

# Measles' vaccination: socio-demographic factors in different continents

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## 1 Abstract

**Background:** Measles is a highly contagious, serious disease caused by a virus and it is one of the leading causes of death among young children, considering that only in 2015, there were 134200 measles deaths globally. Despite this information and the significant efforts to increase the measles immunization, there are still many people that adhere to anti-vax movement, which is a true and destructive phenomenon.

**Objective:** The aim of our essay was to understand and analyze the factors, such as educational level, socioeconomic conditions and health care system characteristics, which influence the people of different region of the world to get vaccinated against measles and why each region has different leading factors.

**Methods:** ResearchGate, Scopus and Web of Science databases were searched for recent observational studies and systematic reviews published in peer-reviewed journals in English. World Bank data from different countries was downloaded, pre-processed and finally analyzed with PCA (Principal Component Analysis).

**Results:** We have found the different factors that affect the measles vaccination. We interpreted these taking into account in a socio-demographic perspective in each country.

**Conclusions:** To achieve high and homogeneous vaccination coverage we must take into account the knowledge developed, which identifies the factors that influence the adherence to vaccination and it is fundamental to interpret them according to the characteristics of each context.

## 2 Introduction

### 2.1 Vaccines History

The story of vaccines did not begin with the first vaccine—Edward Jenner’s use of material from cowpox pustules to provide protection against smallpox. Rather, it begins with the long history of infectious disease in humans, and in particular, with early uses of smallpox material to provide immunity to that disease. Evidence exists that the Chinese employed smallpox inoculation (or variolation, as such use of smallpox material was called) as early as 1000 CE. It was practiced in Africa and Turkey as well, before it spread to Europe and the Americas. Edward Jenner’s innovations, begun with his successful 1796 use of cowpox material to create immunity to smallpox, quickly made the practice widespread. His method underwent medical and technological changes over the next 200 years, and eventually resulted in the eradication of smallpox. There is an active discussion in the public health community on how to assess and incorporate, in addition to safety and measures of protec-

tive efficacy, the full public health value of preventive vaccines into the evidence-based decision-making process of vaccine licensure and recommendations for public health use. The anti-vax movement is a true phenomenon. Unfortunately, it is also a potentially destructive one. The wide variety of anti-vax sites and the number of people that believe the vaccines are not good, makes the phenomenon difficult to comprehend. Google searches were used to identify the highest-ranked anti-vaccine sites using typical search strategies. Arguments were categorized and examined: What themes were common, and why were these arguments appealing?

#### *Safety and Effectiveness:*

- vaccines weaken the immune system
- vaccines don’t actually provide immunity
- vaccines didn’t result in the elimination of smallpox/measles/etc., it was public health/nutrition/poverty
- vaccine preventable diseases are trivial. Measles is “mild”, smallpox was “harmless”, etc.

### *Alternative Medicine:*

- “natural” methods of disease prevention are superior
- allowing children to experience illness is a better approach
- rejection of scientific, clinical and epidemiologic evidence

### *Conspiracy Theories:*

- vaccination is motivated solely by profit-driven pharmaceutical companies
- vaccinations are a tool of the World Health Organization/Illuminati/etc. to control the world/implement the New World Order
- regulators have no interest in protecting the public, they are beholden to Big Pharma
- health professionals are profit-focused and beholden to industry
- health professionals are in denial or are blind to the true effects of vaccines
- health professionals actively and deliberately under-report adverse events to vaccines
- physician that speak out against vaccines (e.g., Andrew Wakefield) are lauded or martyred, no

matter how discredited

### *Religion and Ideology:*

- God created a perfect immune system
- vaccines are cultured in the tissue of aborted fetuses
- animals are tortured in the manufacture of vaccines
- vaccines are tested on children in third world countries

### *Misinformation and Falsehoods:*

- false statements about the presence/absence of thimerosal in vaccines
- statistics/prevalence of communicable disease or diseases such as autism
- unsupportable claims (e.g., smallpox was not contagious, polio caused by diet, rabies is psychosomatic)

*Emotive Appeals:* Personal testimonials are very common, and typically include narratives from parents who attribute injury to vaccines.

*Civil Liberties:* Civil liberty arguments appeal to parental/self-

rights and make accusations of totalitarianism/fascism.

