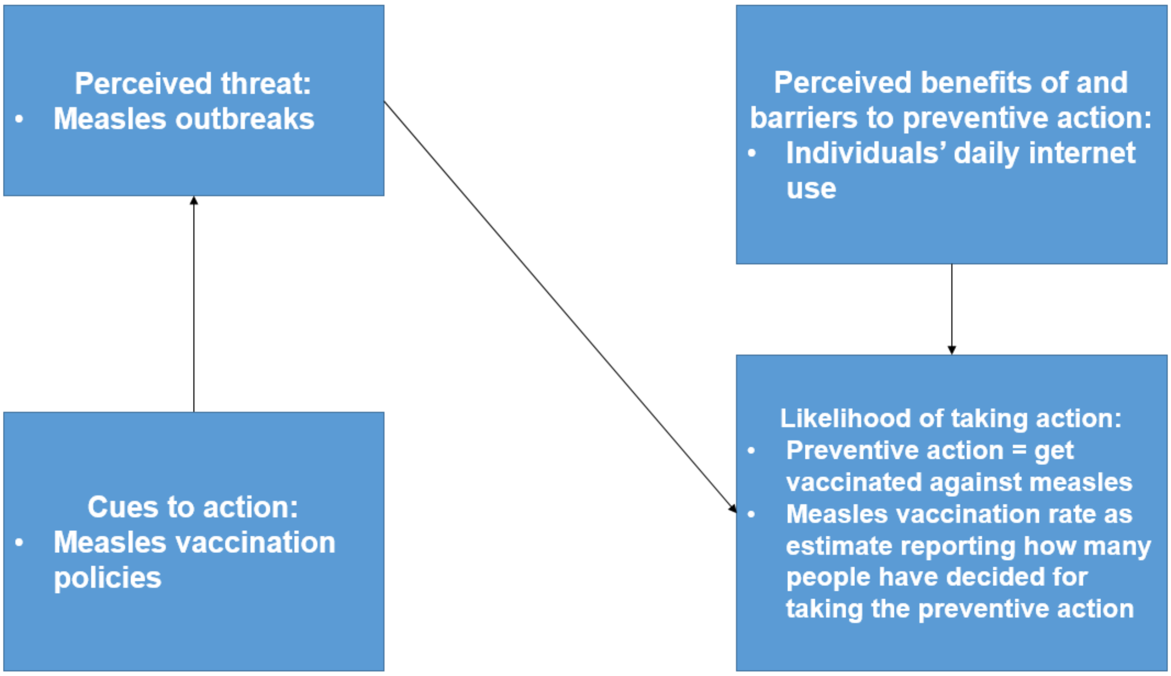


Figure 4: The variables of this research allocated to the constructs of the Health Belief Model

2.2.1 Measles vaccination rate – a sum of individuals’ behaviour

A country’s annual measles vaccination rate, in the frame of the Health Belief Model, forms a measure to estimate how many people have taken the preventive action of receiving vaccinations against measles. The measles vaccination rate can be defined as being a sum of individuals’ behaviours. These behaviours, according to the Health Belief Model, are formed by the prevailing perceived susceptibility, severity and the felt threat of the measles disease, although the power of these determinants are said to be modified by demographic, social psychological and structural variables and cues to action which may influence individual measles vaccination behaviour in each case to a varying extent. Out of these different perceptions and characteristics of individuals, different perceptions of measles vaccinations as preventive action and barriers to take this action result.

2.2.2 Measles cases – strengthening the perceived threat of a vaccine-preventable disease

An outbreak of a vaccine-preventable disease such as measles is treated as a perceived threat in the Health Belief Model that can be prevented by taking the adequate and recently only effective preventive action of getting vaccinated against measles. Humiston et al. (2011) report that Rosenstock, Derryberry and Carriager, when constructing the four previously mentioned factors that later formed the piles of the Health Belief Model in the 1950s, were inspired by the observation that individuals' refusal or delay to get vaccinated against a disease can be associated to the occurrence and re-emergence of vaccine-preventable diseases. As long as individuals were not confronted with an outbreak of a vaccine-preventable disease, their distrust concerning vaccine safety and side effects of vaccines, even if those were scientifically refuted, outweighed the recognition that vaccine-preventable diseases like measles form a serious threat to human health and remain highly contagious. A reason why the perceived susceptibility, severity and threat of measles is low in times where few or no cases are reported can thus be traced back to the fact that individuals, due to never having seen a person suffering from measles and its potentially fatal consequences, are not sufficiently or wrongly informed. Therefore they underestimate the value of measles vaccines, backed by their believes that the likelihood to suffer measles from measles and its physical consequences is low because outbreaks did not occur during their lifetime or at least did not caught enough attention to alarm the public (Humiston et al., 2011, p.136).

2.2.3 Daily internet use – counterproductive or beneficial for the promotion of vaccines?

Internet use is allocated to the construct "perceived benefits of and barriers to preventive action" in the Health Belief Model since the internet nowadays is an important platform for mass media campaigns and the spread of professional and private advice and experiences which quickly spread around the globe. Information that are shared and found online shape the perceptions of individuals on the severity and susceptibility of the measles disease and whether vaccinations are a safe and appropriate preventive action against measles (Jones, Smith, Llewellyn, 2014, p.254).

While for some health prevention campaigns the internet may have been a valuable communication media, the benefits of vaccinations have frequently and mostly falsely been denied online.

As for example revealed by Evrony and Caplan (2017), “organized anti-vaccination groups have contributed to the drop in vaccination compliance and anxieties concerning vaccination”. Organized anti-vaccination groups would “often have a strong presence on social media and well-developed websites (…) attracting people to their cause” (Evrony & Caplan, 2017).

The global advance of social media and internet use have triggered off an accelerated, omnipresent information sharing. The increased access to the internet, easing the use of websites, mobile phone networks and social media are said to have broadly transformed the manner in which people communicate about their environments from “a top-down, expert-to-consumer (vertical) communication [into] a [less] hierarchical, dialogue-based (horizontal) [and interactive] communication within a decade” (Larson, Cooper, Eskola, Katz & Ratzan, 2011, pp.526-528).

The greater amount of information online people of the research populations nowadays having at their disposal nearly everywhere and for free though can turn out to be problematic. It has been observed that with the advance of the internet, public questioning of recommendations expressed by experts and public institutions has become stronger and that a lot of people’s doubts are backed by information they have come across with online, although a lot of internet users are frequently not able to judge which online data are scientifically valid and evidence-based and which online content is based on poor data, misinformation or subjective personal opinions (Larson, Cooper, Eskola, Katz & Ratzan, 2011, pp.526-528). Posts and websites of anti-vaccination movements would frequently lack critical attention. Therefore, according to Evrony and Caplan (2017), vaccination supporters ought to “be aware of, examine and counter claims”, of anti-vaccination groups in public, as crucial counteraction against shrinking vaccination rates. An increasing number of people having used the internet in the EU between 2010 and 2016 is assumed as a factor that fostered the spread of online information published by anti-vaccination groups while vaccination supporters so far have not strongly enough countered false claims of anti-vaccination groups in public (Evrony & Caplan, 2017). Consequently, “[g]overnmental institutions now face the challenge to not only convince parents to vaccinate their [children], but to counter alternative information shared [online] as well”(Graef, 2019, p.11). As stated in the next section, such problems have also been faced by actors involved in the design and implementation of measles vaccination policies.

2.2.4 Measles vaccination policies - the state intervening in individuals' immunisation choices

Measles vaccination policies can be regarded as cues to action either legally requiring or at least recommending when and under which circumstances people subject to the policies are vaccinated against measles in order to prevent measles outbreaks. Since measles vaccination policies set out a framework clarifying how processes needed for proper measles vaccination delivery are organized and coordinated in a country, it can be claimed that measles vaccination policies modify attitudes and certain beliefs of behaviour considered in the Health Belief Model. For instance, one purpose of measles vaccination policies is the attempt to break down perceived barriers to the preventive action of measles vaccinations. Measles vaccination policies inter alia define the corner stones of systems in which measles vaccinations are procured, distributed and administered as well as how the measles vaccination procurement and administration services are financed. Apart from this, these policies also state responsibilities and accountabilities of all actors involved in the measles vaccination service provision to be prepared as good as possible for cases of non-compliance and formulate procedures for vaccination uptake monitoring to be conducted by the authorities in charge (European Observatory on Health Systems and Policies, 2018, pp.11+12).

In regard to a measles policy's ability to steer individual decision-making whether to receive measles vaccinations or not, this master thesis wonders how the measles vaccination policies in the 19 selected countries were related to the measles vaccination rates between 2010 and 2016. More specifically, it is asked whether the relationships between the number of measles cases and measles vaccination rates as well as the association between daily internet use and measles vaccination rates were modified with different strength, depending on whether a country recommends measles vaccinations without sanctioning not vaccinating or legally prescribes measles vaccinations and imposes sanctions on people who reject to be vaccinated. Measles vaccination policies, out of all variables included in this research, have the unique feature of determining whether and how non-compliance with vaccination guidelines is tackled. That is why it is expected that measles vaccination policies are cues to actions with a specific potential of modifying to what extent individuals' perceived threats of measles and measles vaccine eventually determine the likelihood of being vaccinated against measles.

If measles vaccinations are mandatory in a country, measles vaccination rates are expected to be higher than in countries with non-compulsory measles vaccinations. Law that obliges people to be vaccinated against measles and includes sanction in case of non-compliance does not leave the choice to people whether to vaccinate or not. The stronger perceived threat of measles, felt by people during measles outbreaks that may boost measles vaccination rates at these moments, or other cues of action such as online information obtained by a public are expected to be nullified (Yang, Bhoobun, Itani & Jacobsen, 2016, p. 320).

Policies recommending non-compulsory measles vaccinations may still promote measles immunisation since it proves that measles vaccination is on the public health policy agenda of a country and form a framework that regulates the procurement of resources needed for administration of measles vaccinations as well as laws on how measles vaccination administration and monitoring of immunisation coverage are organized. However, in contrast to policies prescribing mandatory measles vaccinations, policies proposing non-mandatory measles vaccination leave the choice whether to vaccinate or not to the people. Therefore, factors that determine people's attitudes towards measles vaccinations, such as the number of measles outbreaks and internet usage, are expected to be related to measles vaccination rates in countries where measles immunisation is not obliged (Yang, Bhoobun, Itani & Jacobsen, 2016, p. 320).

To sum up, by determining that measles vaccinations are mandatory and not vaccinating is sanctioned, the government creates peer pressure. As soon as people got the perception that not vaccinating is regarded as deviant behaviour in their social environment, combined with the fear of sanctions, they are more likely to decide to be vaccinated against measles. The perceived threat of measles and measles outbreaks as well as any other cue of action such as online anti-vaccination campaigns are no longer crucial for the individuals' measles vaccination behaviour if compulsory measles vaccinations are legally adopted. Countries with non-binding measles vaccination recommendations, in contrast, are expected to give more room for the perceived threat of the measles disease, measles vaccination side effects and cues of actions such as online information to determine the individuals' measles vaccination behaviour. In other words, both kinds of measles vaccination policies are modifying factors, according to the Health Belief Model, but it is expected that mandatory measles vaccination policies have a stronger modification power than policies that do not legally prescribe measles vaccinations. The hypotheses to be formulated are based on the idea that mandatory measles vaccination policies form a strong modifying factor that can eliminate the other constructs that impact the likelihood of a preventive action in the Health Belief Model by forcing people to take the preventive action of getting vaccinated against measles and to punish non-compliance, while measles vaccination recommendations are cues to action with a weaker modifying effect. Measles vaccination recommendations leave more room for other modifying factors such as internet use and measles outbreaks which can, as previously described, play a role in the measles vaccination behaviour of individuals and, if aggregated, form and shape the measles vaccination rate. To summarize the findings gathered from applying the Health Belief Model for the present research purpose, five hypotheses are derived which are tested in the later data analysis:

> *Hypothesis 1: The measles vaccination rates between 2010 and 2016 have been higher in EU countries with policies prescribing mandatory measles vaccinations than in countries where measles vaccinations are recommended.*

> *Hypothesis 2: Between 2010 and 2016, an increase in measles cases led to an increased measles vaccination rate in the 19 selected EU countries.*

> *Hypothesis 2a: Between 2010 and 2016, an increased number of measles cases in EU countries with mandatory measles vaccination policies did not lead to an increase in the measles vaccination rates of these countries.*

> *Hypothesis 2b: Between 2010 and 2016, an increased number of measles cases in EU countries with non-compulsory measles vaccination policies led to an increase in the measles vaccination rate of these countries.*

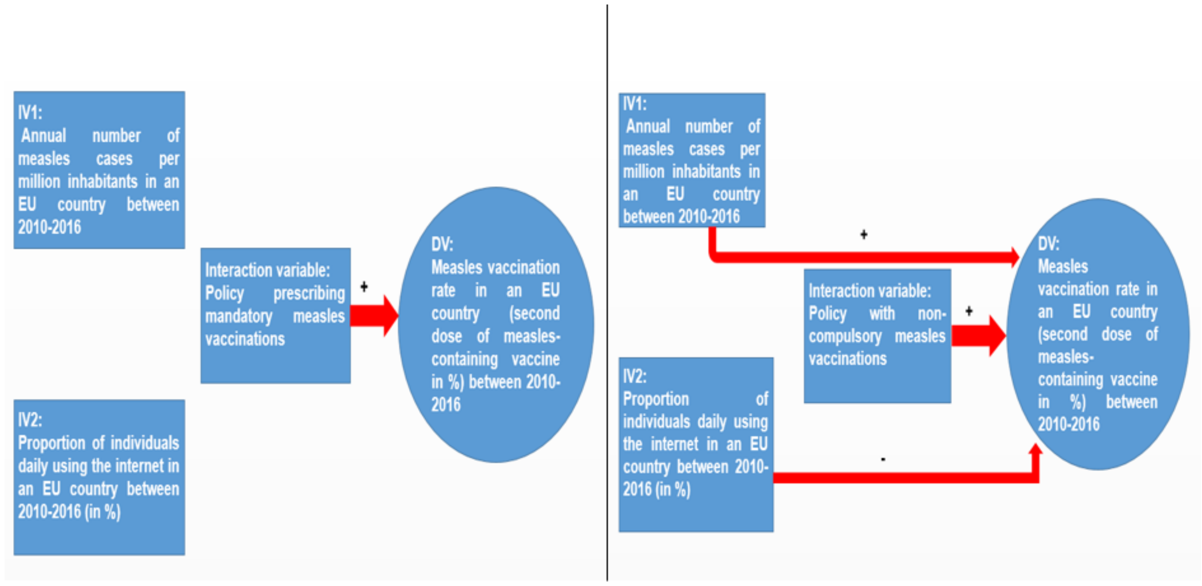
> *Hypothesis 3: Between 2010 and 2016, an increased proportion of people daily using the internet in the 19 selected EU countries led to declining measles vaccination rates in these countries.*

> *Hypothesis 3a: Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with mandatory measles vaccination policies did not lead to a decline in the measles vaccination rates of these countries.*

> *Hypothesis 3b: Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with non-compulsory measles vaccination policies led to a decline in the measles vaccination rates of these countries.*

2.3 The causal model

Figure 5 illustrates the causal model that shall be tested in the course of this research. Its construction was guided by the hypotheses previously derived with the aid of the Health Belief Model. There is one causal model for countries with policies that prescribe mandatory measles vaccinations on the left and a second one for countries in which measles vaccinations are not compulsory but recommended.



Causal model for EU-countries with mandatory measles vaccinations between 2010 and 2016

Causal model for EU-countries with non-compulsory measles vaccinations between 2010 and 2016

Figure 5: Causal models

3. Methodology

The upcoming paragraphs inform about the research design. It is a plan for answering the research question and subquestions of this master thesis and also points out how it is coped with potential reliability and validity threats of this study.

3.1 Way of case selection

This research exclusively focuses on 19 EU member states (Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden and the UK). The nine other EU countries (Austria, Croatia, Cyprus, Finland, Greece, Italy, Luxembourg, Romania and the Republic of Ireland) were excluded from the sample since no sufficient suitable data could be found. The present study serves to learn how the 19 EU countries between 2010 and 2016 used the leeway given by the EU vaccination policy framework to design their individual measles vaccination policies on their national levels. Initially, countries are allocated to groups, one consisting of those countries with mandatory measles vaccination policies and another one of those countries who included non-compulsory measles vaccines in their policies. In this manner it can be seen afterwards whether the policies of one of the two groups generated different outcomes in regard to the dynamics between measles outbreaks and measles vaccination rates and the effects of people's internet use on measles vaccination rates.

3.2 Data collection methods

The data collected for answering the research question were obtained from online sources. Information on EU policies and national measles vaccination policies were gathered from websites of the EU, national governments of its member states, from reports published by international organizations (i.e. WHO and the ECDC) or found in research articles. Statistical data on annual measles vaccination rates, number of measles cases per year and the number of people daily using the internet in the EU countries between 2010 and 2016 are extracted from the WHO, the ECDC and Eurostat (Appendix 2: Sources of the data matrix of the SPSS Analysis).

The characteristics of the collected data are described in more detail in the operationalization section. Figure 6 shows how the data matrix for the case "Belgium 2010" looks like. Afterwards, it will be explained how these data are processed in order to generate findings that answer the given research question and subquestions.

country	year	measlesvaccinationrate	measlescasespermillioninhabitants	dailyinternetusageofindividuals	Policy
Belgium	2010	.83	.38	.59	0

Figure 6: Example of the data matrix of this research before being processed (BEN, 2002; OECD, 2018 & 2018a)

The data matrix consists of six columns, starting with the country name and year, as label for each case, and indicating the vaccination rate in percent, the annual number of measles cases per million inhabitants, whether the measles vaccination policy in a country in the specific year was mandatory or not and the percentage of the proportion of individuals daily using the internet in this country at that moment in time. The whole data matrix processed in the statistical analysis is attached to this thesis (Appendix 3: Data matrix of SPSS analysis).

3.3 Operationalization

The units of analysis are countries, the research setting is formed by 19 member states of the EU between 2010 and 2016. The selected EU member states also form the units of observations on which data are collected.

A case is formed by a member state in a specific year between 2010 and 2016, so that the research in total includes 133 cases (19 countries multiplied by 7 years). If possible, in the statistical tests the data are averaged for each country to account for the fact that the data collected on one country are related to each other. However, this is not possible for all tests due to the small size of the given data set.

As shown in the causal model (Figure 5), there are one dependent variable (DV), two independent variables (IV) and one interaction variable in each of the two policy-scenarios, whose operationalization procedures are described in the following.

3.3.1 Keep track of immunisation coverage - Measles vaccination rates

The dependent variable "measles vaccination rate" is indicated in percent for each EU member state and each year between 2010 and 2016. It will be referred to the coverage rate of the second dose of measles-containing vaccine since herd immunity is achieved when "population coverage for the second dose of measles-containing vaccine is at least 95 %" (ECDC, 2018e, p.8). "[H]igh coverage in children is insufficient to avoid the spread of measles virus, especially when catch-up vaccination in older [age-groups] remains insufficient" (Antona et al., 2013). The procedures to estimate the annual measles vaccination coverage differ among the studied countries (Appendix 1: Composition of the measles vaccination rates in the selected countries).

A measles vaccination rate, equally referred to as measles vaccine coverage, serves as indicator to check whether a country has achieved herd immunity or not. Herd immunity is regarded as one of the effective means to prevent measles outbreaks and is achieved as soon as 95 % of a population has received both doses of measles-containing vaccines (ECDC, 2018e, p.8). Today, the vaccination programmes of the 19 studied EU countries promote a two-dose measles vaccination schedule. The first dose is given during the second year of life, the second dose at an older age that differs between countries but is in all countries scheduled before the 20th year of life (ECDC, 2018a). If one or both measles vaccinations have been missed during childhood, catch-up vaccinations can be received by a person at any time of adulthood unless there are medical reasons not allowing this (ECDC, n.d.).

In all 19 selected EU countries, measles vaccination rates are determined at least annually via public health units at the local, regional and national level. For this, the number of people who were vaccinated in the course of a year ("nominator") is divided by the size of total population ("denominator") (European Observatory on Health Systems and Policies, 2018, p.13). Between EU countries and also among the Autonomous Regions in Spain, the approaches as to what data to use as values for the numerator and denominator when estimating measles vaccine coverages vary (Appendix 1: Composition of the measles vaccination rates in the selected countries). Those should be taken into account when comparing the vaccination rates of the 19 selected EU countries. Three different main sources for the denominator are population registries, records of health care providers or the list of people covered by health insurance funds. Data for the numerator are obtained from data on reimbursements of vaccine service providers or the sales of serums. Reports of healthcare providers or targeted inquiries on a population's vaccine status are two further options for gathering data that can be used to estimate measles vaccination rates (European Observatory on Health Systems and Policies, 2018, p.13).

In Belgium, measles vaccinations rates are determined at the community and the regional level (European Observatory on Health Systems and Policies, 2018, p.47). For this, two main population registries on vaccine status exist, one for the French and German speaking community and a second one for the Flemish community. These are automatic ordering systems used by physicians. Entries in these registries are complemented by information delivered by school health services and regular vaccination coverage studies which are conducted every three or four years. The weighted average is used as an estimate for the Belgian measles vaccine coverage (European Observatory on Health Systems and Policies, 2018, p.49).

In Bulgaria, immunisation providers are obliged to record the vaccinations they perform. These records are compiled in administrative reports by the 28 regional Health Inspectorates, regionally representing the National Ministry of Health. The number of vaccinated children indicated in these reports, being the numerator, is compared with the total number of children registered in Bulgaria and subject to mandatory measles vaccination (denominator) (European Observatory on Health Systems and Policies, 2018, p.54).

The Czech Republic, in contrast, obliges health insurance funds to report the number of vaccinated children by age cohorts defined in the national mandatory vaccination schedule in which both measles vaccinations are included (numerator). As denominator, the total number of children in the corresponding age cohort of the population registry is taken (European Observatory on Health Systems and Policies, 2018, p.68).

