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Examining factors associated with BCG and Poliomyelitis vaccination coverage in Tanzanian and Kenyan children aged 12 to 23 months using DHS surveys

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SIT Study Abroad

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Statistical analysis of variables from the Demographic and Health Survey and estimation of the way they affect the vaccination coverage in Tanzania and Kenya

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Keywords: *Public Health, Vaccination, BCG, Poliomyelitis & Demographic and Health Survey*

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Abstract

The rapid spread of infectious diseases in eastern Africa has made vaccination a major health factor in the region. This study aims to evaluate the factors affecting vaccination coverage with the BCG and Poliomyelitis vaccines in Tanzanian and Kenyan children aged 12 to 23 months. In May 2021, we collected data from the Demographic and Health Surveys (DHS) from 2014-2016 for Kenya and Tanzania and evaluated how different variables such as the sex of the child, maternal age, maternal educational level, availability of health facilities, access to electricity in the household, and birth order affect the vaccination coverage. We used Pearson's chi-squared tests with Yates' continuity correction and Welch Two Sample t-tests to analyze the dependence of vaccination coverage on different variables. We found out that the sex of the child, access to electricity, and birth order do not affect the BCG and Poliomyelitis vaccination coverage, but variables such as the child receiving at least one of the vaccines, maternal age, maternal education, and availability of health facilities significantly affect the BCG and Poliomyelitis vaccination coverage in Tanzania and Kenya.

Keywords: Public Health, Vaccination, BCG, Poliomyelitis & Demographic and Health Survey

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List of Abbreviations

BCG Bacillus Calmette-Guerin. 1

DHS Demographic and Health Survey. 5–7

polio Poliomyelitis. 1, 6

TB Tuberculosis. 1, 6

WHO World Health Organization. 1, 6

1 Introduction

According to the World Health Organization (WHO), a total of 1.4 million people died from Tuberculosis (TB) in 2019, which makes TB one of the top 10 causes of death and the leading cause from a single infectious agent. [1] Tuberculosis is caused by the bacteria *Mycobacterium tuberculosis* and most often affects the lungs. A person with active TB can infect from 5 to 15 people through close contact in one year and without proper treatment 45% of the infected people die.

WHO estimated that the second largest number of new TB cases occurred in the WHO African region, with 25% of the new cases in 2019 recorded there. However, in 1913 the Bacillus Calmette-Guerin (BCG) vaccine was developed, which proved to be up to 80% effective in preventing TB [2] and is currently used all around the world to protect children and adults from the deadly virus.

In 1988, the World Health Assembly adopted a resolution for the eradication of another dangerous virus – Poliomyelitis (polio). Polio is a highly infectious virus that mainly affects children up to the age of 5 and can cause permanent paralysis, usually of the legs. Paralysis can occur even within a few hours of infection and of those paralysed, 5-10% die when their breathing muscles stop. [3]

Two of the three wild polio viruses are now eradicated, and we are currently fighting to eradicate the last one as well. This is possible due to the polio vaccine developed in the early 1950s by the American physician Jonas Salk. Three doses of the polio vaccine provide 99% to 100% protection [4] from the virus, stopping the global spread of Poliomyelitis.

Vaccines have been proven to be cost-effective means of disease prevention. Children who receive vaccines are 80% less likely to contract TB [2], and up to 100% safe from contracting Poliomyelitis [4]. Thus, vaccination in children will drastically reduce the infant deaths caused by these diseases and save millions of lives. However, the impact of vaccination is highly dependent on vaccine coverage and timing of vaccination as immunisation programmes can be successful only if children are protected prior to exposure.

Tuberculosis and poliomyelitis are major global health problems with the African region carrying a disproportionately high share of the global burden of cases and mortalities. Thus, this project seeks to examine the factors that are associated with the timely vaccination in Tanzania and Kenya with specific interest to the BCG and polio vaccines. More importantly, it will examine the demographic factors such as sex of the child, administration of at least one other vaccine, mother's age, mother's education, availability of health facilities, electricity in the household, and birth order that might affect the vaccination coverage in both countries and further compare the current situation in Tanzania and Kenya specifically for each factor.

This study tested whether the aforementioned factors affect the BCG and polio vaccination rates in Tanzania and Kenya and the study is aiming to answer which factors are statistically significant in the examination of the BCG and Poliomyelitis vaccination coverage in Tanzanian and Kenyan children aged 12 to 23 months.

1.1 Objectives & Hypothesis

1.1.1 General Objective

To examine factors associated with BCG and Poliomyelitis vaccination coverage in Kenya and Tanzania in children aged 12 to 23 months.