## 2.2 Measles

Measles is a highly contagious, serious disease caused by a virus. The signs and symptoms of measles include fevers, cough, head cold, sneezing and conjunctivitis along with the classical rashes. Estimates based on modern molecular biology place the emergence of measles as a human disease sometime after 500 AD. About eight million children are thought to have died from measles each year before the vaccine was introduced. Nowadays it is still one of the leading causes of death among young children, considering that only in 2015, there were 134.200 measles deaths globally. Despite this information and the significant efforts to increase the measles immunization, there are still many people that adhere to anti-vax movement and so, as we can imagine, in all the developed countries the problem isn't represented - as it often happens elsewhere - by the availability of the vaccine or by the lack of health facilities: The problem is more re-

lated to social and cultural factors. Surely this phenomenon has been influenced by the controversy over measles-mumps-rubella vaccine and autism, subsequently revealed as a genuine scientific fraud. Also, some parents do not have a direct measles experience and are not properly informed about its contagion and possible complications. In fact, in Figure 1 we can see the results of an interview conducted in Lyon regarding to the perceptions of measles' severity divided into two groups: for each question the parents of children affected by the disease replied and also a group of adults affected by measles in adulthood.

Remember that, being an extremely contagious disease, at least 95% of children should be vaccinated in order to have not more epidemics; It would be enough that this percentage drops of few points to see new epidemic outbreaks appear.

Variables	Parents of childhood cases n = 86	Adult cases n = 62
<b>Perception of measles severity before disease onset (%)</b>		
Not serious	57 (66.3)	45 (72.6)
Serious	26 (30.2)	13 (21.0)
Don't know	3 (3.5)	4 (6.5)
<b>Perception of measles severity after disease onset</b>		
Likert scale (%)		
Low	16 (18.6)	5 (8.1)
Moderate	30 (34.9)	20 (32.3)
Severe	40 (46.5)	37 (59.7)
<b>Knowledge level of the consequences of measles</b>		
School absence	62 (72.1)	31 (50.0)
Hospitalization	51 (59.3)	23 (37.1)
Complications	51 (59.3)	19 (30.6)
Sequelae	39 (45.3)	12 (19.4)
Death	39 (45.3)	8 (12.9)
<b>Reported consequences of measles in respondents</b>		
Medical visit	13 (15.1)	-
Sick leave	46 (53.5)	49 (79.0)
Hospitalization	3 (3.5)	31 (50.0)
<b>Reported consequences of measles in family members</b>		
Medical visit	9 (10.5)	23 (37.1)
Sick leave	6 (7.0)	13 (21.0)
Contamination	7 (8.1)	14 (22.6)
Hospitalization	2 (3.1)	6 (9.7)

Figure 1: Perception of measles severity, knowledge level and consequences of measles among subjects consulting for measles infection in Lyon, France, in 2010–2012. Taken from [3], Touré et al.

### 2.3 Our aim

The approach used for our essay was to deepen our perception of how Humans’ situation, character and awareness can impact the usage of vaccination by understanding and analyzing the factors, such as educational level, socioeconomic conditions and health care system characteristics, which influence the people of different region of the world to get vaccinated against measles and why each region has different leading factors

## 3 Description of the data

The data we have used for our model was taken from “World Bank Data” ([15]). First of all, we have selected from each world region a representing set of countries, the ones showed in the Table 1.

Then, we have thought about the possible factors that can have an impact on the measles vaccination and we have retained some variables (also known as indicators) that most probably could act as proxy for these factors. Notice that we have retrieved also the most im-

portant indicator “**Immunization, measles (% of children ages 12-23 months)**” to set up the methods described below. The full list is provided in the Table 2.

So, we have chosen a range of years that was related to the current period (from 2006 to 2015), we have substituted all the values of the different years with the mean, considering that there was a lot of missing values, and we have put together all the data of countries in different region-based datasets.

Finally, using these regions aggregated data and for each indicator we replaced all the missing values of the country with the mean of that particular indicator in that specific region, in order to deal with all the variables that could miss entirely from the country dataset.