Danish residents have a unique personal identification number to which all vaccines a person receives are allocated. Since 2015, all vaccinations have to be communicated to the Danish Vaccination Registry in which also previously administered vaccines can be added. The numerator for the estimation of vaccine coverage is calculated by birth cohort, being the number of individuals indicated as having been vaccinated against measles. The numerator is divided by the denominator, i.e. the number of individuals within the same birth cohort residing in Denmark at the moment of calculation (European Observatory on Health Systems and Policies, 2018, p.72).

Estonian health care providers are required to report vaccinations to a Health Board that is subordinated to the Estonian Ministry of Social Affairs. The numerator of the Estonian measles vaccination rate is the number of patients notified as vaccinated. The patient lists of health care providers is preferred for the denominator because the Estonian population registry is supposed to be erroneous and including people that are actually not residing in Estonia (European Observatory on Health Systems and Policies, 2018, pp. 75-77).

France is lacking a routine data collection system for vaccinations among adults (Guthmann & Lévy-Bruhl, 2013, p.2). Infant vaccine coverage is calculated with the aid of the database of the statutory health insurances, covering 99 % of the French residents, compared with specifications in mandatory health certificates for children between zero and two years and school surveys (European Observatory on Health Systems and Policies, 2018, pp. 87).

There is no national immunisation register in Germany. Nevertheless, continuous and nationwide surveillance of vaccination coverage is available from school entrance examinations from 2001 on, complemented by anonymized data provided on all age groups and specific risk groups and at district level by the Association of Statutory Health Insurance Physicians (ASHIP). This allows a representative measles vaccination rate for all age groups at least for German citizens with statutory health insurance, meaning for 87 % of the total German population (European Observatory on Health Systems and Policies, 2018, pp.92-94).

In Hungary, health visitors have to report data from each district to the national electronic epidemiological surveillance data base on failed and completed vaccinations and on immigrating and emigrating persons which according to the national immunisation calendar ought to receive mandatory measles vaccinations. These data are used as numerator. The denominator is the total number of children obliged to be immunized against measles in a given year. Hungary thus provides measles vaccination rates for the district, regional and the national level (European Observatory on Health Systems and Policies, 2018, pp. 102).

In Latvia, an electronic immunisation register has been under construction but its operation has not started, yet. There are incomplete data on certain risk groups like migrants, refugees, ethnic minorities as well as on socially and economically disadvantaged people. Vaccination rates in Latvia are calculated at the regional and national level, based on monthly reports from all vaccination providers. For the measles vaccination rate, the denominator is the total number of children aged between 12 and 15 months (for the first dose) or seven years (for the second dose). The numerator is the number of vaccinated persons in these age groups (European Observatory on Health Systems and Policies, 2018, pp. 116+117).

The Lithuanian National Ministry of Health takes the ratio of the number people having received measles vaccinations divided by total number of population to estimate the measles vaccine coverage of the country (European Observatory on Health Systems and Policies, 2018, pp. 120).

Malta estimates its measles vaccination rate at the national level by the data on administered vaccines which immunisation providers enter into a governmental database but insufficient reporting from the private health care sector has been observed (European Observatory on Health Systems and Policies, 2018, pp. 128).

In the Netherlands, the National Institute for Public Health and the Environment monitors and calculates measles vaccination coverage. The estimated measles vaccination rate is determined by dividing the number of administered measles vaccinations by the total number of the Dutch population registry (European Observatory on Health Systems and Policies, 2018, pp.131+132).

Polish vaccination providers forward medical records about measles vaccination via the state county to the National Institute of Public Health which aggregates the data from subnational levels. This data comprise all legal residents of Poland, also non-citizens or people not covered by health insurances. (European Observatory on Health Systems and Policies, 2018, pp. 135-136).

In the Autonomous Regions of Portugal, different information systems and records exist but there is a uniform formula for the calculation of the measles vaccination rate. Primary health care units, subordinated to the National Health Service, determine the measles vaccination rate, using the number of registered individuals born in a specific year and vaccinated against measles as numerator and the total number of registered people born in the same year as the denominator (European Observatory on Health Systems and Policies, 2018, pp. 143-144).

Slovakian Regional Public Health Authorities annually assess measles vaccination coverage based on the population registries and reports of health care providers, checking how many measles vaccines have been administered. These findings are summarized by the National Public Health Authority (European Observatory on Health Systems and Policies, 2018, pp. 155).

In Slovenia, regional public health unites get data on vaccination coverage from vaccinators and pass those on to the National Institute of Public Health. The estimated measles vaccination rate is obtained by comparing the number of children that should receive measles immunisation and the number of children who were vaccinated against measles in the course of a year (European Observatory on Health Systems and Policies, 2018, p.162).

To better coordinate the so far rather heterogeneous immunisation programmes of the autonomous Spanish regions, the Inter-territorial Council of National Health System compiles and analyses data for estimating the Spanish national measles vaccination rate. The Inter-territorial Council of National Health System consists of representatives of all regions, autonomous cities, Ministry of Health as well as of representatives from Social Welfare and Consumption institutions. While autonomous regions agree on the number of people who have received a measles vaccination to be the numerator, there are varying denominators for the different regions. Some regions use the total number of persons entered in the vaccination services registries, others refer to the population health registries or data of official statistical bodies. In the near past, a working group has been established that shall attempt to diminish differences in the vaccination rate estimation procedures (European Observatory on Health Systems and Policies, 2018, pp. 167-168).

The Swedish measles vaccination rate is the quotient of the number of vaccinated children enrolled in childcare units divided by the total number of children of the national population register. In total, 99 % of children in Sweden are enrolled in childcare units (European Observatory on Health Systems and Policies, 2018, p.172).

In the UK, theoretically all ordinary residents ought to be registered with a general practitioner who adds administered vaccinations to a person’s stored clinical information that since 2008 have been digitalized. In practice, this registry, however, is said to be incomplete and to contain duplications. Additionally, there is a Child Health Information System. For the measles vaccination rate, the number of children told to be vaccinated against measles, according to vaccination providers, is divided by the total number of children included in the Child Health Information System (European Observatory on Health Systems and Policies, 2018, pp. 177-178).

An overview on the individual national measles vaccination rates between 2010 and 2016 of the selected 19 EU countries as well as how the measles vaccination rates are estimated in each country is included in the appendices of this master thesis (Appendix 1: Composition of the measles vaccination rates in the selected countries & Appendix 3: Data matrix of SPSS analysis).

Fluctuating measles vaccination rates in the 19 EU countries between 2010 and 2016 are assumed to occur due to numerous factors that shape people's vaccination behaviours and the ability of health care sectors to provide measles vaccinations. In this research it is studied how measles cases and individuals' daily internet use are related to measles vaccination rates in both, countries with mandatory measles vaccinations and countries with voluntary measles vaccination recommendations. The two factors "number of measles cases" and "proportion of individuals daily using the internet" have been operationalized as presented below.

3.3.2 Characteristics and measurement of measles cases

The independent variable "number of measles cases per year" between 2010 and 2016 for each EU member state is reported in numbers. These numbers state the annual cases per year and per million inhabitants to account for varying population sizes among the EU member states.

In 2004, a European Centre for Disease Prevention and Control (ECDC) was founded and offers upon the request of the European Commission and in agreement with its Advisory Forum a measles case definition to ease the identification and reporting of measles as well as to support the improved prevention and control of contagious illnesses within the EU (European Commission, 2008, p.1).

Each of the case definitions of communicable diseases included in the European Commission decision 28/IV/2008 consists of a set of clinical, laboratory and epidemiological criteria which characterize a disease (European Commission, 2008, p.3+4).

Clinical criteria define typical and relevant symptoms and signs that individually or combined constitute an indicative or clear clinical picture of a disease. Clinical criteria for the measles virus are the occurrence of fever (i.e. a human's body surpassing its normal range of body temperature (36-37 C°), combined with a maculopapular rash (i.e. flat red areas on the skin covered with small confluent bumps) and at least one of the following three phenomena:

conjunctivitis (i.e. inflamed eyes), contagious inflammations of the upper respiratory tracts, or coughing (European Commission, 2008, pp.3+41).

Laboratory criteria list laboratory methods applied to diagnose and confirm a case of sickness. For measles, at least one of these four criteria need to be fulfilled: Firstly, a measles virus has to be isolated from a clinical specimen. Secondly, measles virus nucleic acid needs to be detected in a clinical specimen. Thirdly, a measles virus specific antibody response typical for acute infection in serum or saliva can be observed. Fourthly, via a direct fluorescent antibody tests (DFS), the presence of a measles virus antigen, a specific protein on the surface of a measles virus, could be revealed by using specific monoclonal antibodies (European Commission, 2008, pp.3+41). In the frame of a DFS, the mechanisms of an antibody determining the destruction of an antigen are exposed to fluorescent chemicals. An antigen is present if the antibody responds to the attachment of the chemicals with the generation of specific, sensitive protein tags (Cornell University, n.d.).

Epidemiological criteria are met as soon as an epidemiological link can be established (European Commission, 2008, p3). The European Commission (2008, p.3) distinguishes between six epidemiological links during the incubation period, meaning the time period between the infection and manifestation of an illness: (1) animal to human transmission of an infection, (2) a common exposure of a confirmed human case and any other person to the source of an infection, (3) a person’s exposure to contaminated food and drinking water or (4) contact to laboratory confirmed contaminated environmental sources, (5) an ill person working in a laboratory and having potentially been infected there, (6) human to human transmission (European Commission, 2008, p.3).

The European Commission (2008, p.41) only names the human to human transmission out of the six epidemiological links in the epidemiological criteria for measles (European Commission, 2008, p.41). The measles virus is passed on from a person to another via respiratory droplets produced when ill people sneeze and cough. These infectious droplets can remain in the air and on surfaces for approximately two hours. It is estimated that about 90 % of non-immune people getting in touch with the virus will be infected with measles and are contagious from roughly five days before the appearance of rash up to four days afterwards. So far, immunisation has been the single effective prevention against being infected with measles and no targeted antiviral therapy for measles has been developed, yet, turning measles and its complications into a leading cause of childhood deaths around the globe (ECDC, 2018a).

Additionally to the clinical, laboratory and epidemiological criteria, the European Commission offers a three-fold classifications of measles cases: (1) a possible measles case, which can be any individual fulfilling the clinical criteria mentioned above, (2) a probable case, applicable to persons not only meeting the clinical criteria but also having an epidemiological link and, (3) confirmed cases, formed by persons that are not immune against measles and are meeting the clinical and laboratory criteria (European Commission, 2008, p.41).

In 1998, the EU set up a network to improve the surveillance and control of communicable diseases within its member states by establishing a permanent exchange of information via online tools between the prevailing national public health authorities who decide which actions are taken in the EU member states in case of disease outbreaks and related events. The network is considered as being based on two main pillars. One main pillar of this network is the Early Warning and Response System (EWRS), allowing consultation, coordination and information exchange among the national health authorities of the EU member states. The second pillar is formed by the regular data collection on transmittable diseases within the individual member states and autonomous decisions EU member states take on the national level to prevent and control outbreaks of communicable illnesses (Guglielmetti, Coulombier, Thinus, Van Loock, & Schreck, 2006). The EWRS, together with national websites, validated media reports or data on measles cases that are expressed while communicating with national authorities of EU/EEA member states, to which also the 19 selected EU countries of this study belong to, are principal data sources for the ECDC annual monitoring reports (European Center for Disease Prevention and Control, 2014, p.9).

Principally owing to language barriers and the limited scope of this study, information on how measles case notification is regulated in the 19 studied countries and the extent to which these laws differ among countries and may affect the comparability of the data on measles cases are not discussed in more detail in this research. It can at least be said that there is scientific evidence confirming that variety among the national surveillance systems of communicable diseases and the methods and quality of data collection across the selected EU countries has been observed, also applying to the notification of measles cases (Amato-Gauci & Ammon, 2008, pp.1+2). The different scopes, goals, organizational structures and stages of development in the absence of uniform reporting rules and procedures as well as different approaches in data validity checks within the national measles surveillance systems of the individual countries limit the comparability of the selected data. To encounter comparability constraints, the data on measles cases of the 19 selected EU countries have been obtained from the annual reports of the ECDC only, because the ECDC standardises data collection on infectious diseases and the reports on surveillance data of the countries it gains data from (Amato-Gauci & Ammon, 2008, pp.1+2) (Appendix 2: Sources of the Data matrix of the SPSS Analysis).

3.3.3 Internet use

The independent variable "proportion of people daily using the internet" for each EU member state is reported as a percentage of the prevailing number of individuals daily using the internet in a country (Eurostat, 2018). Internet use refers to activities of people during which they use devices to visit any kind of website or apps. In the frame of such activities, people may either passively, rather coincidentally be confronted with information on measles vaccinations or actively search for vaccination topics online (Vrdelja, Kraigher, Vercic, & Kropivnik, 2018, p.936).

For taking first steps towards closing the knowledge gap on the role of mandatory and non-mandatory measles vaccination policies in regard to the relations between the previously described dependant and independent variables, the interaction variable "measles vaccination policy" has been included in each of the causal models.

3.3.4 Measles vaccination policy

The interaction variable "measles vaccination policy" indicates the presence of either legally mandatory measles vaccinations or non-binding measles vaccinations recommendations in a country. In the statistical analysis, the two policy types are distinguished by being translated into a dichotomous variable with the two possible values:

0 stands for countries with a policy not legally binding but only expressing recommendations on measles vaccinations for its general public and only making them mandatory for people who want to work in specific jobs or make use of certain services, (i.e. Belgium (mandatory in Flemish region), Germany (potentially limited access to childcare facilities and healthcare jobs when not being vaccinated against measles) and Latvia (measles vaccinations recommended for general public but required for workers in state institutions and for vaccination service providers).

1 is the code for a policy requiring mandatory measles vaccinations for the whole population or certain age groups.

3.4 Validity and reliability of the proposed operationalization

The research question in this master thesis is answered by using a correlational, longitudinal design. Dooley (2009, p.266) identifies the following validity threats to be checked: Content validity shall be assured by unambiguously indicating the units of analysis, research settings and variables and by clarifying the meaning of concepts of this research and their operationalization before the data processing and analysis (Dooley, 2009, p.90). Statistical data use also informs about inter-item correlation (Dooley, 2009, p.83).

The independent variable “annual number of measles cases”, expressed in total numbers per million inhabitants, and the dependent variable percentage of “measles vaccination rate” of the whole population in each EU country between 2010 till 2016, are sufficiently represented in the operationalization, though they may only give a broad overview on each EU country while not accounting for regional differences observed in the implementation of measles vaccination policies and practices within each country (Dooley, 2009, p.79). Content validity of “measles vaccination policies” and “proportion of people daily using the internet” face a higher threat. The meaning of measles vaccination policy may vary within the EU countries and lead to different interpretations and applications. While some may limit the term measles vaccination policy to rules and recommendations that determine when and where people are vaccinated by whom, this thesis applies a broader definition of measles vaccination policies. This broader definition includes policy arrangements that next to the three aspects mentioned in the previous sentence also concern the financing and distribution of measles vaccines as well as rules on the communication of healthcare authorities and vaccine service providers. A broader insight into the national measles vaccination policy frameworks helps to better assess the results of the later statistical analysis since it makes aware of other factors than the variables included that might have steered a population’s measles vaccination behaviour (e.g. the presence or absence of policy instruments to tackle problems in the procurement and financing of vaccines or legal incentives which encourage parents to vaccinate their children against measles). The percentage proportion of people daily using the internet in an EU country shows how many people spent time online everyday between 2010 and 2016 but it is not told whether those people thereby were either randomly confronted with information on measles vaccinations or purposely searched for information on measles vaccinations and that these information did shape their measles vaccination behaviour. The data collected on the variable of “daily individuals’ internet use” forms a rough but for the time being sufficient proxy to explore the online behaviour of the studied research population.

Internal validity wonders whether the variation in the dependent variable is due to the individual independent variables (Dooley, 2009, p.163). Since it is impossible in this study to perfectly consider all potential "coincidental event outside the study [causing] the observed change in the dependent variable (…), there is no full guarantee that the outcome has exclusively been generated by the examined independent variables only" (Dooley, 2009, p.163) (i.e. declining or growing measles vaccination rate). This is kept in mind when drawing later conclusions on how the interaction variables "policy prescribing mandatory measles vaccinations" or "policy with non-compulsory measles vaccinations" modify the relations between the dependent variable and the independent variables "annual number of measles cases in EU countries" and "proportion of people daily using the internet" and how these three variables relate to the dependent variable "measles vaccination rate" in each of the scenarios illustrated in the causal model (Figure 5).

It is assumed that the chosen sample estimate sufficiently reflects the population which is aimed to study. In order to learn about the situation in the EU, only data of 19 member states are used which are: Belgium, Bulgaria, the Czech Republic, Denmark, Estonia, France, Germany, Hungary, Latvia, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, the Netherlands and the UK.

Croatia, Greece, the Republic of Ireland, Italy, Cyprus, Austria, Romania, Finland and Luxembourg are excluded since the data set needed for this research could not be completed for these nine countries. For this purpose, it is accepted that the external validity of this study is limited. Results of this research should not easily be transferred to other research settings. Each country has its own measles epidemic histories and the interactions between measles vaccination policies and policy environment factors can be different (Dooley, 2009, p.268).

3.4.1 Ethical issues

In the course of the whole thesis, careful wording shall disclose the author's intention to remain as neutral as possible towards potential interest conflicts between supporters and opponents of vaccinations.

In this project, no data are neither collected from identifiable persons, social entities or organizations, nor is semi-public or confidential data about identifiable persons, social entities or organizations used. Therefore, it was not asked for ethical assessment of this master thesis. The author knows that it is her own responsibility to ensure that the research is carried out in line with the information provided above; and that she regularly re-considered and discussed the ethical issues that may be raised in the context of this research project.

3.5 Data analysis

The aim of the data analysis is to evaluate whether mandatory measles vaccination policies prevent the two independent variables "proportion of individuals daily using the internet" and "annual number of measles cases" from interacting with the dependent variable "measles vaccination rates" in the selected research setting. It is also studied how the relationships between the independent and dependent variables in countries which recommend measles vaccinations are related.

Initially, for each EU country there will be a brief report on how the national measles vaccination rates developed between 2010 and 2016, based on published national measles vaccination rates (Appendix 3: Data matrix of SPSS analysis), a boxplot as well as descriptive statistics summarized in tables per country based on this data (Figure 7 & Appendix 4: Descriptive statistics measles vaccination rate per country between 2010 and 2016). This provides an answer to the first subquestion: "What were the measles vaccination rates in the selected EU countries between 2010 and 2016?"

The second subquestion: "Which policy instruments addressed measles vaccination rates in the selected EU countries between 2010 and 2016?" is answered by summarizing what policy instruments were used in the 19 selected EU countries to create a framework in which measles vaccinations are delivered, distributed, administered and monitored at the 19 national levels.

Furthermore, by answering the third subquestion:"What was the relationship between policy instruments and measles vaccination rates in the selected EU countries between 2010 and 2016?", it is explored whether measles vaccination rates between 2010 and 2016 have been higher in EU countries with policies prescribing mandatory measles vaccinations than in countries where measles vaccinations are recommended. This is tested by performing an independent-sample-t-test on the data via SPSS. The independent-sample-t-test appears appropriate since it is a correlation test in which two different groups of units of analysis (the EU countries) are assigned to groups that are exposed to one out of two or more different conditions (Field, 2009, pp.183+325). In terms of this research, the two conditions a country is assigned to is either a measles policy framework which legally prescribes measles vaccinations or a policy framework in which measles vaccinations are only recommended.

To learn more about the relationship between measles cases and measles vaccination rates as well as the relation between internet use and measles vaccination rates under different national circumstances, which are represented by the two different policy scenarios in the causal model, subsequently, information is gathered via SPSS on the associations between the variables described in the hypotheses 2a&b and 3a&b in the prevailing policy scenarios.

For the fourth subquestion: “What was the relationship between the number of measles cases and the measles vaccination rates in the selected EU countries between 2010 and 2016?”, firstly measles outbreaks are identified in the given data set, defined in this context as an annual number of measles cases per million inhabitants higher than 10. Afterwards, graphs showing the studied years on the x-axis and the measles vaccination rates on the y-axis are displayed. On the abscissa of each coordinate system, the years marked in yellow are those in which more than 10 measles cases per million in habitants were reported. Theses years were identified by manually studying the data matrix (Appendix 3: Data matrix of SPSS analysis). Studying graphs, displaying the studied years on the x-axis and the measles vaccination rates on the y-axis, also answers subquestion 4a: “Did the relationship between the number of measles cases and the measles vaccination rates in EU countries with policies prescribing mandatory measles vaccinations differ from the relationship between measles cases and the measles vaccination rates in EU countries with non-compulsory measles vaccination policies?” by formulating conclusions on the relationship between annual measles vaccination rates and measles outbreaks observed in the different national contexts.

Since there is little variation within the countries regarding the data on the daily individuals’ internet use, the correlation test for subquestion 5: “What was the relationship between the proportion of people daily using the internet and measles vaccination rates in the selected EU countries between 2010 and 2016?” is run for the sample as a whole and not per country. A subsequent partial correlation test for each of the two policy groups provides an answer to subquestion 5a: “Did the relation between the proportion of people daily using the internet and measles vaccination rates in EU countries with mandatory measles vaccination policies differ from those in EU countries with non-compulsory measles vaccination policies between 2010 and 2016?”

The next section presents the results of these data analysis procedures.

4. Results

4.1 The state of measles immunity of the 19 selected EU countries between 2010 and 2016

In order to answer subquestion 1: "What were the measles vaccination rates in the selected EU countries between 2010 and 2016?" the collected data on measles vaccination rates are displayed in descriptive formats as tables (Appendix 4: Descriptive statistics measles vaccination rates per country between 2010 and 2016) and as a boxplot (Figure 7).

