

Determinants of Immunization Behavior in Pakistan



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Abstract: *This study aimed to investigate the variation in the income quintile group in Pakistan with respect to immunization coverage. The study used PSLM 2019-2020 data set to investigate how different socioeconomic factors along with income quintile influence the immunization behavior. The findings of study revealed that there exists significant variation in immunization coverage among income quintile group as the probability value of One-Way ANOVA is recorded less than 5%. The linear probit model results confined that the independent variables are responsible for around 72.8% variation in immunization coverage. The income quintile groups showed that the richest families have 10% higher chances to vaccinate their children as compared to other groups. The results of generalized linear logit model depicts that the probability of completing vaccination in richest families are around 69% higher than that of poorest families. Among provinces, only Sind has 17.01% lower vaccination chances to complete vaccination as compared to KPK while Punjab and Balochistan have 6.62% and 0.93% higher chances to immunize the children. The concentration curve showed very small inequality in immunization coverage across all over Pakistan, while the Lorenz curve showed higher inequality for Sind followed by Balochistan, KPK, and Punjab. Both KPK and Punjab have lower inequality than the overall country. It is recommended for the public sector to reduce the consumption dependent household ratio, increase women literacy, and encourage women participation in the labor market.*

Keywords: Income Inequalities, Immunization behavior, Female Literacy

Introduction

Immunization is a process by which an individual or person becomes protected against certain diseases through vaccination, which is often used interchangeably with inoculation or vaccination. According to the World Health Organization (WHO), it is defined as the process whereby a person is made resistant or immune to infectious diseases, typically by the administration of a vaccine. In today's digital and medical era, we have vaccines that are used to prevent more than 20 life-threatening diseases that help people of all places and ages to live healthier and longer lives. According to the WHO Report (2021), immunization around the world currently prevents around 3.5 to 5 million deaths every year from diseases like measles, influenza, pertussis, tetanus, and diphtheria.

Many studies have been carried out to explore different factors influencing immunization behavior around the world. For example, Unshur et al. (2016) identified that different factors such as distance, possession of livestock, education, parental education, mother's willingness to pay, income level of the family, and measles immunization schedule impact immunization behavior. Another study (Anderson, 2014) claimed that lack of knowledge about contraindications and indications for immunization, absence of a reminder system, and poorly trained medical staff reduce immunization uptake in health care facilities. Simultaneously, Shui et al. (2005) found that lack of trust in individuals and organizations who advise on vaccine uptake, lack of linguistically appropriate information and culture, and timing, along with inconvenient location and the income level of parents, certainly influence the immunization behavior of individuals.

It is obvious that a family that is starving for necessities or cannot afford basic needs hardly focuses on health issues and challenges. According to Restrepo-Mendez et al. (2016), income is the main factor that

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influences the immunization behavior of individuals. A very high level of immunization can be seen in rich countries, but in poor countries, it is lower at an alarming level, such as in Africa and some Asian countries (Lemoine et al., 2013). Gust et al. (2003) examined the association between women's empowerment and the benefit of immunization in the USA and concluded that around 57% of parents agreed that immunization is beneficial and necessary for the future health of children, while 17% stated that they do not think that it is beneficial. Those who agreed have been observed in the higher-income quintile group, and the authors found that income is the key accelerating role player in the parents' decision towards immunization.

The Expanded Program on Immunization (EPI) was launched in 1978 in Pakistan with the aim of protecting children by immunizing against childhood measles, tetanus, pertussis, diphtheria, poliomyelitis, and tuberculosis. The EPI program also aims to protect newborns and mothers against tetanus. According to WHO, immunization in Pakistan might avert around 17% of childhood mortality and thus help towards achieving the Sustainable Development Goal of reducing child mortality and morbidity (Ateeq et al., 2022). The United Nations Children's Fund (UNICEF), in its 2021 report, which was published on November 12, 2021, claimed that in Pakistan, the countrywide campaign that targets more than 90 million children who are in the age group 9 months to 15 years is one of the largest in the world (Adnan et al., 2022).

Hence, we can say that not only are the terms of immunization facing severe issues, but also the economic indicators of the country are not giving satisfactory results. Since income and health are directly related to each other, only a wealthy person can sustain and obtain satisfactory health facilities, especially when there are arguments and no acceptance of the insurance system. Therefore, it is important to investigate basic socio-economic factors, i.e., immunization behavior and income quintile groups, related to each other. The topic is taken seriously because around one-third of international economies are considered poor or developing, and Pakistan is among them. Therefore, this study can provide a road map to developing economies on how income quintiles in various regions influence immunization behavior, such that policymakers and health experts can get a brief insight into the rising social issue.

Research Problem

Pakistan's estimated population for 2022 is around 242 million, which makes the country the 5th most populous country in the world (Hadi et al., 2022). The country is divided into five major provinces, i.e., Sindh, Balochistan, Punjab, KPK, and Gilgit-Baltistan, with the administrative region of Islamabad Capital Territory. The population of the country is distributed, with Punjab having the highest share, followed by Sindh, KPK, and Balochistan. Ali et al. (2022) stated that the EPI is the main vaccine provider in the country with a public-private partnership concept, where the national government, WHO, UNICEF, and pharmaceutical companies work together to improve and implement vaccination and immunization in the country. According to a UNICEF report (2021), around 71% of the total under-five population in the country with acute respiratory infection symptoms who were advised or received treatment sought from a health facility or provider, and only 37% of children received ORS for diarrhea (Raja, 2022). The mortality rate in the country has dropped from 140 to 60 per 1000 in 2021 as compared to 1990 (Kalkowska et al., 2022).

The current study aims to examine how income quintiles in various provinces in Pakistan influence the immunization behavior of people. The research objectives of the current study are listed below.

- To study the variation in immunization across different income groups
- To examine the uneducated mother as a reason for incomplete or no vaccination in Pakistan
- To study the guardian's belief in rumors, i.e., making a child disabled regarding the immunization process

Literature Review

Immunization can simply be defined as the process of conferring immunity by other than natural means, such as by using vaccines (Lemonie et al., 2013). Vaccines give immunity to a disease without getting sick and are

made by using different antigens, which give resistance against different viruses and bacteria. Immunization prevents deaths, disabilities, and diseases that are vaccine-preventable, such as tetanus, rubella, poliomyelitis, pneumonia, whooping cough, mumps, and measles (Shui et al., 2005). Jamison et al. (2022) stated that sometimes vaccination and immunization terms are used interchangeably, but in reality, they are quite different from each other. Vaccination is used when a vaccine enters the body through a needle or by mouth through drops (Ali et al., 2022). In contrast, immunization is the process of becoming immune to a disease due to a vaccine.