Table 1: Selected countries from different continents

Region	Countries
North Africa	<i>Egypt, Libya, Algeria, Tunisia, Morocco</i>
Central Africa	<i>Ethiopia, Nigeria, Namibia, D.R. of the Congo</i>
Middle East	<i>Iraq, Saudi Arabia, Syria, Iran, Turkey</i>
West Europe	<i>Italy, France, Great Britain, Germany, Sweden</i>
Asia	<i>China, Japan, India</i>
East Europe	<i>Romania, Russia, Ukraine</i>

Table 2: Chosen Indicators from the World Bank indicators list

Indicators
Population,total
Population, female
Population ages 0-4, male
Population ages 0-4, female
Population density
Population in urban agglomerations of more than 1 million
Teenage mothers (% of women ages 15-19 who have had children or are currently pregnant)
Children in employment, total
Contributing family workers, total
Health expenditure, total
Health expenditure, public
Health expenditure, private
Hospital beds
Physicians
Prevalence of overweight (% of children under 5)
Prevalence of underweight (% of children under 5)
Life expectancy at birth, male
Life expectancy at birth, female
Life expectancy at birth, total
Mortality rate, infant
Mortality rate, under-5
Maternal mortality ratio
School enrollment, secondary
School enrollment, tertiary
Lower secondary completion rate, total
Educational attainment, at least completed lower secondary
Educational attainment, at least completed upper secondary
Educational attainment, at least completed post-secondary secondary
GDP per person employed
GDP growth
GDP per capita
GDP per capita growth
<b>Immunization, measles</b>

## 4 Insights from the data

### 4.1 Measles in the World

In the following six line graphs we can observe the varying of measles vaccination for each country of the world area considered in this project. In the Figure 2 we can see high constant levels of measles immunization during the last 25 years for Iran and Saudi Arabia, about the 95% of coverage. Instead, an interesting result is denoted by the countries such as Syria and Iraq. In fact, from 2010 up to the 2015 (years of war) there was a decrease until reaching very low values, less than 60%, in the last two years. Figure 3 shows an optimal measles' vaccine coverage, generally more than 90%, except for Morocco during the early 2000s, which are still high values. In Central Africa, as shown in the Figure 4, values no higher than 55% up to the 2000s. In particular, there is a 12% peak in Ethiopia during the 90s. Since 2000, there has been an increase in vaccine coverage reaching 80% in 2015 in Ethiopia and Democratic Republic of Congo due to the ONG humanitarian interventions. Generally, in Eastern Europe,

the values are very high, with the exception of Ukraine, which since 2007 has been affected by internal conflicts such as the Donbass war, to which most of the regions in Ukraine participated (Figure 5). In the West Europe, vaccine coverage has generally increased in last years, with the exception of Italy. Until the first months of 2017 the measles vaccine in Italy was strongly recommended, but not mandatory. However, in recent years there has been a decrease in coverage. This is mainly due to some fake news on websites claiming that the vaccine would lead to autism or other complications in adulthood. Furthermore, because of the number of cases of measles disease was very low in the early 2000's, the population was commonly forgetting the severity of the disease and therefore vaccination. Italy's Health Minister Beatrice Lorenzin just announced that Italy will be making vaccinations mandatory for all school children, a move anticipated to come into effect as early as next week. This comes in response to the recent increase in measles outbreaks in Italy, as reported cases of measles rose five fold across the

country in April compared to the same month last year, according to the National Health Institute. In Asia the measles vaccine is mandatory. However, in India the availability of vaccines does not cover the entire population, as long as 2005 did not exceed 70%. China is the state with the highest vaccine coverage, which we examined. This coverage is 99%. The remaining 1% concerns children or people whose vaccine administration is not allowed for some other kind of disease.