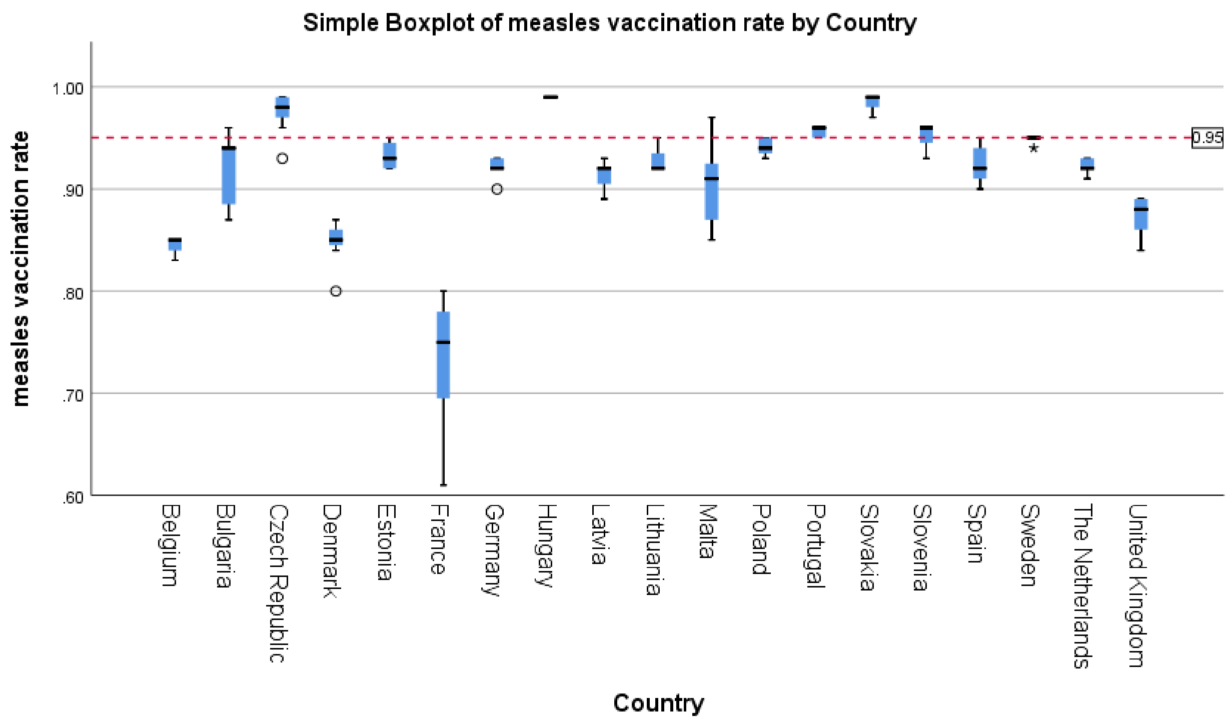


Figure 7: Boxplots on the measles vaccination rates of the 19 selected EU countries between 2010 and 2016

The boxplot (Figure 7) and the descriptive statistics of the countries (Appendix 4: Descriptive statistics measles vaccination rates per country between 2010 and 2016) display that out of the 19 selected EU countries Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Malta, Poland, Portugal, Slovakia, Slovenia and Spain were the 11 countries that reached herd immunity (marked by the red line at 95 % on the y-axis) in at least one year between 2010 and 2016. Belgium, Denmark, France, Germany, the Netherlands and the UK constantly stayed below the herd immunity level in this time period. At this point, it is noted that while the set of countries that reached herd immunity in the studied time period include both, countries with mandatory measles vaccination or non-binding measles vaccinations, all countries who failed to reach herd immunity were subject to non-legally binding measles vaccination recommendations between 2010 and 2016. The section dedicated to the third subquestion will further investigate to what extent policies might have played a role for the trends of national measles vaccination rates in the countries of this sample. What can already be seen with the aid of the boxplot is that the levels and ranges to which measles vaccination rates fluctuated in the individual countries varied between 2010 and 2016. France, out of all countries in the sample, experienced the lowest and at the same time widest range of measles vaccination rates (61 %-80 %) between 2010 and 2016. The prevailing national measles vaccination rates of Belgium (83 %-85 %), Denmark (80-85 %) and the UK (84 %-89 %) lied between 80 % and 89 % during the studied seven years. The ranges of the vaccination rates of Bulgaria and Malta were of similar size, though Bulgaria reports an increase in the measles vaccination rate in the course of the seven years from 86 % to 97 % while in Malta the measles vaccination rate declined from 97 % in 2010 to 86 % in 2016. Latvia slightly failed to reach measles herd immunity, with the lowest measles vaccination rate of 89 % in 2014 and 2016 and the highest measles vaccination rate of 93 % in 2010. The Czech Republic (93 %-98 %), Estonia (92 %-95 %), Germany (90 %-93 %), Hungary (99 %), Lithuania (92 %-95 %), Portugal (95 %-96 %), Poland (93 %-95 %), Slovenia (93-96 %) and Slovakia (97 %-99%), Spain (90 %-95 %), Sweden (95 %) as well as the Netherlands (91 %-93 %) managed to maintain a measles vaccination rate above 90 % between 2010 and 2016, though, as previously mentioned, not all of these countries achieved herd immunity during this time period.

The answer to the first subquestion “What were the measles vaccination rates in the selected EU countries between 2010 and 2016?” thus is that between 2010 and 2016 the measles vaccination rates in the 19 studied countries ranged from 61 % and 99 % with an average measles vaccination rate of 91 % during the studied seven years and a standard deviation of 6 %. (Appendix 3: Data matrix of SPSS analysis & Appendix 4: Descriptive statistics measles vaccination rates for the whole sample and per country between 2010 and 2016). Between 2010 and 2016, the measles vaccination rates stayed at the same level in Hungary (99 %) and did just vary within a range of 1 % to 2 % in Belgium (fluctuating between 83 % and 85 %), the Netherlands (91 %-93 %), Poland (93 %-95 %), Portugal (95 %-96 %), Slovakia (97 %-99 %) and Sweden (94 %-95 %). Greater ranges with a trend to rise could be observed in France (61 %-80 %), Germany (90 %-93 %), Spain (90 %-95 %) and the UK (84 %-89 %). The Czech Republic (93 %-99 %), Denmark (80 %-87 %), Latvia (89 %-93 %) and Malta (85 %-97 %) experienced both, contemporary declines and increases in their national measles vaccination rates between 2010 and 2016. In Bulgaria (87-96 %), Estonia (92 %-95 %), Lithuania (92 %-95 %) and Slovenia (93 %-96 %) the measles vaccination rates were overall decreasing between 2010 and 2016 (Appendix 3: Data matrix of SPSS analysis & Appendix 4:

Descriptive statistics measles vaccination rates for the whole sample and per country between 2010 and 2016).

4.2 Herd immunity does not come easy

Proper delivery of measles vaccination services requires a number of well-functioning processes. Those processes concerning measles vaccinations are regulated, coordinated, implemented and monitored in the frame of national measles vaccination-policy-making in each of the 19 countries included in the sample of this study (European Observatory on Health Systems and Policies, 2018, pp.11+12). Public policymaking is described as making instrument choices. Instrument choices in this context means: the selection of means to achieve policy objectives (Hill, 2013, p.148). The up-coming paragraphs demonstrate four principal kinds of instruments the 19 different countries chose between 2010 and 2016 for their national measles policies, aiming towards the objective of reaching the 95 % threshold of herd immunity as a step towards measles elimination. This provides an answer to the second subquestion: “Which policy instruments addressed measles vaccination rates in the selected EU countries between 2010 and 2016?”

4.2.1 A governing system stating responsibilities and accountabilities and ruling the coordination of all actors involved in the measles vaccination policy process

In each of the 19 selected EU countries, the national Ministries of Health and public health authorities, as local representatives and assistants to promote the Ministry of Health and its policies, regularly debate what problems have been faced in regard to measles immunisation coverage. Examinations to explore the roots of these problems take place and each of the public health unit, in line with their statutory decision-making ability, suggest who should be involved in the formulation and implementation of improvement measures (European Observatory on Health Systems and Policies, 2018, pp.11+12). At this moment, it is thus determined how to decide and what to decide (Hill, 2013, p.154). This also implies to clarify which professional qualifications are required for those who administer measles vaccinations and to ensure that there are sufficient well-trained vaccine suppliers with extensive knowledge of the indications and, if necessary, in rare cases, contra-indications. In the 19 selected EU countries, legal measles vaccination service providers are primary care physicians, nurses, paediatricians and general practitioners of public and private healthcare providers and school health services (European Observatory on Health Systems and Policies, 2018, p.21).

Further policy instruments are necessary to properly implement measles vaccination policies. These instruments require a continuous and smooth cooperation between the multiple governmental levels and the actors involved in providing measles vaccines and administering measles vaccinations.

4.2.2 Policy instruments for the delivery of material and financial resources connected to measles vaccinations

These policy instruments refer to systems for the procurement and distribution of vaccines that ideally prevent serum shortages. To estimate the demanded quantity of measles serum, vaccine wholesalers, distributors and vaccination providers regularly forward data to those responsible for the procurement of measles vaccines on the quantity of measles vaccines administered and recommendations on how much is needed in the course of the next procurement period. Such estimations are usually based on counting the number of people eligible to measles vaccinations according to population registries or registries of health insurances and measles vaccination providers. Moreover, monitoring the occurrence of measles outbreaks and assessing whether there are enough medical resources to fight those can indicate whether a bigger storage of measles vaccine is needed or not. In the 19 selected EU countries, measles vaccine procurement are both, procured by government tenders and via sales on the private market (Smith, Lipsitch, & Almond, 2011, p.4).

An important aspect of a measles vaccination policy is to regulate the payment for those administering measles vaccines and rules how the vaccine itself is paid. In all 19 selected EU countries, measles vaccines are free of charge for children but the financing systems of these countries differ from each other. In Belgium, for some vaccination providers consultation fees have to be paid and adults have to demand for reimbursement. In Bulgaria, France and Slovakia measles vaccinations for children are paid by social health insurances (European Observatory on Health Systems and Policies, 2018, pp. 55-163). In the Czech Republic, Estonia, Latvia, Lithuania, the Netherlands, Poland, Portugal, Slovenia, Sweden and the UK, measles vaccines and vaccination delivery are free of charge and paid from public budgets, although the Slovenian financing of measles vaccination scheme does not include a small number of migrants. In Hungary measles vaccination cost are also fully covered from central government budget, apart from occupation-related mandatory measles vaccines which have to be paid by employers (European Observatory on Health Systems and Policies, 2018, pp. 34-180). In Denmark, measles vaccinations are free for residents aged between four months and 18 years (European Observatory on Health Systems and Policies, 2018, p.78). In Germany, Malta and Spain, measles vaccinations are also for free. However, in Germany the status of a patient (i.e. the age, citizen status and insurance status) as well as varying laws in the sixteen German federal states determine which governmental body or health insurance pays for the delivery of measles vaccinations (European Observatory on Health Systems and Policies, 2018, p. 94). In Malta measles vaccinations only have to be paid by patients who are not subject to a private insurance scheme but nevertheless decide to attend a private vaccination service provider (European Observatory on Health Systems and Policies, 2018, pp. 129). In Spain regional health administrations finance measles vaccinations. Exceptions are formed by patients who are civil servants of the general or judicial administration or the armed forces. Those can chose between private or publicly reimbursed healthcare providers (European Observatory on Health Systems and Policies, 2018, p.168).

4.2.3 Identify those subject to a policy and define their rights and obligations

The national governmental bodies in each of the 19 EU countries decide who should be vaccinated against measles at what age and set up corresponding vaccination schedules (Figure 10). Besides, each of the 19 EU countries formulated laws that determine whether measles immunisations are mandatory, which exemptions are possible and what sanctions can be enforced if people do not comply to the laws (Hill, 2013, p.154), (European Observatory on Health Systems and Policies, 2018, pp.11+12). Although the measles vaccination policies of all 19 EU countries are subject to the EU policy framework and share some structural similarities in regard to the areas they address, the national regulations on measles vaccinations among the studied countries still are to some extent heterogeneous. The differences the present research focuses on is whether a national measles vaccination policy in the selected countries between 2010 and 2016 legally prescribed mandatory measles vaccinations or expressed non-compulsory measles vaccination recommendations. Figure 8 gives a brief overview on the measles vaccine schedules of the 19 studied countries. Apart from the rough distinction between countries where measles vaccination is mandatory and those countries recommending measles vaccinations, a study of the 19 national measles vaccination policies reveals that there are differences among the countries concerning the meaning of mandatory.

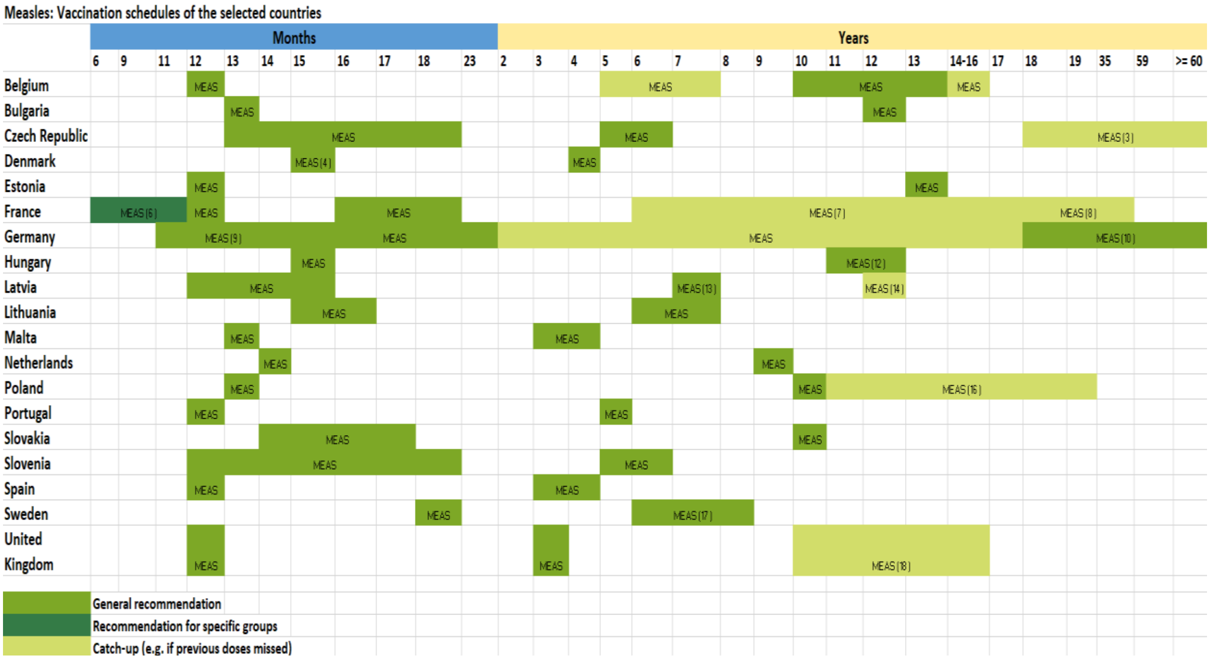


Figure 8: Measles vaccines schedules of the selected countries, (ECDC, n.d.)

Out of the countries in the sample, measles vaccinations are mandatory in Bulgaria, the Czech Republic, Hungary, Poland, Slovakia and Slovenia. However, the national policies of countries that legally prescribe measles immunisation differ among each other in the exemptions and sanctions they propose as well as in the sense that vaccinations either are mandatory for some age groups only or cover the country population as a whole.

In Bulgaria, the first dose is given to children older than 14 months and again at the age of 12 years; unvaccinated children cannot attend kindergarten and parents have to pay a fine. However, it has been observed that parents rejecting vaccinations rather pay the money and thus prevent their child from being vaccinated (European Observatory on Health Systems and Policies, 2018, p.54).

All residents of the Czech Republic staying for 90 days or longer have to be vaccinated. The two measles vaccinations are administered between 13 months and 18 months and at the age of six years. Public authorities continuously check whether there are residents who have not been vaccinated against measles, for instance adult residents from abroad who have just moved to the Czech Republic. Such persons are required to register with a general practitioner and to receive catch up vaccinations. Denying measles vaccinations is only accepted for medical reasons that have to be recorded in a person’s medical report. Otherwise, not vaccinating is regarded as a legal infringement. Fines paid to the Czech state range up to 400 € and can be enforced by the customs office. Moreover, only children who are immune against measles or could be exempted from the measles vaccination obligation due to medical reasons are permitted to go to preschool facilities (European Observatory on Health Systems and Policies, 2018, p.68).

Since 1969, measles vaccinations have been mandatory in Hungary. From 1989 onwards, children are given a first dose when they are 15 months old and a second one between 11 and 13 years. Nevertheless, poor performance of measles vaccination policies in Hungary were reported due to ineffective fines, regional resource shortages in disadvantaged regions and the existence of faked vaccination certificates (European Observatory on Health Systems and Policies, 2018, pp. 103+105).

Poland prescribes mandatory measles vaccines for children aged between zero and 19 years and who stay in Poland for longer than three months. These vaccinations are scheduled at 19 months and 10 years with catch-up opportunities until a child turns 19 years old. Parents not vaccinating their children are threatened with monetary fines (European Observatory on Health Systems and Policies, 2018, p.138).

Slovakia prescribes measles vaccinations for children aged between 15 and 18 months and 11 years (European Observatory on Health Systems and Policies, 2018, p.154).

In Slovenia, children aged between zero and 18 years have to be vaccinated against measles, as well as students younger than 26 years and all healthcare workers, independent how old they are. Measles vaccinations are usually administered initially when children are between 12 and 18 months and for the second time when they are around five or six years old. Monetary fines are enforced in cases of non-compliance to these laws (European Observatory on Health Systems and Policies, 2018, pp.161+163).

There are also three hybrid types: Firstly, Belgium where measles vaccinations are mandatory for children attending public care centres of the French community while measles vaccinations for children are only recommended in the Flemish community (European Observatory on Health Systems and Policies, 2018, p.48). In Belgium, the first measles-containing vaccine is scheduled at the age of 12 months and can be caught up at the age of five to seven years. Children in Belgium ought to receive a second measles-containing vaccine when being aged between ten and 13 years and can caught these dose up until they are 16 years old. Secondly, Germany legally just recommends measles vaccinations but prohibits unvaccinated children the access to daycare facilities unless parents have consulted a physician for medical advice. Parents rejecting the counselling by a physician are punished with a fine of up to 2 500 €. In case of measles outbreaks, children who are not vaccinated are not allowed to be looked after in daycare facilities. Also candidates applying for jobs in medical facilities can be rejected if they are not vaccinated against measles (European Observatory on Health Systems and Policies, 2018, p.92). In Germany, children receive the first measles vaccination dose during their second year of life that can be caught up until they are 18 years old. The second measles vaccine in Germany is recommended before a child turns 23 months. Thirdly, Latvia also just recommends measles vaccinations to its general public (12-15 months for the first dose and 6-7 years for the second dose, catch-up possible till the 13th year of life) but prescribes it for employees of state institutions and vaccination providers (European Observatory on Health Systems and Policies, 2018, p.116). Since these countries, despite potential constraints for unvaccinated citizens, describe their measles vaccination policies as not legally prescribing nationwide compulsory measles vaccinations, Belgium, Germany and Latvia are also treated as countries with non-compulsory measles vaccination policies in the subsequent statistical analysis of this thesis (European Observatory on Health Systems and Policies, 2018, pp.20; 47+48; 76). However, future research with a stronger focus on regional differences in measles vaccination policies within countries or the effectiveness of sanctions to tackle anti-vaccine behaviour could consider to categorize the different measles vaccination policy approaches in more detail to better account for such hybrid types.

Between 2010 and 2016, the remaining ten countries included in the sample of this research, being Denmark, Estonia, Lithuania, Malta, the Netherlands, Portugal, Spain, Sweden and the UK and France, recommend two doses of measles vaccinations without sanctioning not vaccinating. France introduced mandatory measles vaccinations in January 2018 and furthermore allows children to receive the first measles vaccination dose in specific cases when children are younger than 11 months. In the other nine countries the first dose of measles vaccination is recommended to be given between the 12th and 18th month of life of a child and the second one at some point between the age of 16 months and 16 years (ECDC, n.d.), (European Observatory on Health Systems and Policies, 2018, pp.72-177).

As revealed in the operationalization chapter, the 19 selected EU countries have opted for different kinds of registries to regularly identify which citizens in a country are eligible for measles immunisation and to check how many of those received measles vaccinations, as indicated in the annual national measles vaccination rates (Appendix 1: Composition of the measles vaccination rates in the selected countries).

4.2.4 Policy instruments stimulating a monitoring dialogue

Such instruments include the obligations of measles vaccination service providers to regularly report to whom they administered measles vaccinations and the opportunity to share their observations on public attitudes and people's concerns they get aware of while treating their clients. While the former is a tool to estimate a population's vaccination coverage and learn about vaccination gaps, the latter can give valuable input to governmental actors for better understanding the causes of measles vaccination hesitancy and how this could be tackled in the future. The measles policy processes in the 19 selected EU countries are not simple linear processes but consists of "interactions [as well as feedback loops] between political and administrative decision makers" and two groups of citizens: those who are in favour of a policy, for instance because they benefit from it, and those who disfavour the policy, for example if their interests are poorly protected by the policy content (Hill, 2013, pp.145+155).