Immunization is an effective and simple way of protecting newborn children from serious current and future diseases. It not only protects individuals but also protects the broader community by minimizing the spread of various infectious diseases. Without immunization, a newborn baby is at risk of serious illness from diseases such as whooping cough and measles. Datar et al. (2007), in their research work carried out in India, found that health facilities in rural areas have a significant impact on immunization coverage. The authors also found that poorer families do not show any interest in vaccinating their kids, while richer families are found to be interested in the immunization of their kids. Therefore, it can be stated that family status in terms of financial stability plays a very significant role in immunization coverage. Varma & Kusuma (2008) studied different factors influencing immunization, and the authors concluded that parental education, especially a mother's education, is a very important and significant determinant of child immunization. On average, those children whose mothers are educated have 19.85% higher chances of being vaccinated as compared to those whose mother is not educated.

Regarding factors influencing immunization coverage in Pakistan, Muhammad et al. (2022) argue that vaccine hesitancy remained a critical challenge in the country because most of the population is illiterate and usually falls into the trap of rumors and misinformation. The authors found that Sindh remained the lowest immunization coverage province with only 35% vaccination under the EPI program. Similarly, Adnan et al. (2022) found that the income quintile is a major determinant of immunization in Pakistan, as the average per capita income of the country is far below the standard UNO baseline, and people hardly put their focus on immunization. Only those children and parents who are highly motivated to get vaccinated are born in a hospital, but in rural areas, specifically in Balochistan, FATA, and rural Sindh, citizens rarely make antenatal visits or give birth to children in a hospital (Ali et al., 2022). Sometimes, the EPI team or immunizing staff hardly move to these areas; therefore, the majority of house-born children remain unvaccinated. Hadi et al. (2022) proposed that the government can attract more children to be vaccinated by providing some financial incentives or ensuring future benefits such as school admissions are associated with the immunization of children. Only those children can get admission who have a valid birth form from NADRA, and it should be mentioned what vaccines the children have received.

According to World Bank data from 2021, around 5% of the total population in Pakistan lives below the extreme poverty line, with an 8% share of the rural population and a 0.3% share of the population living in urban areas. Around 35.7% of the country's total population lives below the poverty line, earning less than 3.2 USD per day. According to the Wall Street Journal (2017), around 42% of the country's population belongs to the middle and upper class, which means that more than 87 million people in the country are living middle- and upper-class lives. Rural poverty in the country remained a pressing issue, as development in rural areas is observed to be slower than in major urban areas.

Relating the relationship between income quintile groups with immunization behavior, Raza et al. (2018) highlighted that there exists a significant difference in the immunization coverage in rural and urban areas of the country, where it has been observed to have a significant positive relationship between the income quintile groups and immunization behavior. When we move from a lower-income group to a middle one, the likelihood of getting a vaccine on average increases by 13%, while in the case of the middle to the upper, this likelihood increases by 23%. The differential achievements vary in rural and urban areas, where in rural areas people are suffering certain economic crises and hardly manage to focus on health issues. Therefore,

geographic disparities concerning income quintiles in Pakistan have been observed as a major constraint in the receipt of immunization.

The previous studies that have been carried out to explore the impact of different socio-economic factors on immunization have concentrated on and stressed the mother's education as a key factor that influences immunization coverage. For instance, Danish and Muhammad (2014) found that for every year of increase in mother's education, the likelihood of getting vaccinated children, on average, increases by 11.25%. The results from the study of Kibreab et al. (2020) confirmed that children of mothers having primary education are, on average, more likely to be fully vaccinated than those who have no education.

The urban areas are more advanced and comprise all necessities of life. Due to the higher inflow of population to urban areas, the public sector ensures the provision of health facilities to the citizens (Voorman et al., 2017). Therefore, urban areas have more chances to cover immunization. In rural areas, there are certain issues such as weak transportation, dispersed population, higher illiteracy rate, weak communication system, weak internet sources, etc., which reduce the chances of getting awareness about a specific issue. Therefore, the chances of vaccination in rural areas are lower than those in urban areas.

Regarding the distance, Butt et al. (2020) argued that the distance between an individual's residence and immunization has a negative correlation, which means the higher the distance, the lower the immunization coverage. The authors found that besides the immunization center, the distance from residence to the hospital is a major factor. This is because when the distance is too large and the residents have a transportation problem, they prefer to give birth at home, which keeps them unaware of newborn vaccination (Asif et al., 2019). Once a mother misses the birth immunization, the likelihood of completing the immunization falls by approximately 21.54% (Hossain et al., 2021). Therefore, policymakers and researchers need to consider both the nature of the residence and the distance from the residence to the immunization center. The following hypothesis will be tested in the current study.

The literature review provided enough empirical evidence to show how different socio-economic factors influence immunization behavior. However, very limited studies with special reference to Pakistan have explained the role of different socio-economic factors in determining immunization behavior. Our current study is unique in two different ways i.e. the first one is the reliance on the most advanced data set Household Integrated Economic Survey 2019-2020. Secondly, we are going to evaluate both descriptive statistics and logistic regression to show both theoretical and empirical evidence that how different socioeconomic factors at the provincial and country-level influence the Child's immunization in the country.

Anderson's model is the baseline model that the current study will rely on. The current study undertakes the immunization behavior as an outcome variable that is influenced by a set of independent or explanatory variables i.e. income quintile groups, mother's education and profession, parents' beliefs and rumors, type of residence, and distance from the immunization center.

Methodology and Estimation Procedures

As a form of the conceptual and theoretical framework, it is mentioned that our interest is to seek how different socio-economic factors in Pakistan influence immunization behavior. Hence, in the current study, "immunization behavior" is our dependent variable, while income quintile, mother's education, mother's profession, beliefs about rumors, household residence, and distance from the immunization center are independent variables. The equation below shows the mathematical relationship among the considered variables.

$$I.B = f(I.Q, Edu, Prof, Rumo, H.H.R, Dist) \text{ ----- Eq: 1}$$

where I.B represents the immunization behavior, I.Q is income quintiles, Edu is the mother's education, Prof is the mother's profession, Rumo represents the rumors and beliefs of parents, HHR represents the household

residence, and Dist is used for distance from the immunization center. The above mathematical equation can be written in an econometric form as below.

$$I.B = \beta_0 + \beta_1 I.Q + \beta_2 Edu + \beta_3 Prof + \beta_4 Rumor + \beta_5 H.H.R + \beta_6 Dist + \varepsilon \quad \text{---Eq: 2}$$

From Eq: 2, β_0 represents the intercept, while $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ and β_6 are the coefficient values for I.Q, Education, profession, rumors, household residence, and distance from the immunization center. ε are used to represent the error term.