1.1.2 Specific Objectives

1. To compare Tanzania and Kenya in their vaccination coverage of the BCG and Poliomyelitis vaccines.

2. To determine demographic factors influencing BCG and Poliomyelitis vaccination coverage in Kenyan and Tanzanian children aged 12 to 23 months.

1.1.3 Hypothesis

The hypothesis of this study is that that factors such as maternal age and education, child receiving at least one vaccine, and availability of health facilities, would prove to significantly affect the vaccination coverage with the BCG and polio vaccines. We also hypothesize that the sex of the child and the access to electricity in the household would be of no statistical significance.

1.2 Literature Review

Vaccines have been proven to be effective in preventing many serious diseases. However, researchers and policy-makers need to know how effective the vaccines are in order to create policies that would protect the most lives possible. Therefore, extensive research has been conducted to estimate the effectiveness of BCG and polio vaccines. According to a study conducted by Michelsen et al. [6], BCG vaccines are more than 50% effective in preventing Tuberculosis in children in Greenland. This provides a strong incentive for policy-makes to vaccinate as many children as possible. Another study by Garly et al. [7] showed that children in Western Africa with a BCG vaccination had significantly lower mortality rates compared to non-vaccinated children. This was mortality induced by other factors than TB, so this study shows that BCG vaccination might protect children from other infectious diseases and build a stronger immune system overall. However, even though vaccinations prove to be a cost-effective method for fighting disease spread, according to Tesema et al. [8], vaccination coverage in Eastern Africa still remains a major public health obstacle and the complete basic vaccination coverage there does not reach the goals set by WHO and UNICEF.

Thus, researchers started analyzing the factors that might prevent parents from vaccinating their children. Peter Ntenda conducted a major study in Malawi [9], estimating the factors that prevent children there from getting the pentavalent and the rotavirus vaccines. He concluded that factors such as the mother's and father's age and education, the birth order of the child, the region of the country where the family lived, and the access to health facilities were all significant factors affecting the vaccination coverage.

Another study conducted by Porth, et al. [10] concluded that maternal migration significantly affected the full and up-to-date child vaccination in Kenya. According to the researchers, both the migration status and stream (e.g. rural-urban) proved to significantly affect the vaccination coverage.

Additionally, a study by Agocs et al. [11] used data collected by Red Cross volunteers, who visited more than 60, 000 families in Western Kenya in the span of a week in order to find why children were under vaccinated. After statistical analysis was performed, the researchers found out that caregiver hesitancy, not knowing vaccination due date, and vaccine stock-outs were the most common reasons for incomplete vaccinations in children. Further, they suggested a 5-point plan developed by the American Red Cross to engage caregivers in vaccination procedures and achieve higher vaccination coverage rates in Western Kenya.

Based on all these studies, we concluded that evaluation of the factors preventing children from getting vaccinated is essential. However, no study that evaluated the reasons why Tanzanian and Kenyan children might not receive the BCG and polio vaccines on time was present. Therefore, this study focused on examining the factors associated with BCG and Poliomyelitis vaccination coverage in Tanzanian and Kenyan children aged 12 to 23 months.

2 Methodology

2.1 Study Area Description and Data Source

This research focused on Tanzania and Kenya. Since the intention of this study was to examine in close detail the vaccination coverage in both countries, it was inevitable for the researcher to familiarize himself with the culture and health practices of the two countries. Thus, a researcher spent one month in each country observing the culture, traditions, and livelihood of the locals during the *SIT Tanzania: Ecology, Wildlife, and Natural Resource*

Management, Spring 2021 program. Such period provided the researcher with broader understanding of the problems the two countries face and the factors that might affect the public health situation. This study, therefore, did not focus on a specific region, but rather examined the situation in the two countries.

Both countries are located in eastern Africa between latitudes 5° 40' north and 11° 82' south and between longitudes 29° 75' and 41° 45' east. The climate is tropical and mainly dictated by the monsoon winds. There are two distinct monsoon seasons; northeast monsoon (December to March) during which the temperatures range from 22 - 34° C and southeast monsoon (May to October) with temperatures in the range 19 - 29° C. The population of Tanzania is slightly larger than Kenya's and amounts to 58.01 million people as compared to 52.57 million in Kenya.