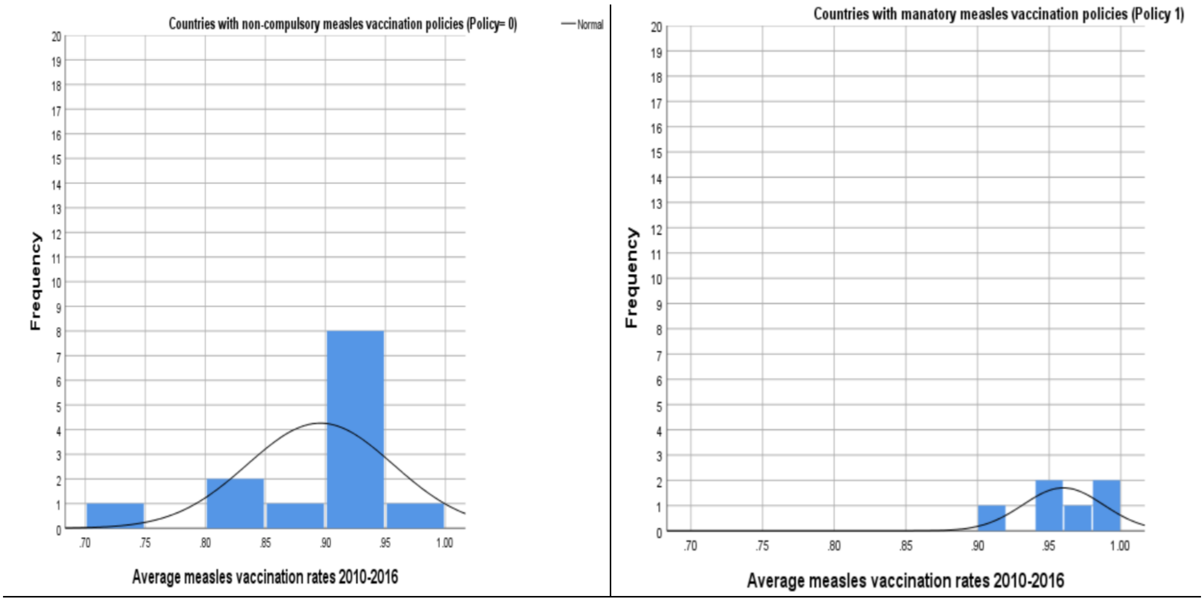
Apart from feedback tools developed and applied on the 19 different national levels, also international organisations concerned with public health offer advice and information material on assessment tools to evaluate policy outcomes and dialogues to communicate the findings among all stakeholders and the decision-makers in the measles vaccination policy cycle. The WHO, the Vaccine European New Integrated Collaboration Effort (VENICE) or the ECDC can be consulted by the studied countries to learn which assessment tools exist and how to use those in their prevailing national contexts to evaluate measles vaccination policy performances and their outcomes (European Observatory on Health Systems and Policies, 2018, p. 18). However, in the frame of this research, no information could be found whether and how these tools recommended by international organizations are used in the countries of this research sample.

To answer the second subquestion: "Which policy instruments addressed measles vaccination rates in the selected EU countries between 2010 and 2016?" it can be said that the governments of the 19 selected EU countries have freedom in determining how all actors in the measles vaccination policy processes are coordinated and what responsibilities and accountabilities they have. Moreover, governments can support the delivery of financial and material resources needed to offer sufficient measles vaccine supply and by identifying who is eligible to receive measles vaccination and how to tackle with non-vaccinating. Finally, different tools on the regional, national and international level are applied to monitor and improve the design and implementation of the prevailing national measles vaccination policies of the 19 selected EU countries.

In the 19 studied EU countries, the national Ministries of Health, in cooperation with health authorities on lower governmental levels and vaccine and vaccination service suppliers form key actors in the measles vaccination policy-making and implementation processes. They develop, apply and elaborate the potential improvements of rules that regulate the need and sufficient supply of measles vaccines, the professional standards measles vaccination service providers have to fulfil as well as what information need to be forwarded between measles vaccination providers and governmental bodies to ensure a proper monitoring of the policy implementation. Besides, all 19 selected EU countries have reimbursement systems at their disposal so that measles vaccinations are free of charge for children. National vaccination schedules inform the public at what age and which persons are entitled to measles vaccinations. While Bulgaria, the Czech Republic, Hungary, Poland, Slovenia and Slovakia expressed legally mandatory measles vaccinations between 2010 and 2016, the other 13 studied EU countries (i.e. Belgium, Denmark, Estonia, France, Germany, Latvia, Lithuania, Malta, the Netherlands, Portugal, Spain, Sweden and the UK) formulated non-mandatory measles vaccination recommendations in this time period. A core difference between countries with mandatory measles vaccinations and countries voluntary measles vaccinations is that countries with compulsory immunisations punish people who reject to get vaccinated or who do not immunize their children whereas not-vaccinating in countries with non-legally binding measles vaccinations is not sanctioned. Sanctions in place in the given research environment between 2010 and 2016 were financial fines or the exclusion of areas of public life, such as childcare institutions or the access to certain professional groups in which the absence of immunity against highly contagious virus infections forms a significant public danger.

4.3 Are compulsory vaccinations a catalyst for measles immunity?

To test the first hypothesis and to answer the third subquestion ”What was the relationship between policy instruments and measles vaccination rates in EU countries between 2010 and 2016?”, an independent-sample-t-test is carried out, comparing the means of the vaccination rates of the 19 selected EU countries. The 19 selected EU countries are assigned to one of the two groups. One group contains all selected EU countries with non-compulsory measles vaccination policies (i.e. Belgium, Denmark, Estonia, France, Germany, Latvia, Lithuania, Malta, Portugal, Spain, Sweden, the Netherlands and the UK), the other group is composed of all countries with mandatory measles vaccination policies (i.e. Bulgaria, the Czech Republic, Hungary, Poland, Slovakia and Slovenia). When creating the means for the countries in each of the groups, it is observed that there was variance in the means of the measles vaccination rates within and among the two groups and that the assumptions for an independent-sample-t-test are fulfilled (Appendix 5: Assumptions independent-sample-t-test & Figure 9).



Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
measles vaccination rate * Policy	133	100.0%	0	0.0%	133	100.0%

Report

measles vaccination rate

Policy	Mean	N	Std. Deviation
0	.8957	91	.06360
1	.9598	42	.03127
Total	.9159	133	.06289

ANOVA Table

			Sum of Squares	Df	Mean Square	F	Sig.
measles vaccination rate * Policy	Between Groups	(Combined)	.118	1	.118	38.212	.000
	Within Groups		.404	131	.003		
	Total		.522	132			

Figure 9: Variation of measles vaccination rates in the 19 selected EU countries between 2010 and 2016

The measles vaccination rates of the countries with mandatory measles vaccination policies (Policy=1) scored on average higher (96 %) than in the countries with non-mandatory measles vaccination policies (90 %) (Policy=0) and the output in Figure 11 shows that this is a statistically significant difference (p=0.001). The average measles vaccination rates of the six countries with mandatory measles vaccination policies between 2010 and 2016 were: Bulgaria

(92 %, left column in right histogram), Poland (94 %) and Slovenia (95 %, together with Poland forming the two countries of the second column in the histogram on the right, Figure 9), Czech Republic with 97 % (third column of the right histogram, Figure 9) and Slovakia (98 %) and Hungary (99 %), fourth column of the right histogram, Figure 9).

In the 13 countries with non-mandatory measles vaccination policies, the following average vaccination rates have been calculated by adding the annual measles vaccination rates of the years 2010 until 2016 and divide these sum by the seven years during which the measles vaccination rates were reported: France (73 %, first column of the left histogram, Figure 9) had by far the lowest average measles vaccination rate between 2010 and 2016, two countries had a measles vaccination rate bigger than 80 % but not surpassing 85 % (Belgium: 84 %, Denmark: 85 %, second column of the left histogram, Figure 9). The UK, with an average measles vaccination rate of 87 % between 2010 and 2016 is represented in the third column of the left histogram (Figure 9). The average measles vaccination rate of eight further countries were between 90 % and 95 % (Malta: 90 %, Latvia: 91 %, Germany: 92 %, The Netherlands: 92 %, Spain: 92 %, Estonia: 93 %, Lithuania: 93 %, Sweden: 95 %, fourth column of the left histogram, Figure 9). With an average measles vaccination rate of 96 % between 2010 and 2016, Portugal was the country with the highest average measles vaccination rate between 2010 and 2016 among the countries which are subject to a non-mandatory measles vaccination policy (fifth column of the left histogram, Figure 9).

The independent-sample-t-test generated a group statistics, confirming that 13 countries in the sample had non-mandatory measles vaccination policies between 2010 and 2016 and an average measles vaccination rate of approximately 90 % with a standard deviation of 6 % during the studied seven years. The six remaining countries of the sample had mandatory measles vaccination policies with an average measles vaccination rate of 96 % and a standard deviation of 3 %. According to the results of the independent-sample-t-test, comparing the average measles vaccination rates of the 13 selected countries in which measles vaccinations are voluntary with the measles vaccination averages of the six countries in which measles vaccinations are mandatory during the studied seven years, it is found that there is a statistically significant higher difference between the two groups ($t=-2.433$, $df=17$, $p=0.026./2=0.013$) (Figure 10). Comparing the means of the two different groups, it can be concluded that on average, the measles vaccination rates between 2010 and 2016 were higher in countries with mandatory measles vaccination policies (mean=96 %) than in the countries with non-compulsory measles vaccination policies (89 %) (Figure 10).

Group Statistics

	Policy	N	Mean	Std. Deviation	Std. Error Mean
VR_mean	0	13	.8957	.06083	.01687
	1	6	.9598	.02810	.01147

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means	
		F	Sig.	t	df
VR_mean	Equal variances assumed	1.622	.220	-2.433	17
	Equal variances not assumed			-3.139	16.960

Independent Samples Test

		t-test for Equality of Means		
		Sig. (2-tailed)	Mean Difference	Std. Error Difference
VR_mean	Equal variances assumed	.026	-.06405	.02632
	Equal variances not assumed	.006	-.06405	.02040

Independent Samples Test

		t-test for Equality of Means 95% Confidence Interval of the Difference	
		Lower	Upper
VR_mean	Equal variances assumed	-.11958	-.00852
	Equal variances not assumed	-.10710	-.02100

Figure 10: Results of the independent-sample-t-test for hypothesis 1

Based on the results of the independent-sample-t-test, the first hypothesis: “The measles vaccination rates between 2010 and 2016 were higher in EU countries with policies prescribing mandatory measles vaccinations than in countries where measles vaccinations are recommended.” is confirmed.

For the third subquestion “What was the relationship between policy instruments and measles vaccination rates in EU countries between 2010 and 2016?”, it is concluded that out of the 19 EU countries, the six countries which legally prescribed measles vaccinations had higher average measles vaccination rates between 2010 and 2016 than the 13 countries with non-compulsory measles vaccination policies.

4.4 Do measles outbreaks make measles vaccinations more attractive?

In order to answer the fourth subquestion "What was the relationship between the number of measles cases and the measles vaccination rates in the selected EU countries between 2010 and 2016?" and to test hypothesis 2: "Between 2010 and 2016, an increase in measles cases led to an increase measles vaccination rate in the selected EU countries", those countries were selected that experienced measles outbreaks (i.e. an annual number of measles cases per million inhabitants>10) between 2010 and 2016. The reason to only include those countries for answering the fourth subquestion is that variation in the number of measles cases is needed to properly examine whether the measles vaccination rates increased with a growing number of measles cases. Without clear changes in the number of measles cases per million inhabitants, fluctuations in measles vaccination rates were caused by other factors that are not further studied here. In the given sample, there are nine countries whose data are suitable for this data analysis: Bulgaria (294.53 measles cases per million inhabitants (MCpM) in 2010); the Czech Republic (21.10 MCpM in 2014), France (23.40 MCpM in 2011 & 13.20 MCpM in 2012), Germany (21.70 MCpM in 2013 & 30.50 MCpM in 2015), Latvia (17.80 MCpM in 2014), Lithuania (11.60 MCpM in 2013 and 17.00 MCpM in 2015), Slovenia (25.30 MCpM in 2014), the Netherlands (149.40 MCpM in 2013) and the UK (30.40 MCpM in 2012 and 30.70 MCpM in 2013). Ten countries (i.e. Belgium, Denmark, Estonia, Hungary, Malta, Poland, Portugal, Slovakia, Spain and Sweden) did not have sufficient variation in the number of measles outbreaks between 2010 and 2016 and are thus excluded from the analysis. For the analysis, the measles vaccination rates of each of the nine examined countries are graphically displayed. On the abscissa of each coordinate system, the years marked in yellow are those in which measles outbreaks higher than 10 cases per million in habitants were reported. These years were identified by manually studying the data matrix (Appendix 3: Data matrix of SPSS analysis). Out of the nine countries in which measles outbreaks according to the data were observed between 2010 and 2016, for a better overview first the graphs of the three countries with mandatory measles vaccination policies (Policy=1; i.e. Bulgaria, Czech Republic and Slovenia) are presented, followed by the graphs of the six countries with non-compulsory measles vaccination policies (Policy=0) which at least once reported an annual number of measles cases per million inhabitants higher than 10 between 2010 and 2016 (i.e. France, Germany, Latvia, Lithuania, the Netherlands, the UK).

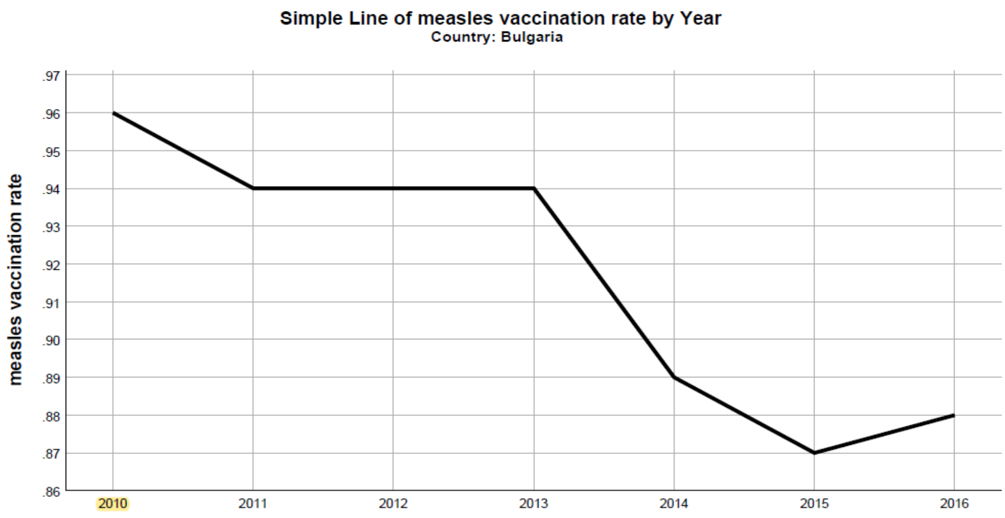


Figure 11: Measles vaccination rates Bulgaria 2010-2016, Policy=1

Bulgaria reported 294.54 MCpM in 2010 (marked in yellow in Figure 11, since MCpM>10). Since the number of MCpM and the measles vaccination rate of the previous year is unknown for this research, it cannot be stated whether this outbreak in 2010 led to an increase in the measles vaccination rate but with the aid of the data matrix (Appendix 3: Data matrix of SPSS analysis) it can at least be said that in the subsequent six years both, the measles vaccination rates and also the number of measles cases were declining (Appendix 3: Data matrix of SPSS analysis & Figure 11).

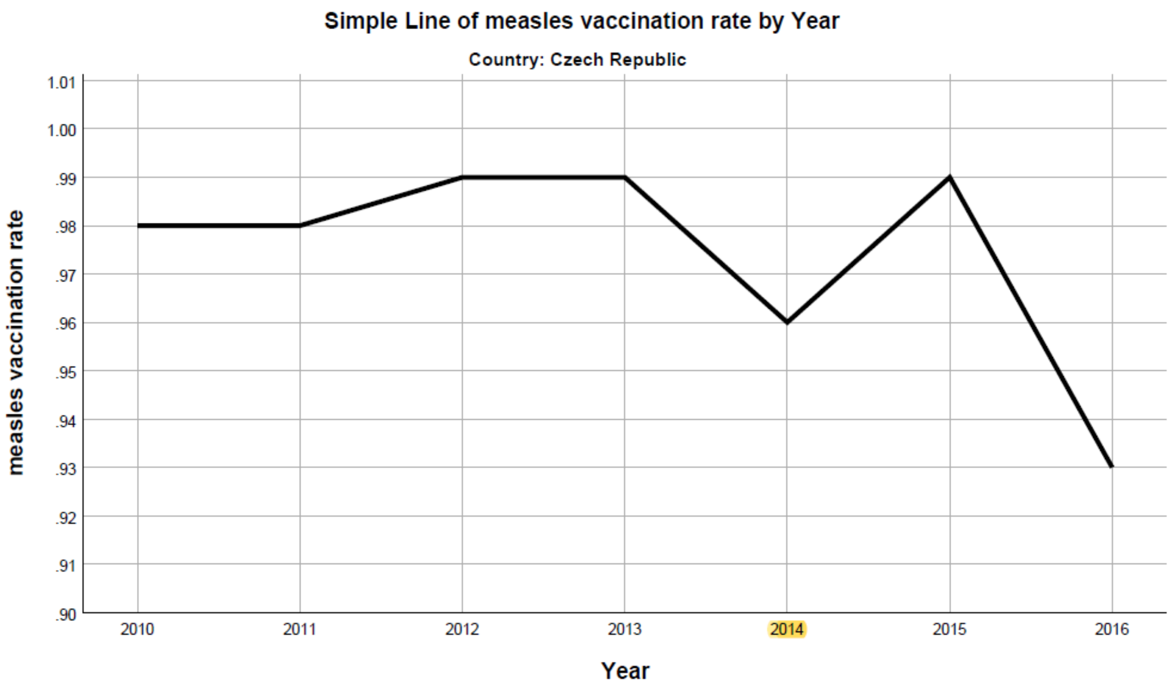


Figure 12: Measles vaccination rates in the Czech Republic 2010-2016, Policy=1

In 2014, when the Czech Republic reported 21.10 MCpM, the national measles vaccination rate in this year decreased by 3 % but recovered in 2015 before declining in 2016 again (Appendix 3: Data matrix of SPSS analysis & Figure 12).

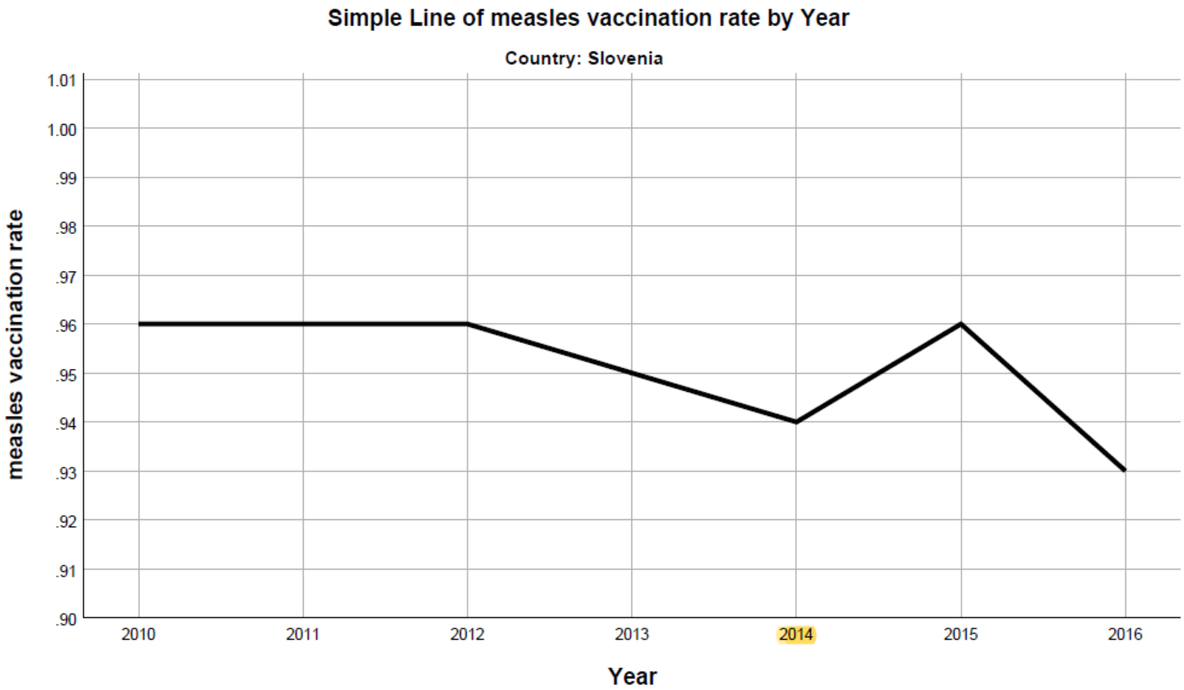


Figure 13: Measles vaccination rates in Slovenia 2010-2016, Policy=1

After two years of declining measles vaccination rates, Slovenia reported a high number of measles cases in 2014 (25.30 MCpM vs.0.1-1MCpM between 2010 and 2013). This measles outbreak could have contributed to the short-term increase of the Slovenian measles vaccination rate in 2015 (Appendix 3: Data matrix of SPSS analysis & Figure 13).

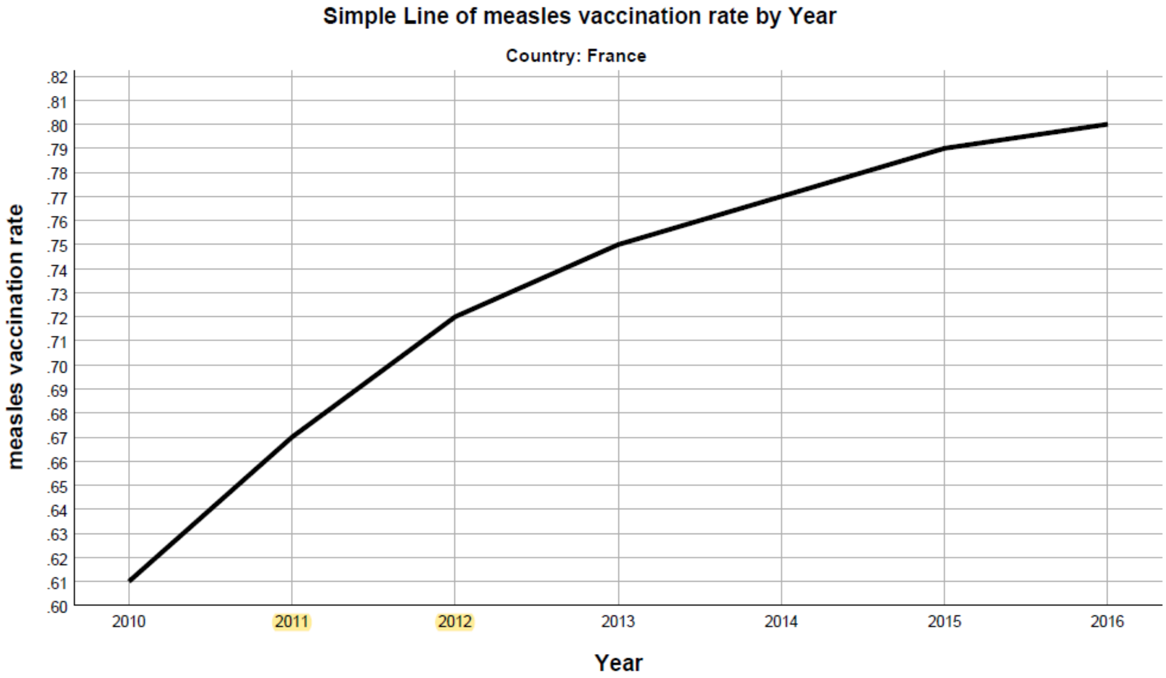


Figure 14: Measles vaccination rates in France 2010-2016, Policy=0

France experienced a measles outbreak covering two successive years in the studied time period (23.4 MCpM in 2011 and 13.20 MCpM in 2012). At the same time, France recorded increasing measles vaccination rates. A correlation between the number of measles cases and the measles vaccination rates between 2010 and 2016 could nevertheless be doubted since the measles vaccination rate not only increased during and immediately after the outbreak but overall between 2010 and 2016 (Appendix 3: Data matrix of SPSS analysis & Figure 14).