The above equation 2 is a linear probability model that is presented in the form of a linear regression model. This is because the dependent variable, i.e., immunization behavior, is a binary dummy variable, i.e., “Yes” and “No” options for the respondents to know their completeness level of immunization. Therefore, the linear regression model is treated as a linear probability regression model, which will tell about the maximum likelihood of variation in the dependent variable due to variation in the response to the independent variables (Ghasedi et al., 2021).

The linear probability model assumes that the probability is a linear function of the independent variables, which tells about the maximum likelihood results (Orr et al., 2013). But our interest is to know the actual probability of success or failure of a certain event due to variation in the explanatory variables. Hence, we can use the linear probability model if and only if the results do not violate the classical linear assumptions. Since the dependent variable is unique and varies from individual to individual, we are not allowed to sort the data set because it will violate the assumption of constant variance, i.e., homogeneity. Therefore, instead of relying on the linear probability model, we need to rely on the logit regression model because the logit model assumes that the natural log of the odds ratios is a linear function of the independent variable.

Hence, based on the nature of the dependent variable, we can say that the “logistic regression model” or “Logit Model” is the best-fitted model for binary variables. The logit models are based on the sigmoid function, which is also known as the logistic function, and is used to model situations where there are two possible outcomes, in our case “Yes” and “No”. This model has used the odds of success of an event as a function of different independent variables, where the starting point of logit regression is given below.

$$\text{logit}(I.B) = \log \left[\frac{p}{(1-p)} \right] = Z = \beta_0 + \beta_1 X + \varepsilon \quad \text{-----Eq:3}$$

Where “P” is the probability of an event occurring and “1” is the odds of an event occurring, “Z” is the linear combination of independent variables with coefficients, and “X” is the set of independent variables that are used to determine the event’s success or failure. The above equation can be solved in the following function that can be used to determine the probability of immunization behavior.

$$P = \sigma(Z) = \frac{1}{1+e^{-Z}} \quad \text{-----Eq:4}$$

The function $\sigma(Z)$ is called the sigmoid function. As the value of “Z” approaches minus infinity, the value of $\sigma(Z)$ or “P” approaches Zero, while as the $\sigma(Z)$ approaches to plus infinity, then the value of $\sigma(Z)$ or “P” approaches to 1.

Hence, based on the above facts and explanation, the current study will rely on the logit regression model to seek the probability of completing immunization across different regions in Pakistan. This method was earlier used by different authors who showed interest in immunization. The current study is unique in nature of both econometric estimations and most importantly for immunization variation across income quintile groups, the current study will focus on the “Lorentz Curve”. The below section sheds light on the acceptability and applicability of the Lorenz Curve.

Derivation of Lorenz Curve

The key area of current research work is to investigate the variation in immunization behavior across different income quintile groups across Pakistan. The literature and theoretical framework briefly explain the

perceptions and findings of different authors showing the influence of income and different explanatory variables on immunization behavior. The income quintile groups measure the neighborhood socioeconomic status, which divides the population into five income groups ranging from the lowest income group to the highest income group so that approximately 20 percent of the population is in each group (Chotikapanich, 1993).

The current study relied on data available from the Pakistan Bureau of Statistics under the name Pakistan Social and Living Standards Measurement (PSLM-2019-2020) for the year 2019-2020. This means that the data set used in the current study is the most recent one, which can help us to gain comprehensive insight into different socio-economic features influencing the dependent variable.

Data Analysis

The frequency distribution is a statistical measure that deals with the arrangement of data concerning their frequencies in rows and columns along with the graphical representation of the data (Ellis & Ferreira-Junior, 2009). The table below provides a summary overview of the major demographic features of the overall sample of the study population with residence distribution.

Table 1

Frequency Distribution of Sample

Province	Rural	Rural %	Urban	Urban %	Total
KPK	162,988	87.62%	23,035	12.38%	186,023
Punjab	610,508	72.11%	236,156	27.89%	846,664
Sindh	482,381	54.51%	402,580	45.49%	884,961
Balochistan	400,704	81.42%	91,443	18.58%	492,147
Total	1,656,581	68.74%	753,214	31.26%	2,409,795

From the sample features, the data set of PSLM 2019-2020 collected data from 2.409 million households. The sample comprises a data set of 186 thousand from KPK with 87% rural households and 12.38% urban households. There were 846 thousand samples from Punjab, with 72% of the household from rural areas and 28% from urban areas. Sind has the largest population of 884 thousand households, with 55% from rural areas and 45% from urban areas. 492 thousand households have been collected from Balochistan, with 81% rural and 19% urban populations. The overall sample results revealed that around 81% of the sample belong to rural areas and 19% of the population is from urban areas. It means that the majority of the sample belonged to Sind, while the highest number of observations were taken from rural areas of the country.

The sample revealed that the majority of our sample is from rural areas. The table below provides a summary overview of immunization behavior, showing whether the children are immunized or not.

Table 2

Children Received Immunization or Not

Province	Yes	Yes %	No	No %	Total	Percentage of total Sample
KPK	23,311	97.60%	572	2.40%	23,883	12.839%
Punjab	47,745	97.61%	1,170	2.39%	48,915	5.777%
Sindh	19,487	97.48%	503	2.52%	19,990	2.259%
Balochistan	10,005	94.48%	584	5.52%	10,589	2.152%
Total	100,548	97.26%	2,829	2.74%	103,377	4.290%

From the above table, around 97% of the total sample who were reported as having children under the age of five have received immunization, while only 2.74% of children have been reported as not having received immunization. Among the provinces, the highest percentage was recorded for Punjab and KPK, where 97.61%

and 97.60% of children have been reported to have received immunization respectively. The lowest number was recorded for Balochistan, where around 94.48% of children have received immunization. The immunization rates in KPK, Punjab, and Sindh were almost the same, with a higher than 97% immunization rate, while for Balochistan, 5.52% did not receive immunization. So, we can say that the immunization rate in the 2019-2020 PSLM results showed a good response to receiving the immunization. But when we look at the overall coverage rate in the last column, we see that the percentage of the total sample is very low, as only KPK has a higher immunization rate, at around 13%. The lowest coverage rate is recorded for Balochistan, which is recorded at 2.152%.