The study used publicly available data obtained from the 2014-2016 Demographic and Health Survey (DHS) for Kenya and Tanzania. The DHS surveys are structured to provide information to monitor and evaluate population and health status in the respective countries. The data for the Tanzanian survey was collected by the National Bureau of Statistics in mainlnd Tanzania and the Office of the Chief Government Statistician in Zanzibar. For the analysis, the study utilizes the short household questionnaires for which 13,634 women were identified as eligible, of whom 13,226 were interviewed, yielding a response rate of 97 percent.

The data for the Kenyan survey was collected by the Kenya National Bureau of Statistics. Again, for the purpose of this study, the short household questionnaires were used for which 16,855 women were identified as eligible, of whom 16,338 were interviewed, yielding a response rate of 97 percent.

The data collection mode was face-to-face in both countries and the questionnaires used are available on the DHS website [5]. The data collection was carried out by 16 field teams in Tanzania: three teams in Zanzibar and 13 teams in mainland Tanzania. Similarly, in Kenya the staff was divided in 48 teams covering each county in the country. The Tanzanian DHS survey was conducted from August 22, 2015, through February 14, 2016, and the

Kenyan one from May 7 to October 20, 2014.

2.2 Study Variables

For the analysis, the study focuses on children between the age of 12 and 23 months. This is due to the fact that WHO recommends that all children are vaccinated for TB and polio by the 24^{th} month of birth. The short DHS household surveys provide us with an extensive list of 1094 variables for each country, but this study focuses on how seven of them affect the vaccination coverage for the BCG and polio vaccines.

2.2.1 Dependent Variables

The dependent variables for this study are the number of vaccinated children with the BCG and polio vaccines in Tanzania and Kenya respectively. According to Tanzanian and Kenyan guidelines, children should receive one BCG vaccine at birth and 3 doses of the polio vaccines, with the third one occurring at the 14th month after birth, but no later than the 23th month. Thus, our dependent variables are first the number of children, aged 12 to 23 months, who received one BCG vaccine, and second the number of children, aged 12 to 23 months, who received the third polio vaccine in Tanzania and Kenya.

2.2.2 Independent Variables

This study examines seven independent variables, which might affect the vaccination coverage with the BCG and polio vaccines. It focuses on how receiving the BCG vaccine affects the polio vaccine coverage, and vice versa, the sex of the child (male/female), the age of the mother (below 28/above 28), education of the mother (no education/primary education/secondary education/higher education), availability of health facilities (no problem / not a big problem / a big problem) , electricity availability (yes/no), and the birth order of the child (1 / 2-3 / 4-5 / 6>).

2.3 Statistical Analyses

First, the total number and the percentage of children who have health cards in Kenya an Tanzania and the percentage of children who have received a BCG and a polio vaccine is summarized. This gives a background to compare the health and vaccination situation in Tanzania and Kenya.

Then, rankings are assigned to the possession of health card variable with No card = -1, No longer has card = 0, Yes, but card not seen = 1, and Yes, card seen = 2. Similarly, we assign rankings to the vaccination coverage responses with No vaccination = -1, Don't know = 0, Yes, reported by mother = 1, and Yes, vaccination date on health card = 2.

These rankings allow us to conduct Welch Two Sample t-tests and see if there is a statistically significant difference between the means of the Tanzanian and the Kenyan results. Such difference would show which country is doing better with distribution of health cards and vaccination coverage.

Then, analysis of the different factors is performed. The results were summarized for each independent variable with pie charts and Pearson's Chi-squared tests with Yates' continuity correction was used to determine whether the dependence is statistically significant, or the independent variable has no effect on the vaccination rates. The data was normally distributed, which allowed us to use these statistical techniques, and all the statistical analyses were performed with *R Studio*.

2.4 Ethical Clearance

This study is exempt from ethical approval because it presents secondary analysis of publicly available data on the DHS website [5]. Additionally, the DHS staff obtained written and informed consent from all participants prior to their enrollment in the study.

3 Results

3.1 Tanzanian and Kenyan Vaccination Coverage

3.1.1 Health Card Possession

First, Table 1 presents the summary for the health card possession ranking. Only 76.21% of the Kenyan mothers could show the health card of their child when asked compared to 85.96% in Tanzania. An interesting observation is that 16.15% of the mothers in Kenya said that their child had a health card but they couldn't show it at the moment, compared to just 2.04% of the mothers in Tanzania. Also, about the same percentage of children didn't have health cards in Tanzania and Kenya – just about 2%.

Table 1: Health card possession in Tanzania and Kenya.