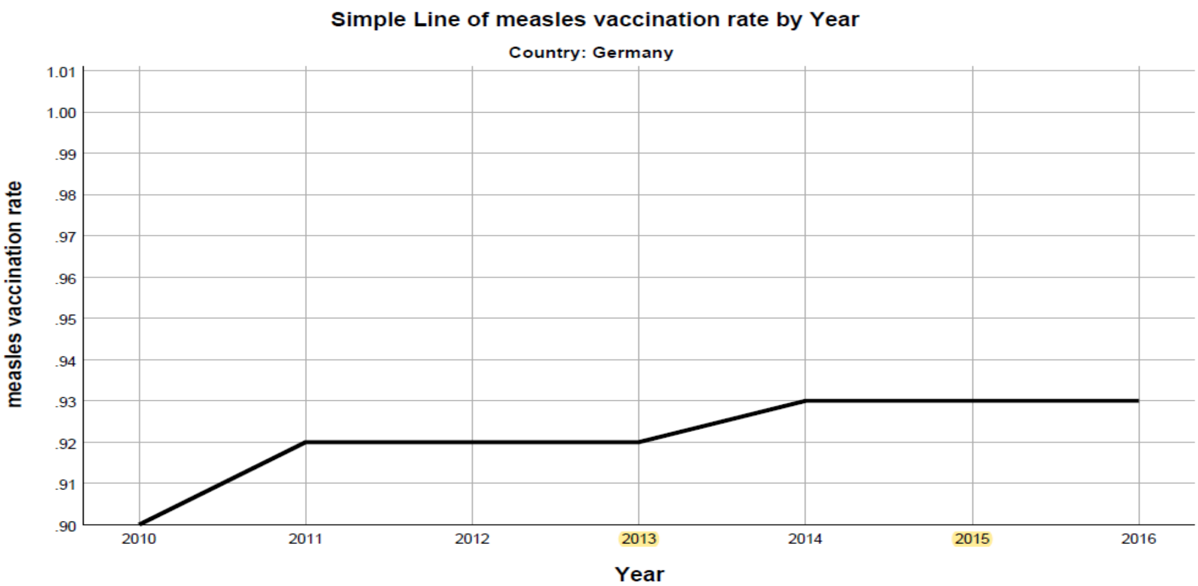


Figure 15: Measles vaccination rates in Germany 2010-2016, Policy=0

Germany registered more than 10 MCpM in 2013 (21.7 MCpM) and in 2015 (30.5 MCpM). While the German measles vaccination rates between 2013 and 2014 slightly grew, after 2015 no changes in the German measles vaccination rates were noticed according to the data used (Appendix 3: Data matrix of SPSS & Figure 15).

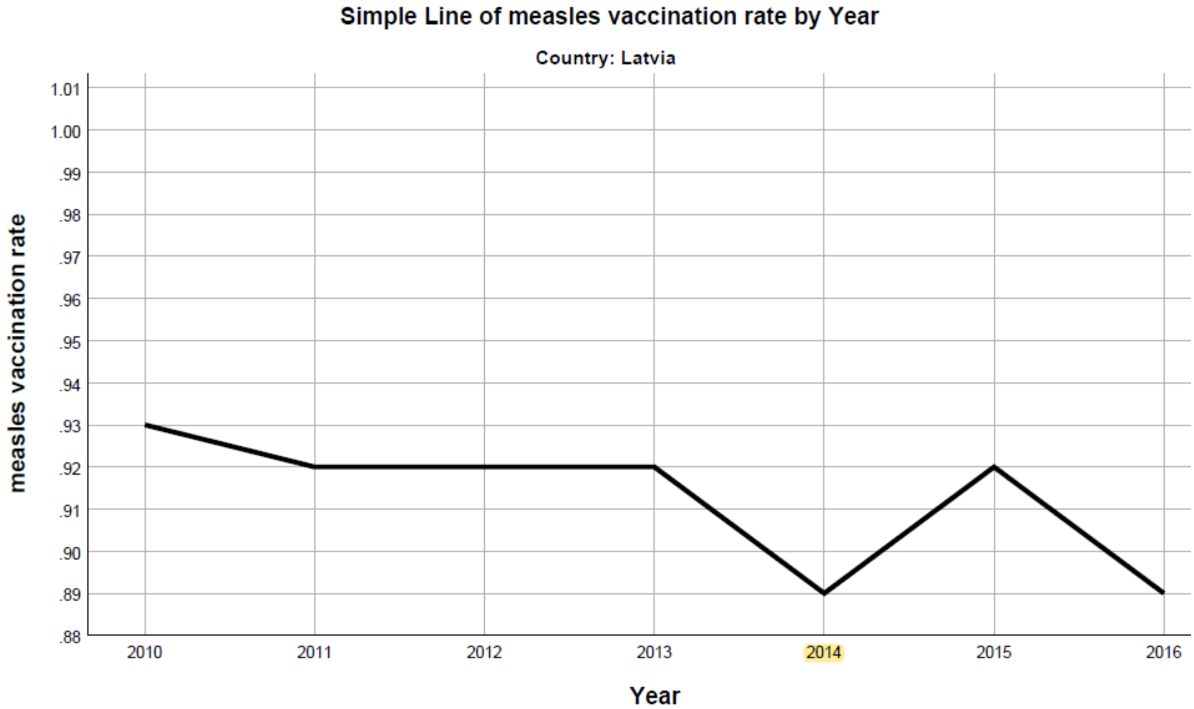


Figure 16: Measles vaccination rates in Latvia 2010-2016, Policy=0

After nearly being eliminated, the number of measles cases in Latvia strongly increased in 2014 (17.80 vs. 0-1.30 MCpM between 2010 and 2013). This outbreak might have been positively related with the Latvian measles vaccination rate in 2015, whose growth, however, reversed again by 2016 (Appendix 3: Data matrix of SPSS & Figure 16).

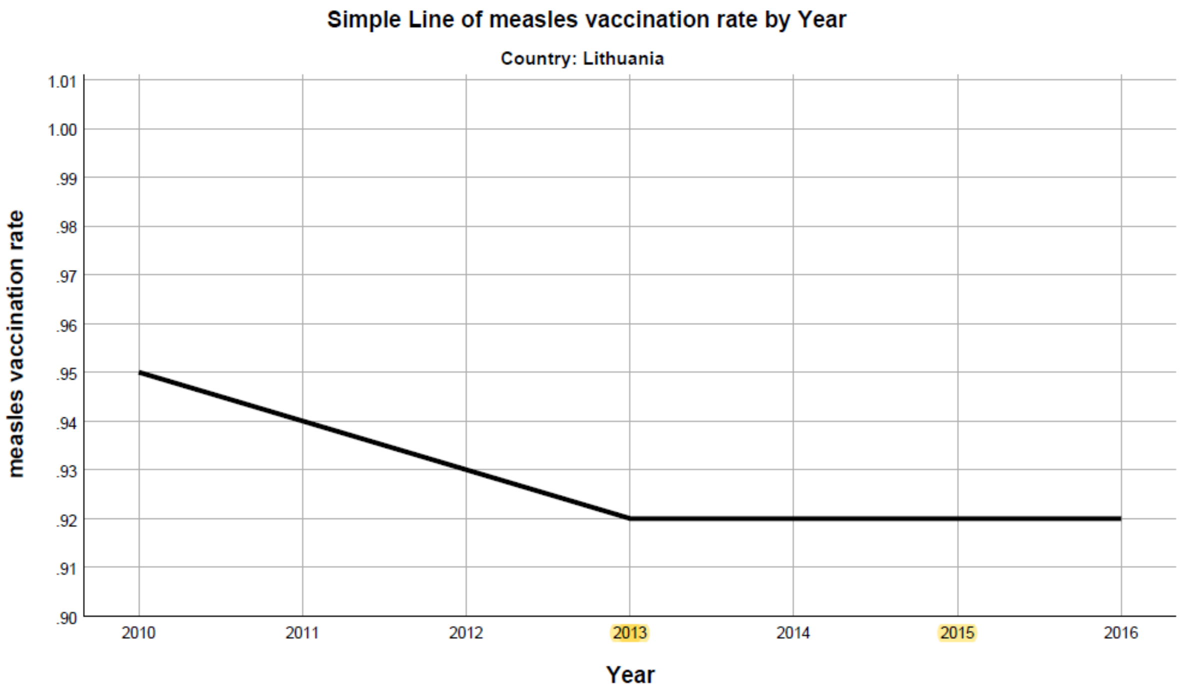


Figure 17: Measles vaccination rates in Lithuania 2010-2016, Policy=0

In Lithuania, the number of measles cases does not appear to be correlated to the measles vaccination rates. While the country reported remarkable growths in the number of measles cases (11.60 MCpM in 2013 and 17.00 MCpM in 2015), the national measles vaccination rates remained consistent between 2013 and 2016 (Appendix 3: Data matrix of SPSS & Figure 17).

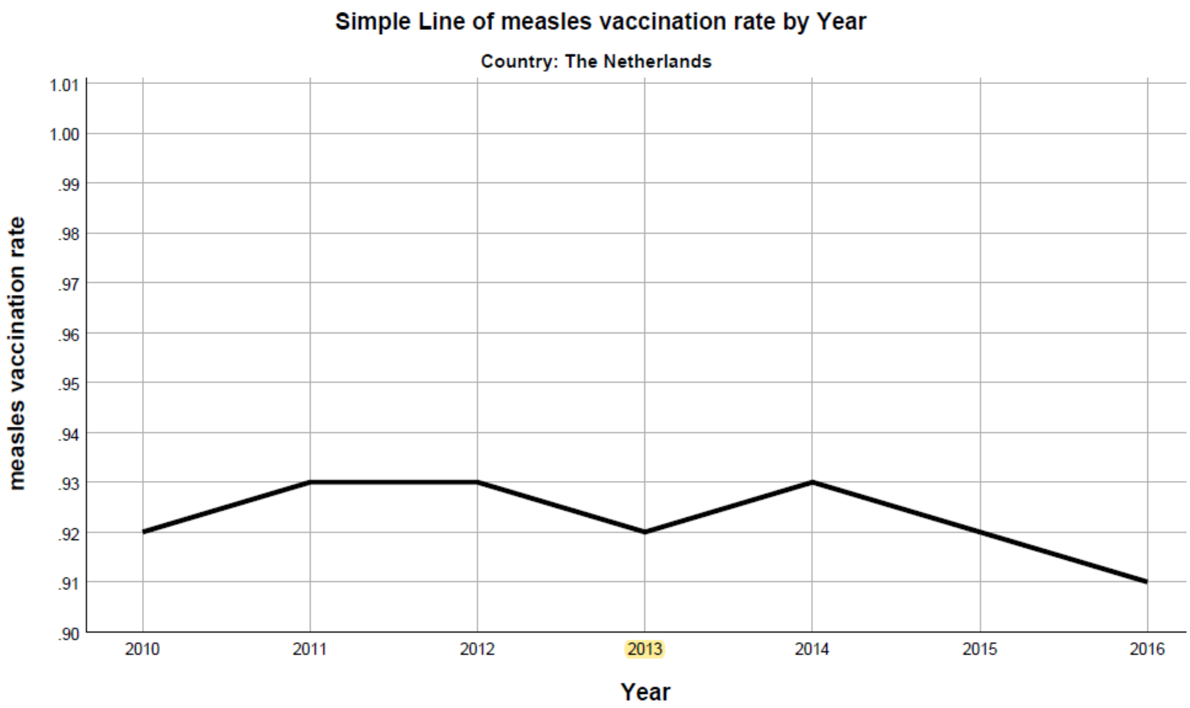


Figure 18: Measles vaccination rates the Netherlands 2010-2016, Policy=0

Also in the Netherlands a slight increase in the national measles vaccination rate could be observed after a measles outbreak (149.40 MCpM) in 2013. After the number of measles cases diminished again, the Dutch measles vaccination rates slightly did, too by 2016 (Figure 18 & Appendix 3: Data matrix of SPSS).

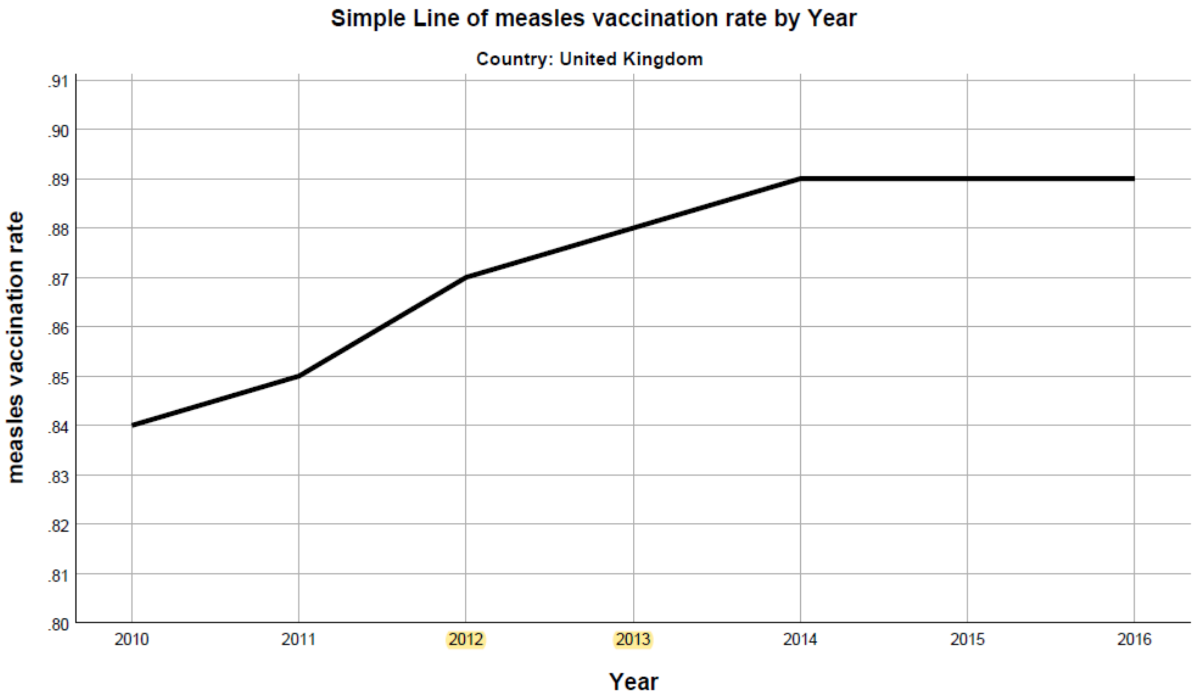


Figure 19: Measles vaccination rates of the UK 2010-2016, Policy=0

Similar to France, the UK experienced a measles outbreak covering two successive years in the studied time period (30.40 MCpM in 2012 & 30.70 MCpM). A correlation between the number of measles cases and the measles vaccination rates between 2010 and 2016, can nevertheless be questioned here since the measles vaccination rate not only increased during and immediately after the outbreak but overall between 2010 and 2016 (Appendix 3: Data matrix of SPSS & Figure 19).

The descriptions above, informing about the measles vaccination rates of those countries in the sample that experienced measles outbreaks between 2010 and 2016 serve to answer the fourth subquestion “What was the relationship between the number of measles cases and the measles vaccination rates in the selected EU countries between 2010 and 2016?” and to test hypothesis 2: “Between 2010 and 2016, an increase in measles cases led to an increase measles vaccination rate in the 19 selected EU countries”. In regard to the relationship between the number of measles cases and the measles vaccination rates in the examined EU countries it can be said that in times of measles outbreaks no changes in the measles vaccination rates could be observed (i.e. Germany, Lithuania, the Netherlands) or that the measles vaccination rates just raised in the short-term in the year after an outbreak (the Czech Republic, Latvia, Slovenia). Besides it is not possible to trace back whether the short-term increases in measles vaccination rates in these countries were primarily triggered off by the measles outbreaks or by other factors that are not considered in this research. The results for Bulgaria, France and the UK are to be regarded as equivocal. Bulgaria reported a measles outbreak in 2010 and since no data on the Bulgarian measles vaccination rate and number of measles cases of 2009 is present, not a lot can be told about a potential correlation between these two variables at this point. In France and the UK, measles outbreaks took place over two successive years. However, since the measles vaccination rates in both countries were continuously rising between 2010 and 2016, it is difficult to determine to what extent the reported measles outbreaks consolidated the positive measles vaccination rate trends between 2010 and 2016 in these two countries. Regarding these findings, with the limited data at hand that showed that measles outbreaks had very little or none impact on the measles vaccination rates in the nine countries, the second hypothesis: “Between 2010 and 2016, an increase in measles cases led to an increase measles vaccination rate in the 19 selected EU countries” is rejected.

4.4.1 Do different policy approaches matter for the association between measles outbreaks and measles vaccination rates?

Allocating the nine countries into two groups, depending on whether their measles vaccination policies between 2010 and 2016 legally prescribed mandatory measles vaccinations or not answers subquestion 4a: “Did the relationships between the number of measles cases and the measles vaccination rates in EU countries with policies prescribing mandatory measles vaccinations differ from the relationship between measles cases and the measles vaccination rates in EU countries with non-compulsory measles vaccination policies?”

Table 3. *Countries with measles outbreaks between 2010-2016, per policy*

Country	Policy	Effect of measles outbreak
Bulgaria	1	Equivocal
Czech Republic	1	No/potentially little short-term effect
Slovenia	1	No/potentially little short-term effect
France	0	Equivocal
Germany	0	No
Latvia	0	No/potentially little short-term effect
Lithuania	0	No
The Netherlands	0	No
UK	0	Equivocal

Hypothesis 2a: “Between 2010 and 2016, an increased number of measles cases in EU countries with mandatory measles vaccination policies did not led to an increase in the

measles vaccination rates of these countries” is rejected since in the Czech Republic and Slovenia a slight rise in the measles vaccination rate was observed. However, it is not perfectly sure whether this rises occurred due to the measles outbreaks. Therefore, it is recommended to dedicate future studies which elaborate in more detail on the timing of each of the measles outbreaks within the year and better estimate their potential effect on the measles vaccination rates of these countries in times of and after the outbreaks. This master thesis does not deal further with the timing and duration of potential effects of outbreaks, primarily because of language barriers. With the just mentioned limitations and the descriptions of the graphs (Figures 11-19) in mind, hypothesis 2b: “Between 2010 and 2016, an increased number of measles cases in EU countries with non-compulsory measles vaccination policies led to an increase in the measles vaccination rate of these countries.” is confirmed for Latvia but rejected for Germany, Lithuania and the Netherlands.

For Bulgaria (Policy 1), France and the UK (both Policy 0) no decision concerning the hypothesis testing could be made with the data at hand. Bulgaria reported 294.54 MCpM in 2010 but since the number of MCpM and the measles vaccination rate of the previous year is unknown in this master thesis, it cannot be clarified whether the outbreak in Bulgaria in 2010 led to an increase in the measles vaccination rate. With the aid of the data matrix (Appendix 3: Data matrix of SPSS analysis) it can at least be said that in the subsequent six years both, the measles vaccination rates and also the number of measles cases in Bulgaria were declining (Appendix 3: Data matrix of SPSS analysis & Figure 11). France and the UK experienced measles outbreaks covering two successive years in the studied time period but a correlation between the number of measles cases and the measles vaccination rates between 2010 and 2016 can also be questioned since the measles vaccination rate not only increased during and immediately after the outbreaks but overall between 2010 and 2016 (Appendix 3: Data matrix of SPSS & Figures 14 & 19).

The answer to subquestion 4a “Did the relationships between the number of measles cases and the measles vaccination rates in EU countries with policies prescribing mandatory measles vaccinations differ from the relationship between measles cases and the measles vaccination rates in EU countries with non-compulsory measles vaccination policies?” is that for the relationship between the number of measles cases and the national measles vaccination rate in the nine studied countries between 2010 and 2016 it did not matter a lot whether measles vaccinations were mandatory or not (Table 3). In the two countries with mandatory measles vaccination rates, only slight short-term increases were observed while in countries with non-compulsory measles vaccination policies no change in the measles vaccination rates was notified during and after measles outbreaks. Moreover, due to lacking information on the precise timing of the individual outbreaks and the duration of potential effects of outbreaks in the prevailing national outbreaks, the validity of these findings is limited.

4.5 The internet – a beneficial or damaging communication media for measles vaccination rates?

During the studied timeframe, in all 19 EU countries a growing proportion of people making daily use of the internet was observed (Eurostat, 2019, Appendix 3: Data matrix of SPSS). Coherent with what is expected in hypothesis 3: “Between 2010 and 2016, an increased proportion of people daily using the internet in the 19 selected EU countries led to declining measles vaccination rates in these countries”, in the present data analysis a statistically significant correlation between the proportion of people daily using the internet and the measles vaccination rates in the research sample could be found ($p=0.01$):

Table 4. *Correlation between measles vaccination rates and internet use*

Correlations

		measles vaccination rate	daily internet usage of individuals
measles vaccination rate	Pearson Correlation	1	-.285**
	Sig. (2-tailed)		.001
	N	133	133
daily internet usage of individuals	Pearson Correlation	-.285**	1
	Sig. (2-tailed)	.001	
	N	133	133

Answering the fifth subquestion “What was the relationship between the proportion of people daily using the internet and measles vaccination rates in the selected EU countries between 2010 and 2016?”, it can be said that the daily internet use of people was correlated to the measles vaccination rates in the 19 selected countries between 2010 and 2016. The third hypothesis “Between 2010 and 2016, an increased proportion of people daily using the internet in the 19 selected EU countries led to declining measles vaccination rates in these countries” expects a negative relationship between the proportion of people daily using the internet and the measles vaccination rates what can be confirmed by the negative Pearson’s R coefficient (Table 4).