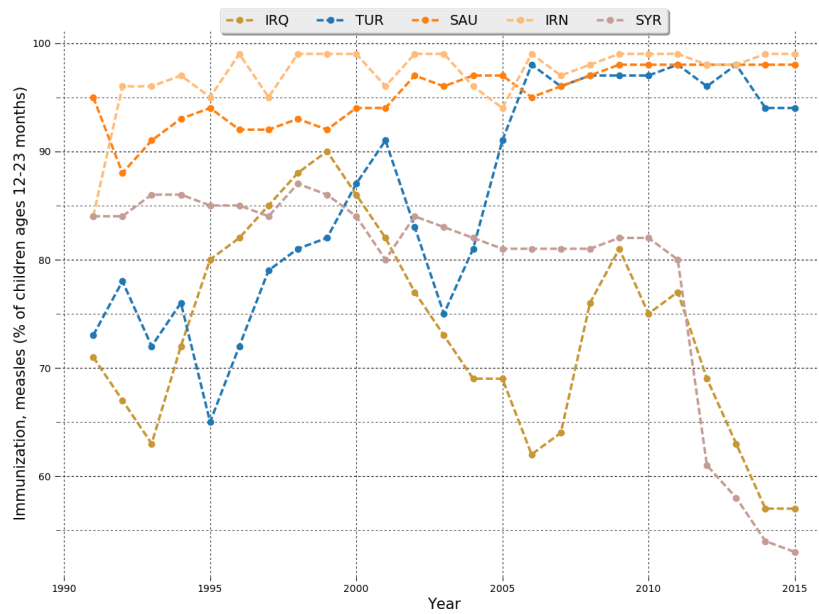


Figure 2: Measles immunization in Middle East

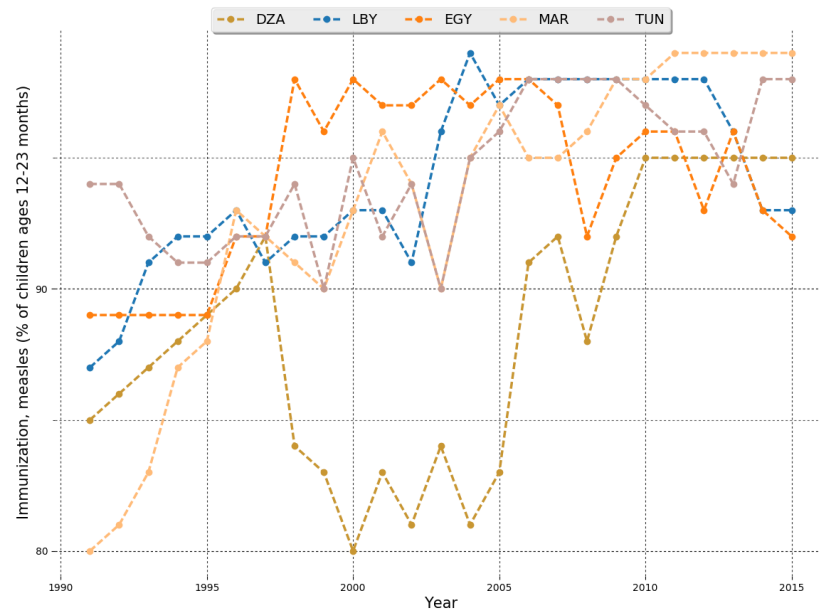


Figure 3: Measles immunization in North Africa

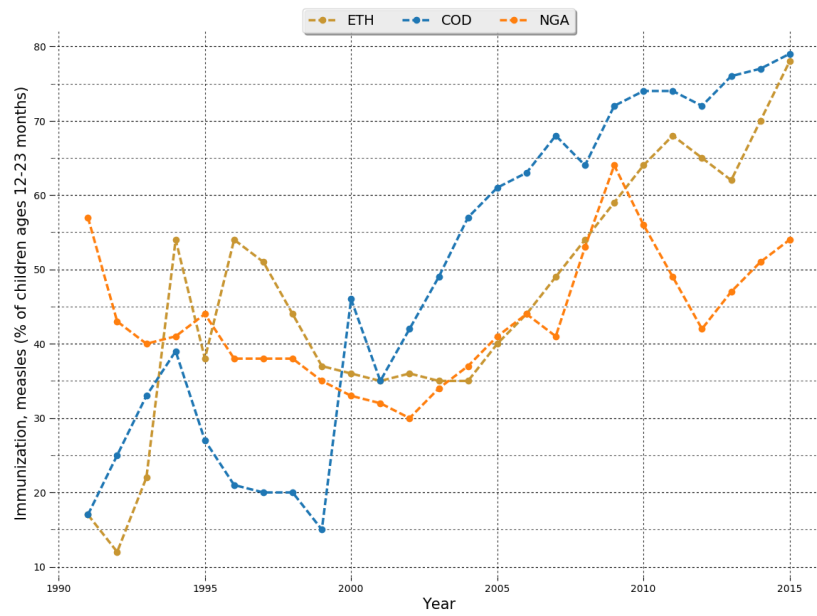


Figure 4: Measles immunization in Central Africa

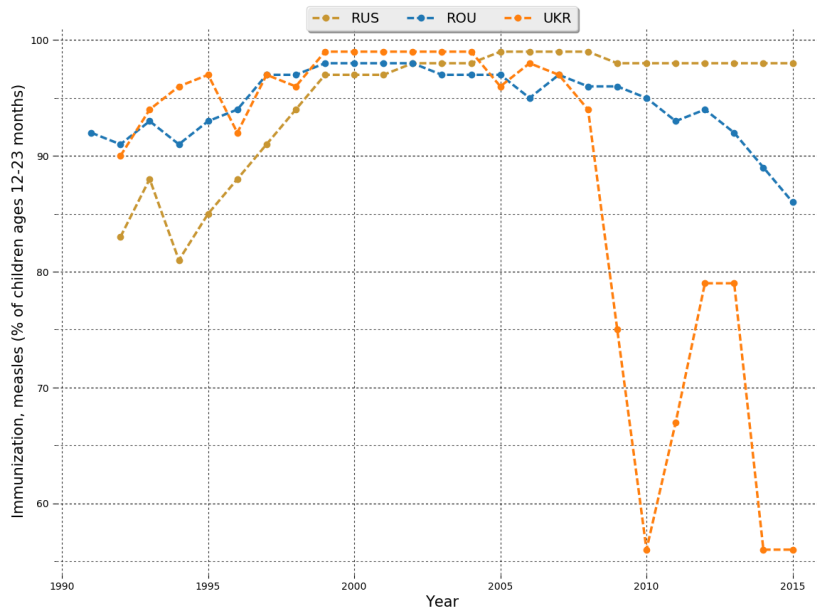


Figure 5: Measles immunization in East Europe

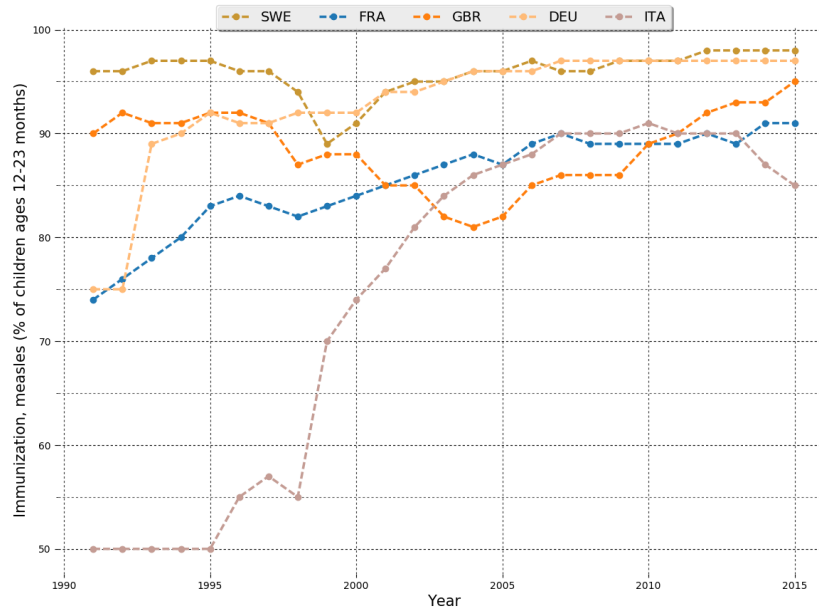


Figure 6: Measles immunization in West Europe

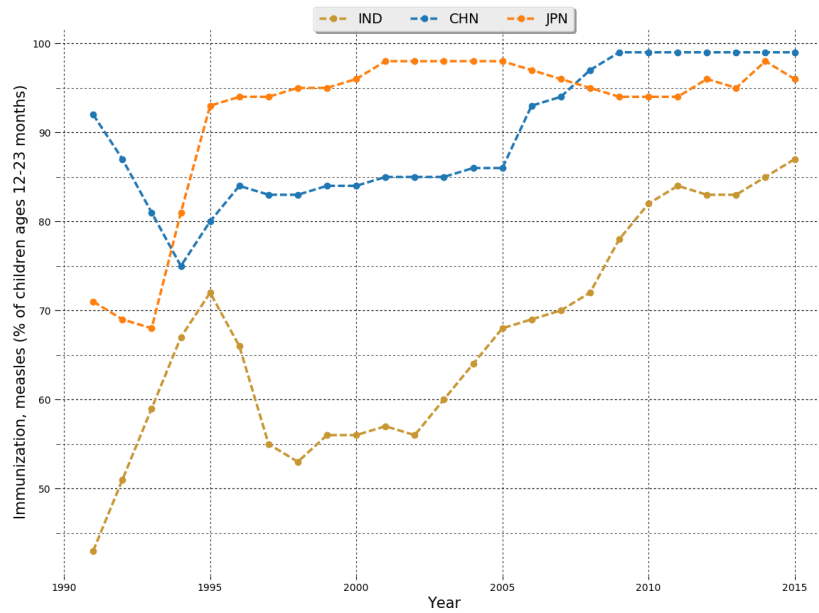


Figure 7: Measles immunization in Asia

## 4.2 Ranks of the selected countries

In the Table 3 we can notice some unexpected high ranked countries such as Morocco that showed as we can see from Figure 3 a huge improvement in the last years. On the other hand, some countries showed a predictable very low rank such as Syria because of the conflicts and instability in the country. One country that deserve to be mentioned is *Burundi* which scored a high average even greater than *Britain*, *France* and *Italy*. Finally, we should remember that these averages don't reflect the number of people being vaccinated, but only the percentage according to the countries' population.

## 5 Literature review

In order to understand what were the previous studies and theories on factors that influence measles vaccination we searched for relevant English observational studies and systematic reviews in bibliographic databases such as ResearchGate [16], Scopus [17] and Web of Science.

Table 3: Averaged ranked measles' immunization in selected countries from 2010-2015

Country Name	Average Immunization
China	99.00
Morocco	98.83
Iran	98.66
Russia	98.00
Saudi Arabia	98.00
Sweden	97.66
Germany	97.00
Tunisia	96.50
Turkey	96.16
Libya	96.00
Japan	95.50
Algeria	95.00