The table below provides a summary overview of immunization behavior in rural and urban areas of the country.

Table 3*Immunization Behavior in Rural and Urban Areas*

Region	Yes	Yes %	No	No %	Total
Rural	74,769	97.19%	2,161	2.81%	76,930
Urban	25,779	97.47%	668	2.53%	26,447
Total	100,548	97.26%	2,829	2.74%	103,377

From the rural and urban immunization data, we can see that in urban areas the immunization is higher, i.e., 97.47%, as compared to rural areas, where the immunization is 97.19%. In rural areas, around 2.81% of households have no immunization, while in urban areas this rate is low, i.e., 2.53%. Hence, we can say that in Pakistan, on average, urban areas have higher immunization as compared to rural areas. Besides, in the urban and rural areas, the mother's literacy, profession, and childbirth place play a key role in determining immunization. The figure below provides information about the reading and writing capacity of mothers.

The Chi-square test has been used to check the association (Bradley & Cutcomb, 1977) between immunization behavior and different demographic features such as read, write, region, province, etc. The table below provides a summary overview of Chi-square results for various demographic features.

Table 4*Chi-Square Degree of Association between Immunization and Demographic Features*

	Province	Yes	No	Total	Chi-Square	p-value
Province	KPK	23,311	572	23,883	343.0904	0.000
	Punjab	47,745	1,170	48,915		
	Sindh	19,487	503	19,990		
	Balochistan	10,005	584	10,589		
Region	rural	74,769	2,161	76,930	5.932	0.000
	urban	25,779	668	26,447		
	Missing	433	11	444		
Can Read	Yes	39,609	1,113	40,722	0.2435	0.885
	No	36,782	1,016	37,798		
	Missing	1	0	1		
Can Write	Yes	38,957	1,096	40,053	0.1187	0.942
	No	651	17	668		
	Missing					

From the above Chi-square test, we can see that the probability value of Chi-square for province and region is less than 5%, which depicts the possibility of a degree of association between province and region with immunization behavior. This reveals that there exists a significant association between the province, region,

and immunization behavior. In contrast, the Chi-square probability values for reading and writing are greater than 5%, suggesting no significant association between reading, writing, and immunization behavior. This reveals that immunization behavior is the same for mothers who can read and write or not. Hence, we can conclude that immunization is associated with regions and provinces but not with the reading and writing ability of mothers.

The income quintile represents the neighborhood socioeconomic status, which divides the population into five major income groups, i.e., the lowest income group, known as the poorest, to the highest group, which represents the richest (Kang & Kim, 2018). The table below provides a summary overview of the total income of households in different regions.

Table 5

Mean Yearly and Monthly Income Across Different Provinces

Province	Mean Yearly	Mean Monthly	Maximum	Minimum	St. Deviation
KPK	280546.1	23378.8417	12000000	0	354615.4
Punjab	276556	23046.3333	18000000	0	386128.1
Sindh	240466.7	20038.8917	6000000	0	248059.6
Balochistan	255342.3	21278.525	4440000	0	214858.8
Total	265569.6	22130.8	18000000	0	334658.8

The mean yearly income for all households in Pakistan is recorded at 265569 PKR while the monthly income for the household in Pakistan is recorded at 22130 PKR per month. The monthly income for KPK is recorded at 23378 PKR while for Punjab and Sind the monthly income of the household is recorded at 23046 and 20038 PKR. Baluchistan's monthly income is recorded at 21278 PKR. These figures reveal that the monthly income for KPK is the highest followed by Punjab and Balochistan. Sind has the lowest per month income. The standard deviation for yearly income in the country is recorded as greater than the mean value, which means there is high dispersion and variation in the monthly income, which can be seen from the minimum and maximum values that have much higher variation.

For finding the income quintiles in the current group, we used the yearly expenditures along with weights (Datta & Meerman, 1980; Wunder, 2012; and Pichora et al., 2018) given by the Pakistan Bureau of Statistics to the various household. The below table provides a summary overview of the frequency distribution of various quintiles across the country.

Table 6

Income Quintile Groups

Quintile	Representation	Freq.	Percent
1	Poorest	29,384	49.06%
2	Poor	13,630	22.75%
3	Middle	8,613	14.38%
4	Rich	5,767	9.63%
5	Richest	2,506	4.18%

There was 59900 families' income have been reported in the available data set. The income quintile has been created based on the yearly expenditures along with assigned weight. There have been found 29384 families that fall in the first quintile represent the poorest class, which was around 49% of the whole quintile. The number of poor or second quintile group was 13630 followed by middle 8613 both having shares of 22.75% and 14.38% respectively. The fourth and fifth quintiles comprised only 13% of whole samples. This indicates that the richest population comprised only 4% of the total population. These results revealed a significant difference in the income distribution in the country. The below table provides summary statistics for the income quintile group with mean income across different regions in the country.

Table 7*Mean Income Quintiles for Provinces*

Province	Mean	Maximum	Minimum	St. Dev
KPK	2.0726	5	1	1.230
Punjab	2.0329	5	1	1.207
Sind	1.8237	5	1	1.116
Balochistan	1.9321	5	1	1.113
Total	1.9713	5	1	1.181

From above table 7, the mean income quintile for KPK is recorded as 2.0726 with a minimum of 1 and a maximum of 5, and a standard deviation of 1.23. This reveals that the majority of the KPK population have middle-family backgrounds. Similarly for Punjab mean quintile value is recorded at 2.0329 while for Sind it is recorded at 1.8237, which is the lowest among all provinces. Balochistan has a mean income quintile group of 1.9321. Therefore, we can say that mostly Sind has the poorest population followed by Balochistan and Punjab respectively.

One of the key objectives of the current study was to seek the possible variation in immunization concerning different income quintile groups across different regions. The current study relied on One-Way ANOVA (Heiberger & Neuwirth, 2009; Ross & Wilson, 2017) as a measuring instrument to seek the possible variation in immunization across the different regions in the country with special reference to the income quintile. The below table provides a summary overview of the major findings of One-Way ANOVA.