The next section checks whether the correlation remains statistically significant and whether the direction of the relationship between the variables “internet use” and “measles vaccination rate” remains the same when studying the 19 countries included in this sample per policy approach, distinguishing between countries with mandatory and non-mandatory measles vaccination policies between 2010 and 2016.

4.5.1 Do different policy approaches matter for the association between daily internet use of individuals and measles vaccination rates?

This section is dedicated to the subquestion 5a “Did the relationships between the proportion of people daily using the internet and measles vaccination rates in EU countries with mandatory measles vaccination policies differ from those in EU countries with non-compulsory measles vaccination policies between 2010 and 2016?” A partial correlation test on SPSS answers whether the two hypotheses: 3a:”Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with mandatory measles vaccination policies did not lead to a decline in the measles vaccination rates of these countries” and 3b:”Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with non-compulsory measles vaccination policies led to a decline in the measles vaccination rates of these countries”, are true for the selected research setting. The corresponding partial correlation test on SPSS has delivered the following results:

Table 5. *Correlations between internet use and measles vaccination rates per policy group*

Correlations: Internet use and measles vaccination rates in countries with non-compulsory measles vaccination policies (Policy=0)

		measles vaccination rate	daily internet usage of individuals
measles vaccination rate	Pearson Correlation	1	-.151
	Sig. (2-tailed)		.152
	N	91	91
daily internet usage of individuals	Pearson Correlation	-.151	1
	Sig. (2-tailed)	.152	
	N	91	91

a. Policy = 0

Correlations: Internet use and measles vaccination rates in countries with mandatory measles vaccination policies (Policy=1)

		measles vaccination rate	daily internet usage of individuals
measles vaccination rate	Pearson Correlation	1	.344*
	Sig. (2-tailed)		.026
	N	42	42
daily internet usage of individuals	Pearson Correlation	.344*	1
	Sig. (2-tailed)	.026	
	N	42	42

a. Policy = 1

Contrary to the expectations of the hypotheses, in countries with non-compulsory measles vaccination policies (Policy=0) no statistically significant relationship between internet use and measles vaccination rates is found in the selected sample (p=0.152). In countries with mandatory measles vaccination policies (Policy=1), there is a statistically significant and positive relation between internet use and measles vaccination rates (p=0.26, Pearson Correlation=0.344). In other words, according to this correlation test, measles vaccination rates in countries with mandatory measles vaccination policies were higher between 2010 and 2016, the higher the percentage of people daily using the internet was. These findings lead to the rejection of hypothesis 3a and hypothesis 3b (Table 5).

As a result, subquestion 5a “Did the relationships between the proportion of people daily using the internet and measles vaccination rates in EU countries with mandatory measles vaccination policies differ from those in EU countries with non-compulsory measles vaccination policies between 2010 and 2016?” can be answered by stating that the relationships between the proportion of people with internet access and measles vaccination rates differ between EU countries with mandatory measles vaccination polices and EU countries with non-compulsory measles vaccination policies. However, the nature of these relationships deviated from what the theoretically derived hypothesis 3a and hypothesis 3b suggested. While hypothesis 3a claimed that ”Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with mandatory measles vaccination policies did not lead to a decline in the measles vaccination rates of these countries”, the partial correlation test conducted with the given data set showed that measles vaccination rates in countries with mandatory measles vaccination policies were higher between 2010 and 2016, the higher the percentage of people daily using the internet was.

Hypothesis 3b stated that ”Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with non-compulsory measles vaccination policies led to a decline in the measles vaccination rates of these countries”, while no statistically significant correlation between internet use and measles vaccination rates in countries with non-compulsory measles vaccination policies is statistically found. Possible explanations for these results will be elaborated in the discussion and conclusion.

5. Conclusions & Discussion

5.1 Conclusions

Achieving herd immunity by a high vaccination coverage against measles is one big goal on the global public health agenda and also has remained a challenge in EU countries.

The present master thesis answers the research question: "To what extent did the mandatory character of measles vaccination policies influence the measles vaccination rates and did this also impact the influence of measles outbreaks and internet access on measles vaccination rates in EU countries between 2010 and 2016?" The present EU country comparison gives input to evaluate and to deeper examine the extent to which mandatory measles vaccination policies appear as an appropriate policy tool for countries intending to achieve and consolidate measles herd immunity in their populations. Measles herd immunity as a policy goal is regarded as a valuable contribution to the WHO goal of globally eliminating measles.

Initially, hypotheses as shown in Table 6 on how the measles outbreaks, measles vaccination rates and individuals' daily internet use are theoretically expected to be related to each other were derived with the aid of the Health Belief Model, once for the case that a country legally prescribes measles vaccinations in its policies and in a second scenario for countries with non-compulsory measles vaccination recommendations.

Table 6. *Hypotheses and findings of their testing*

Hypothesis	Results
Hypothesis 1: The measles vaccination rates between 2010 and 2016 have been higher in EU countries with policies prescribing mandatory measles vaccinations than in countries where measles vaccinations are recommended.	Confirmed for all 19 studied countries
Hypothesis 2: Between 2010 and 2016, an increase in measles cases led to an increased measles vaccination rate in the 19 selected EU countries. (Measles outbreak defined as: annual number of measles cases per million inhabitants >10)	Rejected for Germany, Lithuania and the Netherlands Rejected despite short-term rise in VR for the Czech Republic, Latvia and Slovenia Equivocal findings for France, the UK and Bulgaria (Only these nine countries experiences measles outbreaks between 2010 and 2016➔n=9)
Hypothesis 2a: Between 2010 and 2016, an increased number of measles cases in EU countries with mandatory measles vaccination policies did not lead to an increase in the measles vaccination rates of these countries.	(n=4) Rejected for the Czech Republic and Slovenia Equivocal result for Bulgaria
Hypothesis 2b: Between 2010 and 2016, an increased number of measles cases in EU countries with non-compulsory measles vaccination policies led to an increase in the measles vaccination rate of these countries.	(n=5) Accepted for Latvia Rejected for Germany and the Netherlands Equivocal result for France and the UK
Hypothesis 3: Between 2010 and 2016, an increased proportion of people daily using the internet in the 19 selected EU countries led to declining measles vaccination rates in these countries.	Confirmed for all 19 countries
Hypothesis 3a: Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with mandatory measles vaccination policies did not lead to a decline in the measles vaccination rates of these countries.	Rejected for group of countries with mandatory measles vaccination policies (formed by Bulgaria, the Czech Republic, Hungary, Poland, Slovakia, Slovenia)
Hypothesis 3b: Between 2010 and 2016, an increasing proportion of people daily using the internet in EU countries with non-compulsory measles vaccination policies led to a decline in the measles vaccination rates of these countries.	Rejected for group of countries with non-compulsory measles vaccination policies (formed by Belgium, Denmark, Estonia, France, Germany, Latvia, Lithuania, Malta, Portugal, Spain, Sweden, the Netherlands and the UK)

In a subsequent step, data on measles outbreaks, daily individuals' internet use, measles vaccination rates and information on the state of measles vaccination policies between 2010 and 2016 of 19 EU countries were compiled and analysed.

Descriptive statistics of the annual national measles vaccination rates revealed that the measles vaccination rates of the 19 different countries developed in various manners between 2010 and 2016. Hungary (99 %) reported the same level of measles vaccination coverage in all of the seven studied years. Between 2010 and 2016, differences among the annual measles vaccination rates and the prevailing measles vaccination rates of the previous year were never bigger than 1 % to 2 % in Belgium (83 %-85 %), the Netherlands (91 %-93 %), Poland (93 %-95 %), Portugal (94 %-96 %) and Sweden (94 %-95 %). In the Czech Republic (range: 93 %-99 %), Denmark (80 %-87 %), Latvia (89 %-93 %) and Malta 85 %-97 %), both contemporary declines and increases in the national measles vaccination rates occurred between 2010 and 2016. Overall decreasing measles vaccination rates in this time period were observed in Bulgaria (87 %-96 %), Estonia (92 %-95 %), Lithuania (92 %-95 %), Slovenia (93 %-96 %) and Slovakia (97 %-99 %), while France (61 %-80 %), Germany (90 %-

93 %), Spain (90 %-95 %) and the UK (84 %-89 %) reported overall climbing measles vaccination rates in this time period.

Studying a literature summary of national measles vaccination policy papers showed that all 19 national measles vaccination policies shared some similarities in regard to policy instruments for the regulating and monitoring the implementation of the 19 individual measles vaccination programmes. Measles vaccination policies draw up a framework to arrange the financing, supply and administration of measles vaccines, define occupational qualifications and accountabilities of vaccination providers, give instructions how to contact members of a population that shall be vaccinated and determine what information need to be forwarded from the measles vaccination providers to local and national health authorities so that the measles vaccination coverage can be monitored and possibly improved in the future. Moreover, two principal approaches could be identified with which the 19 studied countries tackle with people who reject measles vaccinations: while 13 countries (Belgium, Denmark, Estonia, France, Germany, Latvia, Lithuania, Malta, Portugal, Spain, Sweden, the Netherlands and the UK) recommended measles vaccinations to the people but not punished not-vaccinating between 2010 and 2016, six countries in the sample (Bulgaria, the Czech Republic, Hungary, Poland, Slovenia and Slovakia) imposed sanctions between 2010 and 2016 on people who rejected to inoculate themselves or their children, either in the nature of fines or a denied access to certain services like daycare for children or exclusion from exercising certain professions that, according to the prevailing national law of an EU member state, require measles immunity.

An independent-sample-t-test confirmed the first hypothesis. As suggested in the first hypothesis, in the studied sample countries with mandatory measles vaccinations had on average higher measles vaccination rates between 2010 and 2016 than countries with non-compulsory measles vaccination recommendations. Thereupon it is wondered whether the policies which legally prescribe measles vaccinations were actually powerful enough to prevent the impact of factors that form individuals' attitudes and their final decision whether to receive measles vaccinations or not. Measles outbreaks and individuals' daily internet use were taken as examples in this master thesis for such factors. According to the Health Belief Model, a measles outbreak that grasps public attention can reinforce the threat people perceive when seeing other persons suffering from a dangerous and contagious illness. As a result, more measles vaccinations will be administered during and after outbreaks to stop this measles from spreading. Thus, measles vaccinations are theoretically expected to be a catalyst for measles vaccination rates. However, studying the graphs of the nine out of 19 countries that experienced measles outbreaks (all cases in which the number of measles cases per million inhabitants was >10) between 2010 and 2016 revealed that this theoretical assumption is not true for Germany, Lithuania and the Netherlands and just of limited validity for the Czech Republic, Latvia and Slovenia. Equivocal findings with the data at hand were obtained for France, the UK and Bulgaria. Bulgaria reported a measles outbreak in 2010 and since no data on the Bulgarian measles vaccination rate and number of measles cases of 2009 are present, not a lot can be told about a potential correlation between these two variables at this point. In France and the UK, measles outbreaks took place over two successive years. However, since the measles vaccination rates in both countries were continuously rising between 2010 and 2016, it is difficult to determine to what extent the reported measles outbreaks consolidated the positive measles vaccination rate trends between 2010 and 2016 in these two countries. Thus the second hypothesis (Table 6) for the sample as a whole is rejected. Assessing the relationship between measles outbreaks and measles vaccination rates per policy group, hypothesis 2a, according to the graphs for the Czech Republic and Slovenia is rejected for the time being, although it cannot be determined in this research whether the short-term rise in measles vaccination rates is associated with the measles outbreaks observed. The same is valid for hypothesis 2b, which is accepted for Latvia but rejected for Germany and the Netherlands. The problem in the frame of this hypothesis testing was that not enough evidence could be gained in the course of this master thesis, principally due to language barriers, to guarantee that the selected numerical increase in measles cases was perceived as such by the government and the population in these countries. This could be one reasons why not a lot more people received measles vaccinations during and after the numerically identified outbreaks or just a small proportion in the short term, what only led to a slight and not long-lasting growth of the measles vaccination rates.

The daily internet use of individuals, in contrast to measles outbreaks, increased gradually and not in a sudden manner at some unpredictable moments in time during the studied seven years. While, according to the Health Belief Model, an increased daily internet use of individuals could imply both benefits and barriers for the achievement of measles herd immunity in a country, the hypothesis expected a negative relationship between the variables “individuals’ daily internet use” and “measles vaccination rates”, based on what previous researchers reported. In the data analysis of this master thesis, controversial findings were generated. When running a correlation with these two variables for the studied sample as a whole, the previously expected negative relationship between “individuals’ daily internet use” and “measles vaccination rates” is confirmed. Splitting the sample for this correlation into two groups, one being the countries with mandatory measles vaccination rates and the second one formed by countries with non-binding measles vaccination recommendations, no correlation could be found between “individuals’ daily internet use” and “measles vaccination rates” in countries with non-mandatory measles vaccination recommendations whereas between “individuals’ daily internet use” and “measles vaccination rates” were positively related with each other, according to the correlation coefficient. The overall found negative relationship derived from a negative Pearson correlation coefficient in the first test may have been obtained because in all countries the percentage of people daily using the internet strongly increased while the measles vaccination rates of all 19 studied countries in total rather declined than increased. A reason why no correlation between “measles vaccination rates” and “internet use” in countries with non-binding measles vaccination recommendations could be that people used the internet incrementally more over the studied time period but were not influenced in their measles vaccination behaviour by online sources, either because they did not actively look for corresponding information online or were also passively not impacted by online-anti-vaccine movements. For the countries with mandatory measles vaccination policies it should be noted that they were all under the power influence of the Soviet Union until a bit more than 30 years ago. Consequently, the positive relationship between “measles vaccination rates” and “individuals’ daily internet use” could be explained by concluding that an increased internet use in these countries and a higher measles vaccination rate at the same time between 2010 and 2016 reflect the gradually, overall improving living conditions in these countries. Thus, the results generated in the statistical analysis should be interpreted carefully regarding the fact that the collected data on internet use might well reflect the growing opportunity to access online sources in the studied countries between 2010 and 2016. However, not enough is known on what websites the internet users accessed and at this state it appears that online-anti-measles-vaccine campaigns did not visibly influence the measles vaccination behaviour of the studied populations between 2010 and 2016.

5.2 Answer to the research question

In summary the answer to the research question is that on average the average measles vaccination rates among the 19 studied EU countries were higher between 2010 and 2016 in countries with legally compulsory measles vaccinations than in countries with non-compulsory measles vaccination recommendations. For the relationship between measles outbreaks and measles vaccination rates it did not matter whether a country legally prescribed measles vaccinations or not. The different findings on the relationships between “internet use” and “measles vaccination rates” appear not directly to originate from the differences in measles vaccination policy approaches but rather from the countries’ different political and economic trajectories in the past. Mandatory measles vaccination policies were only in place in countries which had been under communist, Soviet power influence until few decades ago while the majority of cases of non-mandatory measles vaccination policies are formed by Western European countries (except from Estonia, Lithuania and Latvia). Countries that were under

Soviet power over decades have experienced more remarkable improvements in living standards in the recent past than their Western counterparts where living standards used to be higher already before 1990. Increasing measles vaccination rates and percentages in daily internet use just may reflect the situation of those experiencing the improving living standards in Eastern European countries, rather than being competing forces in the attempt of achieving measles herd immunity.

The results of this research are to be assessed and interpreted carefully, thereby keeping its strengths and limitations in mind. The next sections inform about the strengths and limitations of the present results. Beyond this, recommendations on what future research could look at are included. With the aid of future studies, one could learn more as to why the mandatory character of measles vaccination policies in total do not seem to have had more influence on a populations' measles vaccination behaviour than non-compulsory measles vaccination recommendations or explore other factors which could modify measles vaccination rates and its relationships with measles outbreaks and individuals' internet use than theoretically expected in this thesis.

5.3 Strengths

This master thesis, to the best of the researcher's knowledge, is the first research that combines and tests theories which previously had only been tested in isolated individual national contexts, studying whether mandatory characteristics of measles vaccination policies did shape the interplay between measles vaccination rates, internet use and measles outbreaks differently than non-compulsory measles vaccination recommendations. By compiling data for 19 EU countries on seven years, the study thereby displays a direct country comparison for the time period 2010 to 2016 concerning two different measles vaccination policy approaches. The thesis thus forms a coherent report on the trends in measles vaccination rates and how this indicator might have been impacted by the gradual advancement of the internet in the research population as well as by the occurrence of unpredictable measles outbreaks that might have stimulated the public perception of measles being a health threat that ought to be taken serious.

5.4 Limitations

Three core limitations concerning the quality of the data collected and analysed in the frame of this research are identified:

Firstly, the heterogeneous procedures among the countries to estimate and to report the annual national measles vaccination coverage makes a cross-country comparison on the measles vaccination policy performance difficult. It inter alia raises the question whether the pressure to report measles vaccination rates that testify a high vaccination coverage is higher in countries with mandatory measles vaccinations than in countries with non-compulsory measles vaccination recommendations, where behaviour deviating from the measles vaccination recommendations is not sanctioned. In the selected sample the measles vaccination rates between 2010 and 2016 were on average higher in the six countries with mandatory measles vaccination policies (mean=96 %) than in the 13 countries with non-compulsory measles vaccination policies (mean=89 %) (Figure 9). However, it should be added at this point that the data alone may not sufficiently reflect the events in reality. It could be that countries in which measles vaccination policies are mandatory, it is attempted to compose the measles vaccination rate in a manner that formally ensures compliance to the law. While the policy reports of some countries stated that high measles vaccination rates could be achieved in specific target groups whose data are medically reported and included in the estimation of the measles vaccination rates, in some other countries migration, marginalized groups or vaccine shortages remain problems that may not be detected when focusing on a statistical analysis examining the formal characteristics of measles vaccination policies and national measles vaccination rates. Measles vaccination rates are based on administrative procedures of health care providers which can report on the people who access the services provided by the national health care sectors but not on those who do not want or cannot access the services of measles vaccination for a variety of reasons such as not being willing to get vaccinated, not being eligible to measles vaccination services or due to infrastructural obstacles.

Secondly, the variable “daily internet use of individuals” is rather a rough proxy to assess the internet behaviour of the studied sample. It tells how much time individual persons daily spent online but does not indicate whether websites purposely or randomly accessed played a role in the individual decision-making whether to vaccinate against measles or not.

Thirdly, more information on the identified measles outbreaks, especially on their timing within the year in which they occurred, the public attention paid to each of the outbreaks and the duration and potential power of the effect that measles outbreaks might have had on people’s perceptions towards measles vaccinations could not be gained due to language barriers and time constraints. Such information would have been helpful for a better assessment of the relationships between measles outbreaks and measles vaccination rates.

The next section offers some recommendations for measles-vaccination-policy-making and includes some proposition how future research could build upon the present research results. This future studies could improve the weaknesses of the research design that inter alia due to time constraints could not be completely tackled in this master thesis.

5.5 Recommendations for future research

Since this research did not generate unambiguous results showing that mandatory measles vaccination policies result in consolidated herd immunity, future researchers should further explore what factors have impeded the achievement and consolidation of measles herd immunity in the studied countries. The present master thesis aims to deliver input for such research processes, offering four ideas to build upon the present research:

Firstly, the data set compiled for this research could be complemented so that further studies have a higher statistical power for their results at their disposal. For instance, by collecting data on the selected EU countries that cover more than seven years and/or by searching or gathering data for those countries that were excluded from this study since no suitable data could be found in the course of this research.

Secondly, efforts to establish a better proxy for assessing to what extent the increasing internet use has impacted measles vaccination rates would be desirable, meaning to replace the data used in this study for the variable “internet use” by data that better reflect the frequency of people’s deliberate or random confrontation with vaccination campaigns and anti-vaccine campaigns. Building thereupon, people could be asked in interviews or surveys to what extent the confrontation with online information on measles vaccinations shape their attitudes and decision-making concerning whether to get vaccinated or not. Further items of such questionnaires could be addressed to people’s perception of sanctions for not vaccinating. These suggestions for future research are based on the idea that failures to achieve herd immunity in a country might inter alia be rooted in the policies not sufficiently responding and attracting the people subject to it. The policy recommendations return to this aspect at a later point.

Thirdly, another scientific concern is the continuous revision of the validity of national measles vaccination rates. The present master thesis demonstrates that the composition of the measles vaccination rates differed among the 19 EU countries and frequently included only the age cohorts which according to the national vaccine schedule are supposed to receive measles vaccines. Besides, estimations of a country’s annual measles vaccination coverage usually strongly relied on the careful reportage of measles vaccination providers and local public health authorities. In some countries also general population registries serve as data source. Future research could assess what measles vaccination rates may not tell, concerning the data acquisition and processing. The policy reports, for example, referred to the problem of checking and monitoring the vaccination status of migrants which are not always registered in the population registries or in the registries of health care providers. Future research could additionally assess whether these missing information imply threats for measles herd immunity and attempt to draft vaccination coverage indicators which better account for such phenomena. For instance by modifying the data collection and calculation procedures for estimating a population's measles vaccination coverage.

Fourthly, it would be helpful to learn more about the precise timing of and public attention paid to the measles outbreaks identified with a numerical threshold in the data in section 4.3. This could be done in the frame of country case studies by at first exploring whether a numerical increase in the annual number of measles cases per million inhabitants was covered in the national or global media or at least recognized by the population living in the area with increasing outbreaks and, secondly, analysing whether the confrontation with the illness in a population's environment impacted the public measles vaccination behaviour or not. Due to language barriers, such analyses are not conducted in this master thesis.

5.6 Recommendations for measles vaccination policy-making

Based on the findings of this master thesis, five recommendations for measles vaccination policy-making, applicable for both countries with mandatory and non-mandatory policies, are formulated.