Health Card	Kenya Frequency	Kenya Percentage	Tanzania Frequency	Tanzania Percentage
Yes, seen	2525	76.21%	1518	85.96%
Yes, not seen	535	16.15%	36	2.04%
No longer has card	183	5.52%	172	9.74%
No card	70	2.11%	40	2.27%
Total	3313	100.00%	1766	100.00%

Further rankings are assigned to the answers, as discussed in section 2.3, and a Welch Two Sample t-test is conducted to see if there is a statistically significant difference between the means of the two rankings. The Tanzanian citizens ($M = 1.72$, $SD = 0.73$) compared to Kenyan citizens ($M = 1.67$, $SD = 0.68$) showed better results in the health card survey, $t(3379) = 2.49$, $p = 0.013$.

3.1.2 BCG Vaccination

The BCG vaccination data is summarized in a similar manner in Table 2. It shows that 83.52% of the children in Tanzania have received the BCG vaccine and it is recorded on their health cards compared to just 73.95% of the children in Kenya. Again a large percentage (21.91%) of the mothers in Kenya reported that their child had the BCG vaccine but couldn't show it on the card, compared to just 12.63% in Tanzania. Both countries show low rates of missing BCG vaccination, 4.11% and 3.85% for Kenya and Tanzania respectively.

Table 2: BCG Vaccination coverage in Tanzania and Kenya.

BCG Vaccine	Kenya Frequency	Kenya Percentage	Tanzania Frequency	Tanzania Percentage
Yes, vaccination date on health card	2450	73.95%	1475	83.52%
Yes, reported by mother	726	21.91%	223	12.63%
Don't know	1	0.03%	0	0.00%
No	136	4.11%	68	3.85%
Total	3313	100.00%	1766	100.00%

Rankings are assigned again and Welch Two Sample t-test is uaed to conclude which country is doing better with BCG vaccination. According to the results of our ranking, Tanzania (M = 1.76, SD = 0.65) did better than Kenya (M = 1.66, SD = 0.68) in BCG vaccination efforts, $t(3769) = 5.17$, $p < 0.01$.

3.1.3 Poliomyelitis Vaccination

Similar analysis is conducted for the polio vaccination (Table 3). There are similar trends as with the BCG vaccine. A greater percentage of Tanzanian children (76.67%) had the vaccination recorded in their health cards compared to Kenyan children (70.54%). However, a distinctive difference from previous results is that 17.81% of Kenyan children and 15.40%

of Tanzanian children didn't receive their third dose of the polio vaccine, compared to just 4.11% Kenyan children and 3.85% Tanzanian children not receiving the BCG vaccine.

Table 3: Polio Vaccination coverage in Tanzania and Kenya.

Polio Vaccine	Kenya Frequency	Kenya Percentage	Tanzania Frequency	Tanzania Percentage
Yes, vaccination date on health card	2337	70.54%	1354	76.67%
Yes, reported by mother	386	11.65%	119	6.74%
Don't know	0	0.00%	0	0.00%
No	590	17.81%	272	15.40%
Total	3313	100.00%	1766	100.00%

Once again, rankings were assigned to the survey answers and a Welch Two Sample t-test was conducted. Tanzania (M = 1.46, SD = 1.09) did better than Kenya (M=1.35, SD=1.14) in polio vaccination coverage, t(3699)= 3.60, $p < 0.01$. In this instance there are greater standard deviations in both groups because of the large percentage of children that didn't receive the third dose of the polio vaccine.

3.2 Factors Associated with Vaccination Coverage

Tests were performed to conclude whether seven factors had statistically significant effect on the number of vaccinated children in Tanzania in Kenya. We examined the effects of receiving one of the vaccines, sex of the child, age of the mother, education of the mother, availability of health facilities, availability of electricity, and birth order of the child. The results for each of those are presented in the seven subsection below.

3.2.1 Effects of Receiving One of the Vaccines

First, this study examines how receiving one of the vaccines affects the child's chances of receiving the other. In order to accomplish that, the data is summarized in two contingency tables – one for Tanzania (Table 4) and one for Kenya (Table 5). After contingency tables were used to run Pearson's chi-squared tests with Yates' continuity correction to determine the dependence of receiving one of the vaccines on the vaccination coverage with the other.

Table 4: Contingency table for vaccination with the BCG and polio vaccines in Tanzania.