Table 8*One-Way ANOVA*

Source	SS	df	MS	F	Prob > F
Between groups	35.39403	2	17.69701	12.69	0.000
Within groups	83534.27	59897	1.394632		
Total	83569.67	59899	1.395176		
Chi-Square	35.8271	Prob Ch-Square	0.000		

The above One-Way ANOVA table showing the possible difference in immunization across different income quintile groups revealed significant differences in the immunization behavior. The probability value of F-statistics is recorded as less than 5%, which confirms the presence of significant differences in the immunization behavior across different income quintile groups across Pakistan. The Chi-square probability value is recorded as less than 5%, which also confirms the presence of a significant degree of association between immunization and income quintile groups. Hence, we can conclude that there exists a significant difference in immunization behavior with respect to income quintile groups across Pakistan.

Descriptive Statistics

The below table provides summary statistics to represent the average behavior of numerical and continuous variables used in the sample.

Province	Features	A.C.V	V.A.B	Distance	Income
KPK	Mean	3.2462	1.6404	2.5313	280546
	St.Dev	1.6999	0.7407	1.5430	12000000
	Min	1.0000	1.0000	0.0000	0
	Max	21.0000	5.0000	5.0000	354615
Punjab	Mean	3.7749	1.8133	2.4388	276556
	St.Dev	1.9451	0.8503	1.4712	18000000
	Min	1.0000	1.0000	0.0000	0
	Max	9.0000	6.0000	5.0000	386128

Province	Features	A.C.V	V.A.B	Distance	Income
Sind	Mean	3.3915	1.8081	2.4997	240467
	St.Dev	1.9423	0.9134	1.4780	6000000
	Min	1.0000	1.0000	0.0000	0
	Max	9.0000	6.0000	5.0000	248060
Balochistan	Mean	3.6952	1.8371	2.6292	255342
	St.Dev	1.9775	0.9435	1.5089	4440000
	Min	1.0000	1.0000	0.0000	0
	Max	9.0000	6.0000	5.0000	214859
Overall Pakistan	Mean	3.5532	1.7916	2.5071	265570
	St.Dev	1.9228	0.8754	1.4887	18000000
	Min	1.0000	1.0000	0.0000	0
	Max	21.0000	6.0000	5.0000	334659

(Note: A.C.V is used for antenatal care visits, V.A.B is used for the number of visits after birth, distance represents the distance of residence from the immunization center, time is used for the average time taken to reach the immunization center, and income represent the total yearly income of the households)

The average number of antenatal care visits for overall Pakistan is recorded at 3.55 with a maximum of 21 and a minimum of 1 visit. among provinces, the mean antenatal care visits for KPK, Punjab, Sind, and Balochistan are recorded at 3.24, 3.77, 3.39, and 3.3.69 respectively. The mean visits after birth for the overall country are recorded at 1.79, whereas KPK, Punjab, Sind, and Balochistan have mean visits after birth recorded at 1.64, 1.81, 1.80, and 1.83 respectively. The average distance from the immunization center is recorded at 2.53, 2.43, 2.499, and 2.629 for KPK, Punjab, Sind, and Balochistan respectively. This means that on average Balochistan has a higher distance but the antenatal care visits before and after birth in the province are on average higher than in other provinces. The average total yearly income for KPK, Punjab, Sindh, and Balochistan is recorded as 280546, 276556, 240467, and 214859 PKR, respectively.

Linear Probability Model

In econometrics, the linear probability model (LPM) is a special case of the binary regression model, where the outcome variable for each observation takes the value of two possible options i.e. Yes or No (Caudill, 1988). Battey et al. (2019) further added that the vector of parameters can be estimated by using least squares techniques, while Breen et al. (2018) stated that it might be inefficient and need to rely on weighted least square in which the model iteration is used to supply the estimates of conditional variance that varies between observations. Hence, it would be a maximum likelihood observation technique.

Since our interest is to use the probabilities of associated variables influencing immunization behavior and immunization, the behavior itself is a binary variable. Therefore, our major interest is in the logit model but the linear probability model is been used just to seek the total variation in the dependent variable due to variation in the independent variable by reducing the heteroskedasticity using the robust regression technique. The below table provides a summary overview of linear probability model results

Table 9

Results of Linear Probability Model

Source	SS	df	MS	Number of obs	=	59,886
Model	1.225377	8	0.153172	F(8, 59877)	=	6.11
Residual	1501.07	59,877	0.025069	Prob > F	=	0.000
Total	1502.295	59,885	0.025086	R-squared	=	0.728
				Adj R-squared	=	0.6271
				Root MSE	=	0.15833
Immunization	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
Poor	-0.0039**	0.0017	-2.38	0.017	-0.0072	-0.0007

Middle	0.0055*	0.0020	2.81	0.005	0.0017	0.0094
Rich	0.0094*	0.0023	4.04	0.000	0.0048	0.0139
Richest	0.0100*	0.0033	2.98	0.003	0.0034	0.0165
region	-0.0019	0.0014	-1.39	0.165	-0.0046	0.0008
Punjab	-0.0034***	0.0019	-1.81	0.070	-0.0070	0.0003
Sind	-0.0005	0.0020	-0.26	0.795	-0.0045	0.0034
Balochistan	-0.0033	0.0026	-1.28	0.201	-0.0083	0.0018
Literacy	-0.1278*	0.0133	-9.597	0.000	-0.3893	0.1338
Visit Number	0.0044***	0.0024	1.81	0.07	-0.0004	0.0091
Visits Number	-0.0036	0.0048	-0.76	0.448	-0.0130	0.0058
Distance	-0.0143**	0.0073	-1.96	0.051	-0.0287	0.0000
Time	0.0118	0.0093	1.27	0.203	-0.0064	0.0300
cons	1.9777	0.0024	807.38	0.000	1.9729	1.9825

(Note: ***, **, & * represents the significant of variables at 10%, 5%, & 1% respectively)

From the coefficient values, we can see that the coefficients of income quintile groups, provinces, antenatal care visits before birth, and distance have statistically significant impacts on immunization behavior. Since the coefficient values are directly measured, hence by multiplying the coefficient values by 100, we can get the percentage changes in the outcome variable due to variation in the respective variables.

The earlier estimations of the linear probability model helped us to estimate the total variation caused by explanatory variables in the outcome variable. Through the logit regression model, we will estimate the exact probability values that explain the possible variation in the dependent variable due to changes in the independent variables (Delle-Site et al., 2019). The below table provides a summary overview of logit regression results.