5.6.1 Scrutinize the effectiveness of sanctions

Although measles vaccination rates were on average somewhat higher in the studied countries with mandatory measles vaccination rates (96 % on average between 2010 and 2016) than in the countries with non-mandatory measles vaccination rates (90 % on average between 2010 and 2016) overall no clear pattern could be observed in the hypothesis tests of this master thesis that clearly indicates that mandatory measles vaccinations are necessarily a better tool for the achievement of herd immunity against measles compared to voluntary measles vaccination recommendations. In other words, sanctions for not vaccinating against measles form a sufficient but not necessary tool for herd immunity against measles. Additionally, in the theory section of this thesis it is pointed out that people nowadays tend to more critically question what they are told from their doctors than some decades ago and require dialogue-based and interactive communications with their healthcare providers (Larson, Cooper, Eskola, Katz & Ratzan, 2011, pp.526-528). In some countries in which not vaccinating against measles is sanctioned, also cases were reported in which parents managed to circumvent fines, for instance with the aid of fake vaccination certificates of family paediatricians as reported from Hungary (European Observatory on Health Systems and Policies, 2018, p.105). Other sanctions in place such as prohibiting unvaccinated children the access to daycare facilities and educational institutions (e.g. in Germany) either were expedient since the access of unvaccinated children to childcare facilities can only be denied if they endanger other children, meaning not before a measles case occurs, or because the exclusion of children from schools would infringe their right to education. Therefore it is doubtful whether sticking to mandatory measles vaccinations or introducing compulsory vaccination is advisable. It is worth to take a closer look on the implementation of measles vaccination policies in countries in which herd immunity could be achieved also without mandatory measles vaccinations. In the studied sample Estonia, Lithuania, Malta, Portugal, Spain and Sweden achieved at least once a measles vaccination coverage equal to or higher than 95 % between 2010 and 2016 although measles vaccinations were not mandatory according to their national legislations. Remarkable is that all these six countries have a strong emphasis on enhancing trust between measles vaccination providers and parents by giving the opportunity for health consultations also outside healthcare facilities as well as to regularly stimulate public awareness of the importance of measles vaccinations via annual media campaigns and maintaining a nationwide access to measles vaccination service suppliers. This results in the recommendation to carefully and regularly monitor the effectiveness of sanctions or consider to replace them with persuasive strategies which strengthen the people's trust in vaccinations in practice. The next recommendation reflects on aspects governments may keep in mind when developing persuasive strategies aimed to contribute to an increasing measles vaccination coverage.

5.6.2 Persuasive measles vaccination policies instead of sanctions

Governments should be able to credibly convince people that measles vaccination policies do not serve the vaccine industry but serve to protect a population from serious illnesses. It might be a complex but valuable task for governments to come up with communication means with which more can be learned about contemporary public opinions and doubts concerning medical actions governments legally prescribe or recommend in pursuit of their public health policy goals. Two sorts of policy instruments are pointed out here: firstly, the creation of rewards for people who get vaccinated against measles and, secondly, the opportunity of people to get informed and educated about measles vaccinations as well as to remove patients' doubts.

A regular, empathic communication between governmental health authorities, health service providers and the population is to be considered as essential since people might react in a very sensitive manner if they perceive their governments as too strongly determining which medical treatments a person has to undergo. In the worst case, feeling patronized in one's health treatment decisions may even result in the erosion of people's openness towards measles vaccinations. A convinced measles vaccine-opponent may not be persuaded by the argument that not vaccinating does not only put himself at the risk to suffer from a severe illness but also that he turns into a person transmitting the disease to others, possibly without noticing. Forcing such persons to be vaccinated may only radicalize their reluctance towards measles vaccines and their distrust in conventional medicine and pharma industries. People who reject to receive measles vaccinations, except those with medical exemptions, should not be convinced by being legally forced to get vaccinated but may be convinced by experiencing disadvantages of not being vaccinated. Instead of the measles vaccination obligation, measles vaccination policies should better include incentives a citizen benefits from when getting vaccinated against measles such as bonuses provided by health insurances. Rewarding people who get vaccinated against measles can be justified by underlining that each individual that decides to get vaccinated against measles makes a valuable contribution to eliminate a highly-contagious diseases who can be transmitted even before a person suffers from its tangible symptoms. People who deliberately decide not to contribute to the elimination of such illnesses should no longer free-ride on the contributions of people who decide to get vaccinated.

To oblige people of being confronted and getting informed about measles and measles vaccinations by attending consultations with vaccination providers such as their general practitioners or via more frequent vaccination campaigns carried out by public health authorities may be better means to ideally encourage or at least give thought-provoking impulses to those rejecting measles vaccinations for ideological reasons or believe in mostly scientifically poorly proven content of anti-vaccine propaganda. Sharing the task of educational work in regard to vaccinations is considered as reasonable since vaccination providers may not have enough time to answer all questions of their patients in a satisfying manner and may easily be neglected. Vaccinations, as a prevention for illnesses, are for many people a possible but not absolutely necessary treatment, forming a big difference compared to the treatment of illnesses where not treating can lead to immediate harms. If their medical service providers do not sufficiently inform people about the importance of vaccinations, more questions will rise in many people's head and in times of growing daily internet use of individuals the probability that persons attempt to find answers on their doubts online is high. Health authorities and medical service providers therefore should actively take efforts to turn measles vaccinations into a topic on which people are aware of across borders and throughout their whole lives. Some hints on how this could be done are given in the next recommendation.

5.6.3 Make use of the internet

The hypothesis testing showed that internet use did not have an impact on the vaccine behaviour in countries with non-compulsory measles vaccinations and a positive relation to the measles vaccination rates in countries with mandatory measles vaccinations. Governments and health care providers could make more frequent use of the internet to inform about the benefits and importance of measles vaccinations. Concerning the increasing proportions of people daily using the internet, chances are estimated as high that online users will come across such measles vaccination online campaigns. Governments thereby also have the chance to encounter claims of anti-vaccine movements.

5.6.4 Think about cross-border vaccination coverage estimates

One issue that occurred in the frame of the conceptualization and operationalization of the variable “measles vaccination rate” in the frame of this master thesis was that the 19 studied EU countries opted for different procedures to estimate the measles vaccination coverage within their population (Appendix 1: Composition of the measles vaccination rates in the selected countries). This means that measles vaccination rates often just account for the population registered in a country (i.e. Belgium, Denmark, Lithuania, Malta, the Netherlands, Portugal, Slovakia) or are based on calculations derived from specific birth cohorts only (i.e. Bulgaria, the Czech Republic, France, Hungary, Latvia, Sweden, the UK) while in other cases just the measles vaccination coverage among the people who are entitled to measles vaccination services by being registered as a patient and/or at a statutory health insurance is considered in the measles vaccination rate (Estonia, Germany, Poland, Slovenia) (Appendix 1).

Therefore the precision of the measles vaccination coverage estimates may be limited, in particular in times of a refugee crises (2015) where a lot of people crossed country borders within the EU without always being properly registered. Such challenges will remain as long as EU citizens and migrants can easily cross national borders in the EU and raises the question how the monitoring of measles vaccination coverage can be assured across borders.

The ECDC already made a good start in aggregating public health data of European countries. In regard to measles vaccination rates, a further step could be to develop an EU-wide homogenous procedure to calculate measles vaccination coverage. This could ease country comparisons, help to better handle migration movements of people within the EU and result in more precise estimates on the actual measles vaccination coverage of the people living and traveling within the EU.

5.6.5 Monitoring vaccination status on a life-long basis

The 19 national vaccination calendars (Figure 8) studied in this master thesis show that both doses of measles vaccinations are scheduled to be administered in childhood, to babies, toddlers or young teenagers who cannot decide themselves whether to get vaccinated or not. Some countries also just account for childhood measles vaccination coverage when estimating the annual national vaccination rate (i.e. Bulgaria, the Czech Republic, France, Hungary, Latvia, Sweden and the UK) while not having a systematic monitoring system on adults' vaccination statuses at their disposal. By treating measles and measles vaccination as a health affair predominantly limited to childhood, catch-up vaccinations and monitoring the vaccination status of adults in regard to measles can be expected to be neglected and this final policy recommendation advises to change this. Healthcare providers should be required to check whether some of their patients might have faced different kind of constraints like poor infrastructure or resource scarcity which might have hindered them from being vaccinated against measles. Health providers should be given the chance to talk to those people who were not vaccinated during their childhood, carefully respond their questions and be able to offer catch-up vaccines.

Informing and life-long lasting dialogues on immunisation can form an important step to the overarching goal of achieving herd immunity against measles in a country and across its borders. A continuous public dialogue on the severity of measles and vaccine safety could increase the chance that people see the sense behind governments being concerned with people who deny measles vaccinations or even punish not-vaccinating. For this, it is essential to establish a perception of measles vaccinations being a benefit and a medical enrichment which can prevent numerous people from unnecessarily suffering and dying from a quickly spreading disease – in the EU and across its borders.

References

Amato-Gauci, A., & Ammon, A. (2008). Eurosurveillance. The surveillance of communicable diseases in the European Union – a long-term strategy (2008-2013), 13(26), 1–3. Retrieved from https://www.eurosurveillance.org/content/10.2807/ese.13.26.18912-en

Antona, D., Lévy-Bruhl, D., Baudon, C., Freymuth, F., Lamy, M., Maine, C., Parent du Chatelet, I. (2013). Measles Elimination Efforts and 2008–2011 Outbreak, France. *Emerging infectious diseases*, *19*(3), 357–364. Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3647670/

Bollettino epidemiologico nazionale (BEN). (2002). Measles increase in Italy. Retrieved December 27, 2018, from http://www.epicentro.iss.it/ben/2002/aprile02/2_en

Carrillo-Santisteve, P., & Lopalco, P. L. (2012). Measles still spreads in Europe: who is responsible for the failure to vaccinate? *Elsevier*, *18*(5), 50–56. Retrieved from https://ac.els-cdn.com/S1198743X14613616/1-s2.0-S1198743X14613616-main.pdf?_tid=7b576788-4c56-4d11-a183-cc09dbf7efaa&acdnat=1541957086_8d209c09253e011b458f5dbbcd552d1e

Centers for Disease Control and Prevention. (2015, November 13). Global routine vaccination coverage, 2014. Retrieved November 13, 2018, from https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6444a5.htm

Cornell University. (n.d.). Case Studies in Microscopy - Direct Fluorescent Antibody Test. Retrieved April 28, 2019, from https://courses.cit.cornell.edu/biomi290/microscopycases/methods/fabs.htm

De Veaux, R., Velleman, P. ., & Bock, D. (2016). *Stats Data and Models* (4th Edition). Harlow, United Kingdom: Pearson Education.

Dooley, D. (2009). Social Research Methods (4th ed.). Essex, United Kingdom: Pearson Custom Publishing.

ECDC (European Center for Disease Prevention and Control). (2018a). Factsheet about measles. Retrieved October 1, 2018, from https://www.ecdc.europa.eu/en/measles/facts/factsheet

ECDC (European Center for Disease Prevention and Control). (2018b). Vaccine hesitancy. Retrieved October 1, 2018, from https://www.ecdc.europa.eu/en/immunisation-vaccines/vaccine-hesitancy

ECDC (European Center for Disease Prevention and Control). (2018c, October 12). Number of measles cases by month and notification rate per million population by country, EU/EEA, 1 September 2017–31 August 2018. Retrieved October 13, 2018, from https://ecdc.europa.eu/en/publications-data/number-measles-cases-month-and-notification-rate-million-population-country-3

ECDC (European Center for Disease Prevention and Control). (2018e, April). Measles and Rubella Surveillance 2017. Retrieved October 12, 2018, from https://ecdc.europa.eu/sites/portal/files/documents/Measles-and-Rubella-Surveillance-2017.pdf

ECDC. (2018d, October 12). Measles notification rate per million population by country, EU/EEA, 1 September 2017–31 August 2018. Retrieved October 13, 2018, from https://ecdc.europa.eu/sites/portal/files/documents/measles-rubella-monitoring-report-october-2018.pdf

European Academies Science and Advisory Council (EASAC), & Federation of European Academies of Medicine (FEAM). (2018, April 18). Press release EASAC and FEAM How can European countries improve vaccination in the wake of the measles outbreak? Retrieved October 13, 2018, from https://knaw.nl/en/news/news/how-can-european-countries-improve-vaccination-in-the-wake-of-the-measles-outbreak

European Center for Disease Prevention and Control. (2014). Implementing the ECDC Action Plan for Measles and Rubella. Retrieved from https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/measles-rubella-implementing-action-plan.pdf

European Center for Disease Prevention and Control. (2018). Risk of measles transmission in the EU/EEA. Retrieved from https://ecdc.europa.eu/sites/portal/files/documents/Measles-rapid-risk-assessment-European-Union-countries_0.pd

European Centre for disease prevention and control (ECDC). (n.d.). Vaccine Scheduler. Retrieved April 25, 2019, from https://vaccine-schedule.ecdc.europa.eu/Scheduler/ByDisease?SelectedDiseaseId=8&SelectedCountryIdByDisease=-1

European Commission. (2017, December 4). Strengthened cooperation against vaccine preventable diseases [Roadmap]. Retrieved October 14, 2018, from https://ec.europa.eu/info/law/better-regulation/initiatives/ares-2017-5925775_en

European Commission. (n.d.). Childhood immunisation. Retrieved November 13, 2018, from https://ec.europa.eu/health/vaccination/childhood_immunisation_en

European Commission. (2008, April 28). COMMISSION DECISION of 28/IV/2008 amending Decision 2002/253/EC laying down case definitions for reporting communicable diseases to the Community network under Decision No 2119/98/EC of the European Parliament and of the Council . Retrieved April 24, 2019, from http://ec.europa.eu/health/ph_threats/com/docs/1589_2008_en.pdf

European Commission. (2018). Vaccination. Retrieved March 17, 2019, from https://ec.europa.eu/health/vaccination/overview_en

European Observatory on Health Systems and Policies. (2018). *The organization and delivery of vaccination services in the European Union* (Prepared for the European Commission). Retrieved April 15, 2019, from: http://researchonline.lshtm.ac.uk/4650185/1/2018_vaccine_services_en.pdf

Eurostat. (2018). Digital economy and society statistics - households and individuals. Retrieved December 15, 2018, from https://ec.europa.eu/eurostat/statistics-explained/index.php/Digital_economy_and_society_statistics_-_households_and_individuals

Eurostat. (2019). Individuals - frequency of internet use 2009-2018. Retrieved April 27, 2019, from: https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database

Evrony, A., & Caplan, A. (2017). The overlooked dangers of anti-vaccination groups' social media presence. Human Vaccines & Immunotherapeutics, 13(6), 1475–1476. Retrieved November 13, 2018 from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5489284/

Field, A. (2009). Discovering Statistics Using SPSS (3rd ed.). London: SAGE.

Graef, M. (2019). Responses to HPV Vaccination Campaigns in the Netherlands - An analysis of discussions on Twitter.

Guglielmetti, P., Coulombier, D., Thinus, G., Van Loock, F., & Schreck, S. (2006). The Early Warning and Response System for communicable diseases in the EU: an overview from 1999 to 2005. Eurosurveillance, Europe's journal on infectious disease surveillance, epidemiology, prevention and control, 11(12). Retrieved from https://www.eurosurveillance.org/content/10.2807/esm.11.12.00666-en#html_fulltext

Guthmann, J. P., & Lévy-Bruhl, L. (2013). *Assessment of Vaccination coverage in France: Current Sources and Data* (French Institute for Public Health Surveillance). Retrieved April 17, 2019 from http://opac.invs.sante.fr/doc_num.php?explnum_id=8807

Hill, M. (2013). *The Public Policy Process* (6th ed.). London and New York, United Kingdom & United States of America: Routledge

Humiston, S. G., Macuse, E. K., Zhao, Z., Dorell, C. G., Howes, C., & Hibbs, B., Smith, P. J. (2011). Parental Delay or Refusal of Vaccine Doses, Childhood Vaccination Coverage at 24 Months of Age, and the Health Belief Model. Public Health Reports, 126(2), 135–146. Retrieved from https://journals.sagepub.com/doi/pdf/10.1177/00333549111260S215

Jones, C. ., Smith, H., & Llewellyn, C. (2014). Evaluating the effectiveness of Health Belief Model interventions in improving adherence: a systematic review. Health

Psychological Review, 8(3), 253–269. Retrieved from https://doi.org/10.1080/17437199.2013.802623

Larson,, H. J., Cooper, L. Z., Eskola, J., Katz, S. L., & Ratzan, S. (2011). Addressing the vaccine confidence gap. *The Lancet*, *378*(9790), 526–535. Retrieved from https://doi.org/10.1016/S0140-6736 (11) 60678-8

Larson, H., De Figueiredo, A., Karafillakis, E., & Rawal, M. (2018). State of vaccine confidence in the EU 2018. Retrieved November 13, 2018, from https://ec.europa.eu/health/sites/health/files/vaccination/docs/2018_vaccine_confidence_en.pdf

OECD. (2018). Data Child vaccination rates. Retrieved December 27, 2018, from https://data.oecd.org/healthcare/child-vaccination-rates.htm

OECD. (2018a). Population. Retrieved from https://data.oecd.org/pop/population.htm

Smith, J., Lipsitch, M., & Almond, J. W. (2011). Vaccine production, distribution, access and uptake. Retrieved April 26, 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3164579/pdf/nihms315317.pdf

Vrdelja, M., Kraigher, A., Vercic, D., & Kropivnik, S. (2018). The growing vaccine hesitancy: exploring the influence of the internet. *European Journal of Public Health*, *28*(5), 934–939. Retrieved from https://doi-org.ezproxy2.utwente.nl/10.1093/eurpub/cky114

WHO. (2018). WHO/Europe: Measles and rubella - Policy. Retrieved from http://www.euro.who.int/en/health-topics/communicable-diseases/measles-and-rubella/policy

World Health Organization & European Observatory on Health Systems and Policies. (2018). The organization and delivery of vaccination services in the European Union - prepared for the European Commission. Retrieved November 13, 2018, from https://ec.europa.eu/health/sites/health/files/vaccination/docs/2018_vaccine_services_en.pdf

World Health Organization (WHO). (n.d.). European Region. Retrieved November 13, 2018, from http://www.who.int/choice/demography/euro_region/en/

World Health Organization (WHO). (2018a). Measles-key facts. Retrieved March 16, 2019, from https://www.who.int/news-room/fact-sheets/detail/measles

World Health Organization (WHO). (2018b). Measles-containing vaccine 2nd dose. Retrieved May 4, 2018, from http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tscoveragemcv2.html

World Health Organization (WHO). (2018c). Measles Reported cases by country. Retrieved May 4, 2018, from http://apps.who.int/gho/data/view.main.1540_62?lang=en

Yang, T., Bhoobun, S., Itani, T., Jacobsen K.H. (2016, September 1). Europe should consider mandatory measles immunization for school entry, *Journal of the Paediatric infectious diseases society*, Volume 5, Issue 3, Pages 319-322, https://academic.oup.com/jpids/article/5/3/319/2580285

Zimmermann, R. K., Giebink, G. S., Bosch Street, H., & Janosky, J. E. (1995). Knowledge And Attitudes Of Minnesota Primary Care Physicians About Barriers To Measles And Pertussis Immunization. The Journal of the American Board of Family Practice, 8(4), 270–277. Retrieved from https://www.jabfm.org/content/jabfp/8/4/270.full.pdf

Appendix 1. *Composition of the measles vaccination rates in the selected countries*

Country	Numerator	Denominator	Other	Sources
Belgium			Weighted average calculated with data obtained from two main population registries (one for Flemish and a second for French/German speaking community). These registries contain information of physicians and are complemented by complemented by information delivered by school health services and regular vaccination coverage studies conducted every three or four years. (European Observatory on Health	

Country	Numerator	Denominator	Other	Sources
			Systems and Policies, 2018, p.49).	
Bulgaria	Number of vaccinated children indicated in Health Inspectorates reports	Total number of children registered in Bulgaria and subject to mandatory measles vaccination		(European Observatory on Health Systems and Policies, 2018, p.54).
Czech Republic (the)	Number of vaccinated children by age cohorts defined	Total number of children in the corresponding age cohort of the population registry		(European Observatory on Health Systems and Policies, 2018, p.68).
Denmark	Number of individuals indicated as having been vaccinated against measles in a birth cohort	Number of individuals within the same birth cohort residing in Denmark at the moment of calculation		(European Observatory on Health Systems and Policies, 2018, p.72).
Estonia	Number of patients notified as vaccinated at the National Health Board	Patient lists of health care providers		(European Observatory on Health Systems and Policies, 2018, pp. 75-77)
France	Specifications in mandatory health certificates for children between	Database of statutory health insurances,	No routine data collection for adults.	(European Observatory on Health Systems and Policies, 2018, pp. 87).

Country	Numerator	Denominator	Other	Sources
	zero and two years and school surveys	covering 99 % of the French residents		
Germany	School entrance examinations from 2001 on, complemented by anonymized data provided on all age groups and specific risk groups and at district level	Citizens with statutory health insurance per age/risk group at the prevailing district level, meaning for 87 % of the total German population	No national immunisation registry	(European Observatory on Health Systems and Policies, 2018, pp.92-94)
Hungary	Data on completed measles vaccinations	Total number of children obliged to be immunized against measles in a given year		(European Observatory on Health Systems and Policies, 2018, pp. 102)
Latvia	Number of vaccinated persons in age groups included in the denominator	Total number of children aged between 12-15 months (for the first dose) or seven years	Incomplete data on certain risk groups like migrants, refugees, ethnic minorities as well as on socially and economically disadvantaged people.	(European Observatory on Health Systems and Policies, 2018, pp. 116+117)

Country	Numerator	Denominator	Other	Sources
		(for the second dose)		
Lithuania	Ratio of the number people having received measles vaccinations	Total number of population		(European Observatory on Health Systems and Policies, 2018, pp. 120).
Malta	Data on administered vaccines entered by immunisation providers into a governmental database	Total number of people in the population registry	Insufficient reporting by the private healthcare sector observed	(European Observatory on Health Systems and Policies, 2018, pp. 20+128).
Netherlands (the)	Number of administered measles vaccinations reported to the National Institute for Public Health and the Environment	Total number of the Dutch population registry		(European Observatory on Health Systems and Policies, 2018, pp.131+132).
Poland	Number of people who, according to healthcare providers, have received measles vaccinations	Total number of people listed by healthcare providers	Migration has been regarded as making valid and reliable data collection more difficult	(European Observatory on Health Systems and Policies, 2018, pp. 135-136).
Portugal	Number of registered individuals born in a specific year and vaccinated against measles	Total number of registered people born in the same year		(European Observatory on Health Systems and Policies, 2018, pp. 143-144).