Egypt	94.33
Burundi	93.83
Great Britain	92.00
Romania	91.50
France	89.83
Italy	88.83
India	84.00
Uganda	79.33
Namibia	79.16
DR Congo	75.33
Ethiopia	67.83
Iraq	66.33
Ukraine	65.50
Syria	64.66
Nigeria	49.83

In particular, it's interesting the fact that almost all the papers and reviews report as one of the most important the education level of the parents: Rammohan et al. [5] and Haque et al. [6] says that the paternal education is a leading factor while Azam et al. [4] shows that also the maternal education has a positive effect on vaccination.

In the same time, Logullo et al. [1], Tauil et al. [2], Duy Kien et al. [7] and Torun et al. [8] mention as some leading factors the socioeconomic characteristics, such as living in rural area, mother under 20 years of age, high/low socioeconomic status and others.

## 6 Description of the Method

The aim of this analysis is to determine the factors influencing the decision to vaccinate or not the children in the chosen continents. For this reason, we decided to use the principal component analysis (PCA). This multivariate method is usually applied to identify hierarchy and sets of interrelated variables. Hence, we are summarizing the meaning of the 33 chosen variables

in a smaller set of variables. From the given results the PCA yielded a three-factor solution, explaining the 70% of variance on average and summarizing most of the relevant information in the dataset matrix. The recurring factors in each continent are three: education, wealth and poverty. These interact in a different way due to the story of the continent. The Table 4 represents a summary of the main factors for measles' vaccination in the considered continents. As we can see, these factors are similar and repeated. Now we examine in detail each continent.