Table 10

Logit Regression Results

Immunizations	Odds Ratio	Std. Err.	z	P>z	[95% Conf. Interval]
Poor	-0.09274*	0.00612	-15.101	0.000	-0.1815 -0.056
Middle	0.0729*	0.0153	4.7647	0.000	0.0170 0.2880
Rich	0.2513*	0.0586	4.2883	0.000	0.1782 0.413
Richest	0.6989*	0.1826	3.8274	0.000	0.419 1.166
Region	0.30707	0.2063	1.488	0.142	0.312 1.182
Punjab	0.0662*	0.0125	5.296	.0000	0.0014 0.1452
Sind	-0.1739*	0.0462	-4.07	0.000	-1.087 1.268
Balochistan	0.0093*	0.00295	-3.152	0.000	-1.143 1.259
Literacy	0.1701*	0.0610	-2.786	0.004	-0.904 0.0178
Mother's Profession	0.0226*	0.0520	4.346	0.000	-0.3458 0.1427
Visit Numbers	0.217	0.1342	1.612	0.142	0.999 0.348
Visits Number	0.2064*	0.0315	6.552	0.000	0.098 0.432
Distance	-0.076**	0.037	2.054	0.021	-0.14 0.074
Time	-0.0124*	0.0041	3.036	0.000	-0.00177 0.0172
_cons	0.7342	0.6271	-0.36	0.718	0.138 3.917
Generalized linear Models		No. of Obs	59,886		
Optimization :	MQL Fisher scoring	Residual df	59,879		
	(IRLS EIM)	Scale parameter	1		
Deviance =	524625.127852	(1/df) Deviance	0.778124		
Pearson =	562795.1245	(1/df) Pearson	0.865736		
Variance function:	V(u) = u*(1-u/region)	[Binomial]			
Link function :	g(u) = ln(u/(region-u))	[Logit]			
		BIC	-11.0874		

(Note: ***, **, & * represents the significant of variables at 10%, 5%, & 1% respectively)

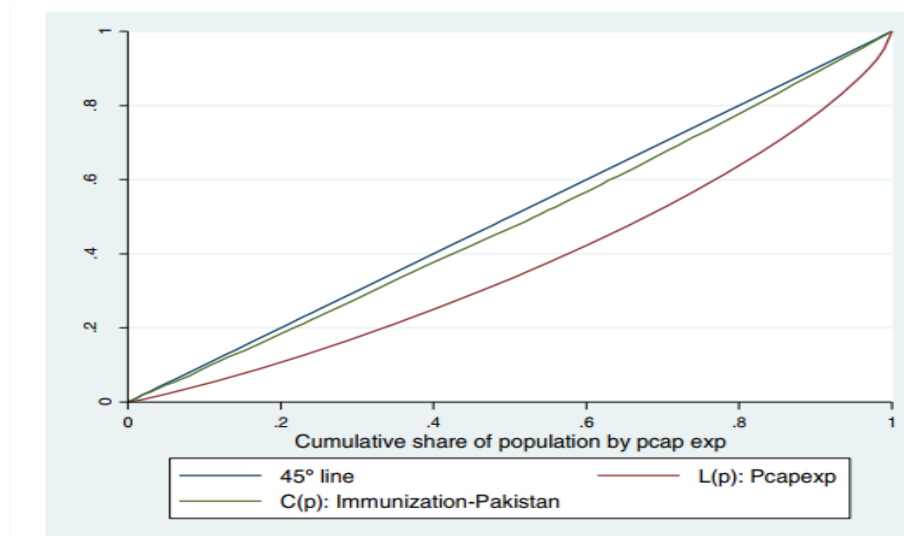
The coefficient values, terms of odds ratios through the marginal effects mechanism, reveal that besides regions and the number of antenatal care visits before birth, all other considered variables showed a significant impact on immunization behavior. From income quintile groups, the coefficients of poor, middle, rich, and richest families are interpreted with respect to the lowest income group which in our case was the poorest family. The coefficient of income quintile “poor” is recorded at -0.09274, which is statistically significant at 5%, revealing that, on average, immunization in poor families is 9.274% lower than that of the poorest family. In contrast, the coefficient of middle and rich families are recorded at 0.0729 and 0.2513 which suggests that on average middle and rich families' immunization behavior or their response to complete the immunization is 7.29% and 25.13% higher as compared to the poorest families respectively. The coefficient value for the richest families is recorded at 0.6989, showing that the respective group has the highest chance to complete the immunization. The results reveal that for the richest families the completion of immunization is around 69.89% higher than that of the poorest families.

The coefficient for the mother's profession is recorded as 0.0226 with a standard error of 0.0052, giving a Z-score value of 4.346 and having a probability value of z-score less than 5%. The results suggest that those mothers who are professionals or doing the job on average have a 2.26% higher chance to complete the immunization of their children. The coefficient for antenatal care visits after birth suggests that with every one extra visit to the doctor after birth, the immunization on average increases by 20.64%. The results are statistically significant at 1%.

The incidence of immunization services can be described by its concentration curve that plots the cumulative percentage of the immunization on the y-axis against the cumulative percentage of the population ranked by income quintiles. The 45-degree line of equality represents perfect equality in the distribution of utilization benefits. If the curve coincides with the line of equality, the immunization is equally distributed across income quintiles. In contrast, if the concentration curve lies above the equality line, then immunization is more concentrated and is said to dominate the equality line and the distribution can be said pro-poor. On the other hand, if the curve lies below the equality line then it reveals the immunization services are pro-rich. The blow figure provides a summary overview of the immunization concentration curve for Pakistan.