Country	Numerator	Denominator	Other	Sources
Slovakia	Number of vaccinated people according to reports of health care providers	Total number of people in the population registry		(European Observatory on Health Systems and Policies, 2018, pp. 155).
Slovenia	Number of children who were vaccinated against measles in the course of a year according to reports of regional public health units	Number of children that should receive measles immunisation		(European Observatory on Health Systems and Policies, 2018, p.162)
Spain			Heterogeneous immunisation programmes of the autonomous Spanish regions, the Inter-territorial Council of National Health System compiles and analyses data for estimating the Spanish national measles vaccination rate	(European Observatory on Health Systems and Policies, 2018, pp. 167-168).
Sweden	Number of vaccinated children enrolled in childcare units	Total number of children of the national population register (covers 99 % of children in Sweden)		(European Observatory on Health Systems and Policies, 2018, p.172).

Country	Numerator	Denominator	Other	Sources
United Kingdom (the)	The number of children told to be vaccinated against measles, according to vaccination providers	Total number of children included in the Child Health Information System		(European Observatory on Health Systems and Policies, 2018, pp. 177-178).

Appendix 2. *Sources of the Data matrix of the SPSS Analysis*

Variables	Sources
Measles vaccination rates of the 19 selected EU countries (2010-2016)	http://apps.who.int/immunization_monitoring/globalsummary/timeseries/tscoveragemcv2.html
Measles vaccination policies of the 19 selected EU countries	http://researchonline.lshtm.ac.uk/4650185/1/2018_vaccine_services_en.pdf
Annual number of measles cases per million inhabitants per country (2010-2016) of the 19 selected countries	2010: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/measles_report_2010_euvacnet.pdf 2011: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/SUR_EMMO_European-monthly-measles-monitoring-February-2012.pdf, (p.3) 2012: https://www.ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/measles-rubella-monitoring-February-2012.pdf, (p.3) 2013: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/measles-rubella-monitoring-february-2014.pdf, (p.4) 2014: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/Measles-rubella-monitoring-first-quarter-2015.pdf, (p.4) 2015: https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/2016_issue_1_%20Measles%20rubella%20monitoring_final.pdf, (pp.3+4)

	2016: https://ecdc.europa.eu/sites/portal/files/documents/measles%20-rubella-monitoring-170424.pdf http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do
Proportion of people daily using the internet in the 19 selected EU countries (2010 and 2016)	available from: https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database via: Digital economy and society➔ICT usage in households and by individuals➔Connection to the internet and computer use➔Internet use➔Individuals-frequency of internet use (Data Explorer)➔ Settings: Information Society Indicator: Frequency of Internet Access: daily, Unit of measure: Percentage of individuals; Individual type: All individuals

Appendix 3. *Data matrix of SPSS analysis*

Country	Year	VR	MCpM	FInt	Policy	VR_mean
Belgium	2010	83%	0.38	59%	0	84%
Belgium	2011	83%	5.10	65%	0	84%
Belgium	2012	85%	3.90	65%	0	84%
Belgium	2013	85%	3.40	68%	0	84%
Belgium	2014	85%	6.30	71%	0	84%
Belgium	2015	85%	4.20	73%	0	84%
Belgium	2016	85%	7.10	74%	0	84%
Bulgaria	2010	96%	294.53	33%	1	92%
Bulgaria	2011	94%	2.10	37%	1	92%
Bulgaria	2012	94%	0.10	40%	1	92%
Bulgaria	2013	94%	2.20	43%	1	92%
Bulgaria	2014	89%	0.00	46%	1	92%
Bulgaria	2015	87%	0.00	46%	1	92%
Bulgaria	2016	88%	0.10	49%	1	92%
Czech Republic	2010	98%	0.00	38%	1	97%
Czech Republic	2011	98%	0.20	41%	1	97%
Czech Republic	2012	99%	2.10	44%	1	97%
Czech Republic	2013	99%	1.30	54%	1	97%
Czech Republic	2014	96%	21.10	60%	1	97%
Czech Republic	2015	99%	0.90	63%	1	97%
Czech Republic	2016	93%	0.70	65%	1	97%
Denmark	2010	85%	0.09	76%	0	85%
Denmark	2011	86%	1.50	78%	0	85%
Denmark	2012	87%	0.40	81%	0	85%
Denmark	2013	86%	3.00	84%	0	85%
Denmark	2014	84%	5.20	85%	0	85%
Denmark	2015	80%	1.60	87%	0	85%
Denmark	2016	85%	0.50	89%	0	85%
Estonia	2010	95%	0.00	57%	0	93%

Estonia	2011	95%	0.50	59%	0	93%
Estonia	2012	94%	3.00	59%	0	93%
Estonia	2013	92%	1.50	63%	0	93%
Estonia	2014	93%	0.00	73%	0	93%
Estonia	2015	92%	3.00	77%	0	93%
Estonia	2016	92%	1.50	77%	0	93%
France	2010	61%	8.03	60%	0	73%
France	2011	67%	23.40	62%	0	73%
France	2012	72%	13.20	65%	0	73%
France	2013	75%	4.20	66%	0	73%
France	2014	77%	4.10	68%	0	73%
France	2015	79%	5.50	68%	0	73%
France	2016	80%	1.20	70%	0	73%
Germany	2010	90%	0.96	60%	0	92%
Germany	2011	92%	2.00	63%	0	92%
Germany	2012	92%	2.00	65%	0	92%
Germany	2013	92%	21.70	69%	0	92%
Germany	2014	93%	5.40	72%	0	92%
Germany	2015	93%	30.50	75%	0	92%
Germany	2016	93%	4.00	78%	0	92%
Hungary	2010	99%	0.00	48%	1	99%
Hungary	2011	99%	0.10	55%	1	99%
Hungary	2012	99%	0.20	58%	1	99%
Hungary	2013	99%	0.10	62%	1	99%
Hungary	2014	99%	0.00	66%	1	99%
Hungary	2015	99%	0.00	63%	1	99%
Hungary	2016	99%	0.00	71%	1	99%
Latvia	2010	93%	0.00	49%	0	91%
Latvia	2011	92%	0.04	53%	0	91%
Latvia	2012	92%	1.30	57%	0	91%
Latvia	2013	92%	0.00	60%	0	91%
Latvia	2014	89%	17.80	61%	0	91%
Latvia	2015	92%	0.00	66%	0	91%
Latvia	2016	89%	0.00	68%	0	91%
Lithuania	2010	95%	0.06	45%	0	93%
Lithuania	2011	94%	0.20	47%	0	93%
Lithuania	2012	93%	0.60	49%	0	93%
Lithuania	2013	92%	11.60	53%	0	93%
Lithuania	2014	92%	3.70	57%	0	93%
Lithuania	2015	92%	17.00	56%	0	93%
Lithuania	2016	92%	7.50	60%	0	93%
Malta	2010	97%	0.00	49%	0	90%
Malta	2011	85%	1.00	55%	0	90%
Malta	2012	91%	0.00	57%	0	90%
Malta	2013	88%	4.80	59%	0	90%
Malta	2014	94%	0.00	63%	0	90%
Malta	2015	91%	2.40	70%	0	90%
Malta	2016	86%	0.00	71%	0	90%

Poland	2010	94%	0.03	42%	1	94%
Poland	2011	95%	0.10	45%	1	94%
Poland	2012	95%	1.60	46%	1	94%
Poland	2013	93%	2.20	47%	1	94%
Poland	2014	95%	2.90	51%	1	94%
Poland	2015	94%	1.20	52%	1	94%
Poland	2016	93%	3.50	57%	1	94%
Portugal	2010	95%	0.05	38%	0	96%
Portugal	2011	96%	0.02	42%	0	96%
Portugal	2012	96%	0.70	45%	0	96%
Portugal	2013	96%	0.10	48%	0	96%
Portugal	2014	96%	0.00	51%	0	96%
Portugal	2015	95%	0.00	55%	0	96%
Portugal	2016	95%	0.00	60%	0	96%
Slovakia	2010	99%	0.00	58%	1	98%
Slovakia	2011	99%	0.04	56%	1	98%
Slovakia	2012	99%	0.20	60%	1	98%
Slovakia	2013	99%	0.00	61%	1	98%
Slovakia	2014	98%	0.00	62%	1	98%
Slovakia	2015	98%	0.00	60%	1	98%
Slovakia	2016	97%	0.00	68%	1	98%
Slovenia	2010	96%	0.15	54%	1	95%
Slovenia	2011	96%	1.10	54%	1	95%
Slovenia	2012	96%	1.00	53%	1	95%
Slovenia	2013	95%	0.50	58%	1	95%
Slovenia	2014	94%	25.30	58%	1	95%
Slovenia	2015	96%	8.70	61%	1	95%
Slovenia	2016	93%	0.50	64%	1	95%
Spain	2010	92%	0.67	44%	0	92%
Spain	2011	91%	4.30	47%	0	92%
Spain	2012	90%	9.70	50%	0	92%
Spain	2013	91%	2.70	54%	0	92%
Spain	2014	93%	3.30	60%	0	92%
Spain	2015	95%	1.00	64%	0	92%
Spain	2016	95%	0.80	67%	0	92%
Sweden	2010	94%	0.06	76%	0	95%
Sweden	2011	95%	0.30	80%	0	95%
Sweden	2012	95%	3.20	80%	0	95%
Sweden	2013	95%	5.50	81%	0	95%
Sweden	2014	95%	2.70	83%	0	95%
Sweden	2015	95%	2.30	82%	0	95%
Sweden	2016	95%	0.30	85%	0	95%
The Netherlands	2010	92%	0.09	76%	0	92%
The Netherlands	2011	93%	0.30	79%	0	92%
The Netherlands	2012	93%	0.60	81%	0	92%
The Netherlands	2013	92%	149.40	83%	0	92%
The Netherlands	2014	93%	8.60	84%	0	92%
The Netherlands	2015	92%	0.40	85%	0	92%

The Netherlands	2016	91%	0.40	86%	0	92%
United Kingdom	2010	84%	0.65	66%	0	87%
United Kingdom	2011	85%	1.70	70%	0	87%
United Kingdom	2012	87%	30.40	73%	0	87%
United Kingdom	2013	88%	30.70	78%	0	87%
United Kingdom	2014	89%	2.10	81%	0	87%
United Kingdom	2015	89%	1.40	83%	0	87%
United Kingdom	2016	89%	8.80	88%	0	87%

Appendix 4. *Descriptive statistics measles vaccination rates for the whole sample and per country between 2010 and 2016*

Sample

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	133	.61	.99	.9159	.06289
Valid N (listwise)	133				

Country = Belgium

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.83	.85	.8443	.00976
Valid N (listwise)	7				

a. Country = Belgium

Country = Bulgaria

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.87	.96	.9171	.03592
Valid N (listwise)	7				

a. Country = Bulgaria

Country = Czech Republic

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.93	.99	.9743	.02225
Valid N (listwise)	7				

a. Country = Czech Republic

Country = Denmark

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.80	.87	.8471	.02289
Valid N (listwise)	7				

a. Country = Denmark

Country = Estonia

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.92	.95	.9329	.01380
Valid N (listwise)	7				

a. Country = Estonia

Country = France

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.61	.80	.7300	.06904
Valid N (listwise)	7				

a. Country = France

Country = Germany

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.90	.93	.9214	.01069
Valid N (listwise)	7				

a. Country = Germany

Country = Hungary

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.99	.99	.9900	.00000
Valid N (listwise)	7				

a. Country = Hungary

Country = Latvia

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.89	.93	.9129	.01604
Valid N (listwise)	7				

a. Country = Latvia

Country = Lithuania

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.92	.95	.9286	.01215
Valid N (listwise)	7				

a. Country = Lithuania

Country = Malta

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.85	.97	.9029	.04309
Valid N (listwise)	7				

a. Country = Malta

Country = Poland

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.93	.95	.9414	.00900
Valid N (listwise)	7				

a. Country = Poland

Country = Portugal

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.95	.96	.9557	.00535
Valid N (listwise)	7				

a. Country = Portugal

Country = Slovakia

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.97	.99	.9843	.00787
Valid N (listwise)	7				

a. Country = Slovakia

Country = Slovenia

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.93	.96	.9514	.01215
Valid N (listwise)	7				

a. Country = Slovenia

Country = Spain

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.90	.95	.9243	.01988
Valid N (listwise)	7				

a. Country = Spain

Country = Sweden

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.94	.95	.9486	.00378
Valid N (listwise)	7				

a. Country = Sweden

Country = The Netherlands

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.91	.93	.9229	.00756
Valid N (listwise)	7				

a. Country = The Netherlands

Country = United Kingdom

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation
measles vaccination rate	7	.84	.89	.8729	.02059
Valid N (listwise)	7				

a. Country = United Kingdom

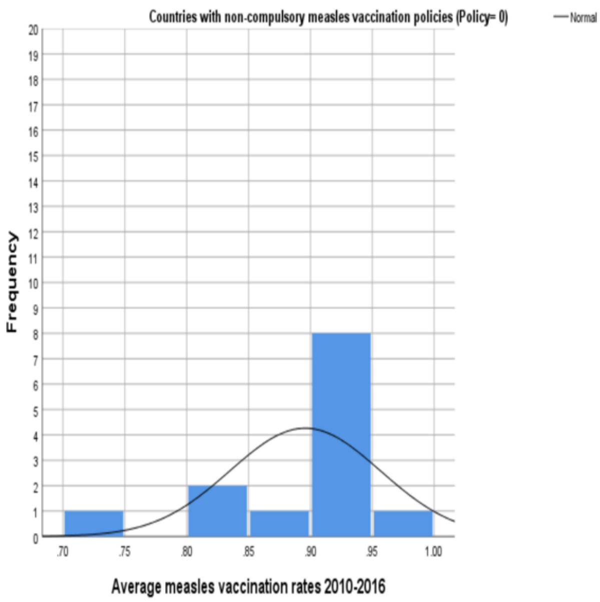
Appendix 5. *Assumptions independent sample t-test*

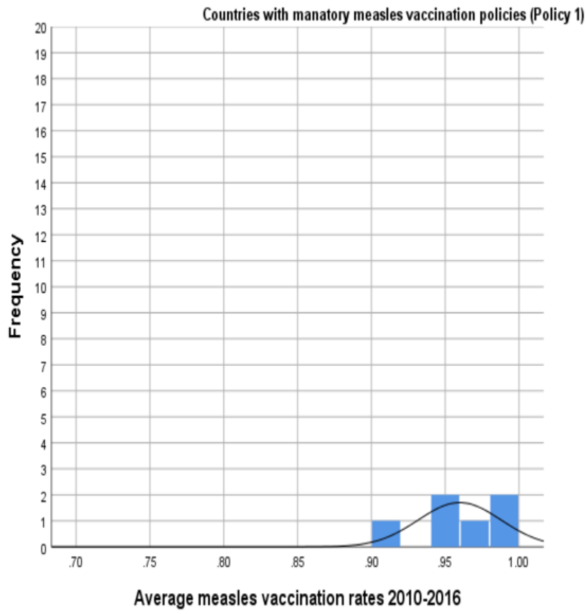
(De Veaux, Velleman, Bock, 2016, p. 618)

Randomized Condition: The 19 selected EU countries are assigned to each of the two groups that are compared in the frame of the independent sample t-test according to their measles vaccination policies being mandatory or not. Before assigning the 19 EU countries to one of these two groups, the countries were randomly selected out of all 28 EU countries and the data processed in the statistical analysis has been gathered from 19 independent countries over seven years so that their annual measles vaccination rates are assumed to be independent from each other.

Independent Groups Assumption: Randomized cases and data selection gives independent groups.

Nearly Normal Condition:





Case Processing Summary

	Cases					
	Included		Excluded		Total	
	N	Percent	N	Percent	N	Percent
measles vaccination rate * Policy	133	100.0%	0	0.0%	133	100.0%

Report

measles vaccination rate

Policy	Mean	N	Std. Deviation
0	.8957	91	.06360
1	.9598	42	.03127
Total	.9159	133	.06289

ANOVA Table

			Sum of Squares	df	Mean Square	F	Sig.
measles vaccination rate * Policy	Between Groups	(Combined)	.118	1	.118	38.212	.000
	Within Groups		.404	131	.003		
	Total		.522	132			

Appendix 6. *Syntax file*

```
****New variable: mean measles vaccination rate per country***.
AGGREGATE
  /OUTFILE=* MODE=ADDVARIABLES
  /BREAK=country
  /VR_mean=MEAN(VR).

*** Boxplot vaccination rates per country for section 4.1; Subquestion 1***.
DATASET ACTIVATE DataSet1.
* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=country VR MISSING=LISTWISE
REPORTMISSING=NO
  /GRAPHSPEC SOURCE=INLINE.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: country=col(source(s), name("country"), unit.category())
  DATA: VR=col(source(s), name("VR"))
  DATA: id=col(source(s), name("$CASENUM"), unit.category())
  GUIDE: axis(dim(1), label("Country"))
  GUIDE: axis(dim(2), label("measles vaccination rate"))
  GUIDE: text.title(label("Simple Boxplot of measles vaccination rate by Country"))
  SCALE: linear(dim(2), include(0))
  ELEMENT: schema(position(bin.quantile.letter(country*VR)), label(id))
END GPL.

****Descriptives measles vaccination rates per country (complementing boxplot in
Subquestion 1 & Appendix: Descriptive statistics measles vaccination rates per country
between 2010 and 2016***.
SORT CASES  BY country.
SPLIT FILE SEPARATE BY country.

DESCRIPTIVES VARIABLES=VR
  /STATISTICS=MEAN STDDEV MIN MAX.

SPLIT FILE OFF.
```

```
***Histograms per policy group to check normality (Appendix: Assumptions independent sample t-test + section 4.3; subquestion 3, Hypothesis 1) ****.
GRAPH
  /HISTOGRAM=VR_mean
  /PANEL ROWVAR=Policy ROWOP=CROSS.

****Anova for histograms per policy groups (Appendix: Assumptions independent sample t-test + section 4.3; subquestion 3; Hypothesis 1)****.
DATASET ACTIVATE DataSet1.
MEANS TABLES=VR BY Policy
  /CELLS=MEAN COUNT STDDEV
  /STATISTICS ANOVA.

***Preparations for independent-sample-t-test (section 4.3; subquestion 3, Hypothesis 1 and Appendix: Results independent sample t-test)****.
SPLIT FILE OFF.
***Reduce sample size from N=133 to N=19 countries (section 4.3; subquestion 3; Hypothesis 1 and Appendix: Results independent sample t-test)****.
USE ALL.
COMPUTE filter_$=(year = 2010).
VARIABLE LABELS filter_$ 'year = 2010 (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

****Independent sample t-test VR-means per policy, N=19, Hypothesis 1 (section 4.3 subquestion 3; Hypothesis 1 and Appendix: Results independent sample t-test)****.
T-TEST GROUPS=Policy(0 1)
  /MISSING=ANALYSIS
  /VARIABLES=VR_mean
  /CRITERIA=CI(.95).


****Filter off***.
FILTER OFF.
```

```
USE ALL.
EXECUTE.
**For 4.4, Hypotheses 2, 2a & 2a and subquestions 4 & 4a***.
****Graphs vaccination rates per year and country for N=9 (countries were the annual
number of McpM was >10 at least once, i.e. Czech Republic, Slovenia, Bulgaria, Germany,
Lithuania, The Netherlands, Latvia, France and the UK****.

DATASET ACTIVATE DataSet1.
USE ALL.
COMPUTE filter_$=(filter_$).
VARIABLE LABELS filter_$ 'filter_$ (FILTER)'.
VALUE LABELS filter_$ 0 'Not Selected' 1 'Selected'.
FORMATS filter_$ (f1.0).
FILTER BY filter_$.
EXECUTE.

* Chart Builder.
GGRAPH
  /GRAPHDATASET NAME="graphdataset" VARIABLES=year VR filter_$[name="filter__"]
MISSING=LISTWISE
    REPORTMISSING=NO DATAFILTER=filter_$(VALUES=ALL UNLABELED=INCLUDE)
  /GRAPHSPEC SOURCE=INLINE.
BEGIN GPL
  SOURCE: s=userSource(id("graphdataset"))
  DATA: year=col(source(s), name("year"))
  DATA: VR=col(source(s), name("VR"))
  GUIDE: axis(dim(1), label("Year"))
  GUIDE: axis(dim(2), label("measles vaccination rate"))
  GUIDE: text.title(label("Simple Line of measles vaccination rate by Year"))
  GUIDE: text.footnote(label("Filtered by filter_$ (FILTER) variable"))
  ELEMENT: line(position(year*VR), missing.wings())
END GPL.

****Filter off***.
FILTER OFF.
USE ALL.
EXECUTE.
```

For section 4.5 , Hypothesis 3, subquestion 5*.

```
****Correlation VR FInt***.
DATASET ACTIVATE DataSet1.
CORRELATIONS
  /VARIABLES=VR FInt
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.
```

****For section 4.5.1, Hypotheses 3a & 3b and subquestions 5 & 5a***.

```
***correlation VR FInt per policy***.

DATASET ACTIVATE DataSet1.
SORT CASES  BY Policy.
SPLIT FILE SEPARATE BY Policy.


CORRELATIONS
  /VARIABLES=VR FInt
  /PRINT=TWOTAIL NOSIG
  /MISSING=PAIRWISE.

SPLIT FILE OFF.

***descriptives measles vaccination rates whole sample***.

DATASET ACTIVATE DataSet1.
DESCRIPTIVES VARIABLES=VR
  /STATISTICS=MEAN STDDEV MIN MAX.
```