## 7 Results

**West Europe:** According to the ECDC, there is no guarantee that compulsory insurance will provide a greater coverage for the vaccine. The World Health Organization and UNICEF estimated that in the 2010-2015 period in Europe there was a fall in overall vaccine coverage (just under 2%), compared to the highest (around 95%) in 2012-2013. Nevertheless, average vac-

cine coverage in Europe (just over 93%) remains second in the ocean region (around 94%), far above the world average (around 86% ). Indeed, in fifteen European countries, compulsory vaccination does not exist. Austria, Cyprus, Denmark, Estonia, Finland, Germany, Ireland, Iceland, Lithuania, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom have a different approach based on recommendation, prevention and information. Data show that in these countries the vaccination coverage is similar to the one in the countries where it is compulsory. There is no epidemic and no public health threat but only a slight fall in vaccine covers that can be faced with the recommendation. From study already done<sup>1</sup> [3], the measles' disease is still present in Europe because of suboptimal immunization levels. Single-dose vaccination was introduced to childhood immunization programs in France in 1983, and a second injection was recommended

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<sup>1</sup> *Knowledge and risk perception of measles and factors associated with vaccination decisions in subjects consulting university affiliated public hospitals in Lyon, France, after measles infection*, Abdoulaye Touré, Bruno Lina, Daniel Floret, Philippe Vanhems, 2014

in 1998, leading to a significant decrease in annual incidence.