Figure 1

The Utilization of Incidence of Immunization Services in Pakistan



From the Figure, we can see that the immunization curve line goes almost straight with the equality line. The graph reveals that throughout Pakistan immunization behavior or immunization acceptance does not vary so highly. It is evident because the immunization vaccine across the country is available for free and the public program through EPI promotes and reaches every household in the country to confirm that either the children

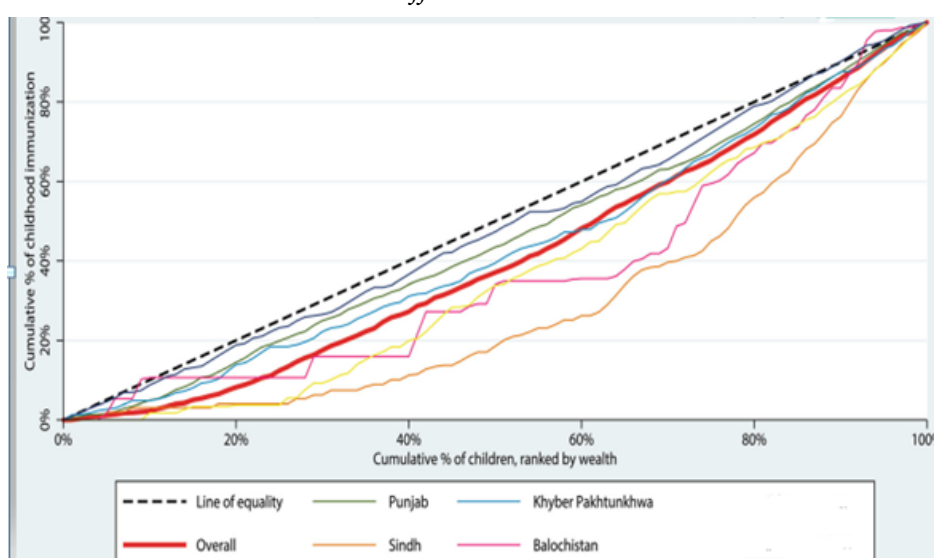
have missed their vaccine or not. The concentration curve for immunization services for 2019-2020 is quite close to the 45-degree line indicating the somewhat proportionate distribution of utilization benefits. The services reveal the pro-rich behavior with the shares of the poorest to richest.

From the concentration curve, we found that there is too small variation in receiving immunization across Pakistan, but our key objective of the study is to explore the variation in immunization across different income groups in different provinces of the country. A Lorenz Curve is a graphical representation of the distribution of wealth or income within a population where the graph's percentiles of the population against the income of people or below that percentile. For the current study, we followed five steps as discussed by Jann (2016) listed below.

The below curve represents the Lorenz Curve representation of Immunization across different provinces in Pakistan.

Figure 2

Immunization Variation Across Different Provinces in Pakistan 2019-2020



From the above Lorenz Curve, we can see that the overall variation in immunization across different income groups in Pakistan is quite closer to the equality line. There can be seen a very high distance between the equality line and Sindh's immunization curve, showing that there is higher inequality of immunization as compared to other provinces. Balochistan stands second with higher inequality in immunization across different income groups. There can be seen very low inequality for KPK and Punjab as both these provinces have lower inequality than the overall one. Hence, we can conclude that immunization across different income quintile groups in Pakistan has higher equality in KPK and Punjab while the inequality is much higher in Sindh followed by Balochistan.

Conclusion and Policy Implications

There has been found significant variation in the immunization behavior with respect to different income quintile groups. The Gini coefficient as of 2018 estimates for the country was recorded at 31.6, which makes the country medium in terms of Gini disparity. The human development index in 2019 for the country recorded 0.557, which makes the country medium developed and stands at 154th position in the world. This indicates that the majority of the population in the country lives in the middle and below the poverty line. The government initiative to support poor people in the form of the Benazir Income Support Program, Ahsas Rashion Program, and other aid programs certainly up their level of living but in meantime, these programs make household consumption dependent on families. Therefore, it is recommended for the public sector to

redesign and redistribute the public support with a new form like supporting small businesses or productive means.

This investigation endorses a significant positive role of a mother's education in the completion of immunization. The women's literacy rate in Pakistan is far below the average of South Asian Economies. Therefore, it is important to encourage and promote female education in rural areas of Sind, Balochistan, and KPK.

Another important finding of the study was the negative relationship between distance from the immunization center and immunization behavior. The study found that on average every one-kilometer increase in the distance will reduce immunization by 7.6%. Therefore, it is recommended for the public and private sectors to increase the number of immunization centers across Pakistan.

References

- Adnan, M., Sattar, T., Kafait, A., & Faiz, M. I. (2022). Socio-medical and demographic hindering blockades in implementation of expanded program on immunization among mothers working in brick kilns: A study of District Vehari, Pakistan. *Review of Applied Management and Social Sciences*, 5(1), 31–42.
- Ali, A., Zar, A., & Wadood, A. (2022). Factors associated with incomplete child immunization in Pakistan: Findings from Demographic and Health Survey 2017–18. *Public Health*, 204, 43–48. <https://doi.org/10.1016/j.puhe.2022.01.003>
- Anderson, E. L. (2014). Recommended solutions to the barriers to immunization in children and adults. *Missouri Medicine*, 111(4), 344–348.
- Asif, A. M., Akbar, M., Tahir, M. R., & Arshad, I. A. (2019). Role of maternal education and vaccination coverage: Evidence from Pakistan Demographic and Health Survey. *Asia Pacific Journal of Public Health*, 31(8), 679–688. <https://doi.org/10.1177/1010539519889765>
- Ateeq, S., Basheer, F., & Javaid, M. S. (2022). Knowledge, attitude and practice towards primary immunization in Pakistani parents: A hospital-based study. *Pakistan Armed Forces Medical Journal*, 72(Suppl. 2), S316–S319.
- Batthey, H. S., Cox, D. R., & Jackson, M. V. (2019). On the linear in probability model for binary data. *Royal Society Open Science*, 6(5), Article 190067. <https://doi.org/10.1098/rsos.190067>
- Bradley, D. R., & Cutcomb, S. (1977). Monte Carlo simulations and the chi-square test of independence. *Behavior Research Methods & Instrumentation*, 9(2), 193–201.
- Breen, R., Karlson, K. B., & Holm, A. (2018). Interpreting and understanding logits, probits, and other nonlinear probability models. *Annual Review of Sociology*, 44, 39–54. <https://doi.org/10.1146/annurev-soc-073117-041429>
- Butt, M., Mohammed, R., Butt, E., Butt, S., & Xiang, J. (2020). Why have immunization efforts in Pakistan failed to achieve global standards of vaccination uptake and infectious disease control? *Risk Management and Healthcare Policy*, 13, 111–124. <https://doi.org/10.2147/RMHP.S211170>
- Caudill, S. B. (1988). An advantage of the linear probability model over probit or logit. *Oxford Bulletin of Economics and Statistics*, 50(4), 425–427. <https://doi.org/10.1111/j.1468-0084.1988.mp50004005.x>
- Chotikapanich, D. (1993). A comparison of alternative functional forms for the Lorenz curve. *Economics Letters*, 41(2), 129–138. [https://doi.org/10.1016/0165-1765\(93\)90186-G](https://doi.org/10.1016/0165-1765(93)90186-G)
- Datar, A., Mukherji, A., & Sood, N. (2007). Health infrastructure and immunization coverage in rural India. *Indian Journal of Medical Research*, 125(1), 31–42. https://doi.org/10.25259/IJMR_20071251_031
- Datta, G., & Meerman, J. (1980). Household income or household income per capita in welfare comparisons. *Review of Income and Wealth*, 26(4), 401–418. <https://doi.org/10.1111/j.1475-4991.1980.tb00175.x>
- Delle Site, P., Kilani, K., Gatta, V., Marcucci, E., & de Palma, A. (2019). Estimation of consistent logit and probit models using best, worst and best–worst choices. *Transportation Research Part B: Methodological*, 128, 87–106. <https://doi.org/10.1016/j.trb.2019.07.014>
- Ellis, N. C., & Ferreira-Junior, F. (2009). Construction learning as a function of frequency, frequency distribution, and function. *The Modern Language Journal*, 93(3), 370–385. <https://doi.org/10.1111/j.1540-4781.2009.00896.x>
- Ghasedi, M., Sarfjoo, M., & Bargegol, I. (2021). Prediction and analysis of the severity and number of suburban accidents using logit model, factor analysis and machine learning: A case study in a developing country. *SN Applied Sciences*, 3, Article 13. <https://doi.org/10.1007/s42452-020-04081-3>
- Gust, D. A., Woodruff, R., Kennedy, A., Brown, C., Sheedy, K., & Hibbs, B. (2003). Parental perceptions surrounding risks and benefits of immunization. *Seminars in Pediatric Infectious Diseases*, 14(3), 207–212.
- Hadi, Q. U. A., Oelrichs, R., Kashif, A., Yunus, H., Lara Oliveros, C. A., & Beith, A. (2022). Immunization financing assessment: Pakistan.

- Heiberger, R. M., & Neuwirth, E. (2009). One-way ANOVA. In *R through Excel* (pp. 165–191). Springer.
- Hossain, I., Masood, T., Sultan, A., Sardar, R., Setayesh, H., Shimp, L., & Yonus, S. (2021). Rethinking strategies to address inequity in immunization services towards achieving universal immunization coverage (UIC) in Karachi, Pakistan. *World*, 11, 39–49.
- Jamison, A. F., McCormick, B. J. J., Hussain, E., Thomas, E. D., Azam, S. I., Hansen, C. L., & Rasmussen, Z. A. (2022). Determinants of vaccine coverage and timeliness in a northern Pakistani village. *PLOS ONE*, 17(2), Article e0263712. <https://doi.org/10.1371/journal.pone.0263712>
- Jann, B. (2016). Estimating Lorenz and concentration curves. *The Stata Journal*, 16(4), 837–866. <https://doi.org/10.1177/1536867X1601600403>
- Kalkowska, D. A., Badizadegan, K., & Thompson, K. M. (2022). Modeling scenarios for ending poliovirus transmission in Pakistan and Afghanistan. *Risk Analysis*, 43(4), 660–676. <https://doi.org/10.1111/risa.13983>
- Kang, J. H., & Kim, C. W. (2018). Relationship between catastrophic health expenditures and income quintile decline. *Osong Public Health and Research Perspectives*, 9(2), 73–80. <https://doi.org/10.24171/j.phrp.2018.9.2.06>
- Lemoine, M., Nayagam, S., & Thursz, M. (2013). Viral hepatitis in resource-limited countries and access to antiviral therapies: Current and future challenges. *Future Virology*, 8(4), 371–380. <https://doi.org/10.2217/fvl.13.11>
- Muhammad, S. Z., Shaikh, N., Asad, D., & Fatima, N. (2022). Challenges to mass immunization against COVID-19 in Pakistan: A lower-middle income vaccine-hesitant country. *Journal of Global Health*, 12.
- Orr, N., Elliott, M. N., Burkhart, Q., Haviland, A., & Weinick, R. M. (2013). Racial/ethnic differences in Medicare experiences and immunization: The role of disease burden. *Medical Care*, 51(9), 823–831. <https://doi.org/10.1097/MLR.0b013e31829c8d77>
- Pichora, E., Polsky, J. Y., Catley, C., Perumal, N., Jin, J., & Allin, S. (2018). Comparing individual and area-based income measures: Impact on analysis of inequality in smoking, obesity, and diabetes rates in Canadians 2003–2013. *Canadian Journal of Public Health*, 109(3), 410–418.
- Raja, T. M. (2022). Current trends in Extended Immunization Program in Pakistan. *Rawal Medical Journal*, 47(2), 248.
- Restrepo-Méndez, M. C., Barros, A. J., Wong, K. L., Johnson, H. L., Pariyo, G., França, G. V., Wehrmeister, F. C., & Victora, C. G. (2016). Inequalities in full immunization coverage: Trends in low- and middle-income countries. *Bulletin of the World Health Organization*, 94(11), 794–805. <https://doi.org/10.2471/BLT.15.162172>
- Ross, A., & Willson, V. L. (2017). One-way ANOVA. In *Basic and advanced statistical tests* (pp. 21–24). SensePublishers.
- Shui, I., Kennedy, A., Wooten, K., Schwartz, B., & Gust, D. (2005). Factors influencing African-American mothers' concerns about immunization safety: A summary of focus group findings. *Journal of the National Medical Association*, 97(5), 657–666.
- Unshur, A., Kikuvu, G., & Karama, M. (2016). Determinants of vaccination coverage among pastoralists in northeastern Kenya. *East African Medical Journal*, 93(8), 333–334.
- Varma, G. R., & Kusuma, Y. S. (2008). Immunization coverage in tribal and rural areas of Visakhapatnam district of Andhra Pradesh, India. *Journal of Public Health*, 16(6), 389–397. <https://doi.org/10.1007/s10389-008-0186-9>
- Voorman, A., Hoff, N. A., Doshi, R. H., Alfonso, V., Mukadi, P., Muyembe-Tamfum, J. J., & Rimoin, A. W. (2017). Polio immunity and the impact of mass immunization campaigns in the Democratic Republic of the Congo. *Vaccine*, 35(42), 5693–5699. <https://doi.org/10.1016/j.vaccine.2017.08.063>
- Wunder, T. A. (2012). Income distribution and consumption-driven growth: How consumption behaviors of the top two income quintiles help to explain the economy. *Journal of Economic Issues*, 46(1), 173–192.