From the PCA analysis results that the first PC is the most important for the model. In West Europe, this is due to a strong positive impact of GDP per capita and a negative impact on children employment and the rate of children mortality. This is deducible by the fact that in rich countries, such as those considered, children employment is banned and the infant mortality rate is very because of other kind of factors. The second factor that most affect the choice of vaccination is the trust that citizens have towards the health service offered.

**East Europe:** Most of the East Europe countries has a compulsory vaccination. Hence, the most important factors for these countries is related only to the quality of the hospitals. But in the sample of considered countries there is the Ukraine, where there is no compulsory vaccination; this affect the second PC in which the education level of the population is correlated to the vaccination rate.

**North Africa and Central/South Africa:** The main factor for the whole continent of Africa is the parents' education. But, due to the socio-demographic differences of the African countries, the first PC is also affected by other factors. For example in North Africa is related to how much the government spends on the citizens' health. Instead in Central and South Africa the first PC is also influenced by the effect of children employment.

**Middle East:** In the Middle East, we have chosen countries that in the considered years have experienced severe periods of war, dictatorships and poverty. This justifies the results achieved in the first PC, in fact economic factors such as GDP growth and the percentage of children enrolled in school affect the vaccinations choices of citizens, especially those with measles. Parents' education instead appears as a second important factor.

**Asia:** In Asia there are several factors that affect the results obtained. In fact in Japan seroepidemiological

studies conducted disclosed that measles epidemics differed from community to community; in rural areas, epidemics appeared at intervals of several years with the accumulation of susceptibles, and in urban areas, measles was endemic affecting younger children <sup>2</sup>, as we can see in the variable "Population in urban agglomerations" that affects the first PC. The second PC's value is influenced by the high children employment's rate in China. India's vaccine deficit has several causes: little investment by the government; and low demand as a consequence of a poorly educated population and the presence of anti-vaccine advocates<sup>3</sup>, as we can see in the other factors affecting the first two PCs. In China the children employment rate is high.

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<sup>2</sup> *Measles and measles vaccine in Japan*, Isomura S. , 1993

<sup>3</sup> *India's Vaccine Deficit: Why More Than Half Of Indian Children Are Not Fully Immunized, And What Can—And Should—Be Done*, Ramanan Laxminarayan, Nirmal Kumar Ganguly, 2009

Table 4: Results

Region	Principal components
West Europe	<i>PC1: GDP per capita</i> <i>PC2: Health Public Expenditure</i> <i>PC3: Life Expectancy</i>
East Europe	<i>PC1: Healthy Expenditure</i> <i>PC2: Education</i> <i>PC3: % Population female</i>
North Africa	<i>PC1: Education and Healthy factors</i> <i>PC2: Children Employment</i> <i>PC3: Health Expenditure</i>
Central Africa / South Africa	<i>PC1: Education and Healthy factors</i> <i>PC2: Health Expenditure and Children Education</i> <i>PC3: Population Total</i>
Middle East	<i>PC1: Economic factors</i> <i>PC2: Health Expenditure</i> <i>PC3: Education</i>
Asia	<i>PC1: Health Expenditure</i> <i>PC2: Children's Healthy</i> <i>PC3: Population</i>

quently cited factors. Therefore strengthening the contacts and relationships between the health care services and families with low educational level/low socio-economic status appear to be an important action to improve vaccination coverage. Thereby, to intensify vaccination coverage taking into account the factors identified in the selected articles becomes a challenge for the different countries.

## 8 Conclusions

In conclusion, to achieve high and homogeneous vaccination coverage we must take into account the knowledge developed, which identifies the factors that influence the adherence to vaccination and it is fundamental to interpret them according to the characteristics of each context. Overall, Health Expenditure, GDP per capita and parents' Education were the most fre-



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