	Vaccinated with Polio in Tz	Not accinated with Polio in Tz
Vaccinated with BCG in Tz	1482	216
Not Vaccinated with BCG in Tz	12	56

The results for Tanzania show that 1482 (83.92%) of the children received both vaccines by the age of 23 months and only 56 (3.17%) of the children had neither vaccine. A chi-square test of independence was performed to examine the relation between getting the BCG vaccine and getting the polio vaccine in Tanzania. The relation between these variables was significant, χ^2 (1, N = 1766) = 238.15, $p < 0.01$. Thus, getting one of the vaccines definitely affect the chances of the child getting the other vaccine as well.

Table 5: Contingency table for vaccination with the BCG and polio vaccines in Kenya.

	Vaccinated with Polio in KE	Not accinated with Polio in KE
Vaccinated with BCG in KE	2669	505
Not Vaccinated with BCG in KE	53	83

A similar analysis was concluded for Kenya. The results show that 2669 (80.63%) of the children received both vaccines and only 83(2.51%) received neither. After conducting a chi-square test of independence, χ^2 (1, N = 3310) = 178.65, $p < 0.01$, we found out that there was significant association between receiving the BCG and the polio vaccine.

Thus, both in Tanzania and in Kenya receiving one of the vaccines affects the child's chances of receiving the other vaccine.

3.2.2 Sex of the Child

Second, the study analyzed whether the sex of the child will affect the chance of getting the BCG and polio vaccines. In Figure 1 and Figure 2 the summarized data for both countries are presented. There was a greater percentage of girls in both countries – we observed 51.3% girls in Tanzania and 51.6% girls in Kenya.

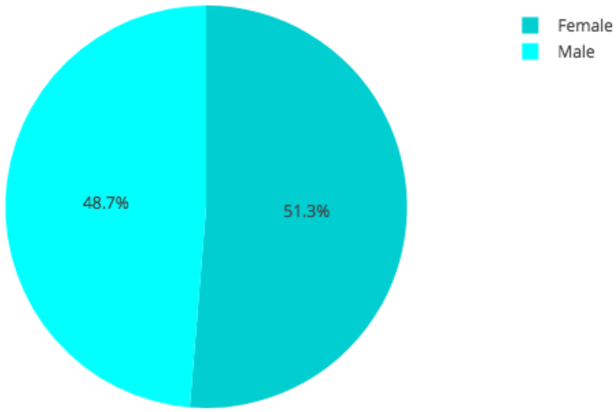

Figure 1: Summary of the sex of the sample of children in Tanzania

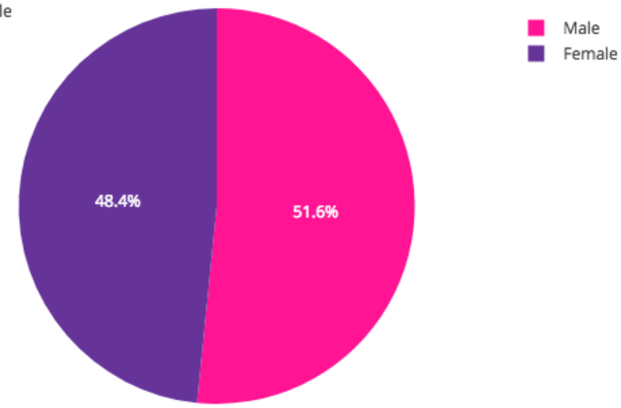

Figure 2: Summary of the sex of the sample of children in Kenya

In order to determine whether the sex had any influence on vaccination coverage in both countries, a chi-squared test was conducted. There is no significant association between the sex of the child and receiving the BCG vaccine in Tanzania, χ^2 (3, N = 1766) = 3.5605, p = 0.31. Similarly, there was no significant association between the sex and BCG vaccination in Kenya either, χ^2 (4, N = 3310) = 1.79, p = 0.77.

A chi-square test was conducted for the polio vaccine as well, and the results were similar. There was no significant relation between the polio vaccination and the sex of the child neither in Tanzania, χ^2 (3, N = 1776) = 4.05, p = 0.26, nor in Kenya, χ^2 (3, N = 3310) = 0.45, p = 0.93.

Thus, the sex of the child did not affect the receiving either vaccine in Tanzania and Kenya.

3.2.3 Age of the Mother

The maternal age in the study ranged from 16 to 49 years in Tanzania and 15 to 48 years in Kenya. The mean age of the mother was 28.41 and 27.88 in Tanzania and Kenya respectively, with the most mothers (6.23%) being 21 years old at the time of the study in Tanzania and most mothers (3.29%) being 28 years old at the time of the study in Kenya.

For more precise results from the chi-squared tests, the mothers were split in two groups – those with age below 28 and those with age above 28. The groups are summarized in the two pie charts below (Figures 3 & 4).

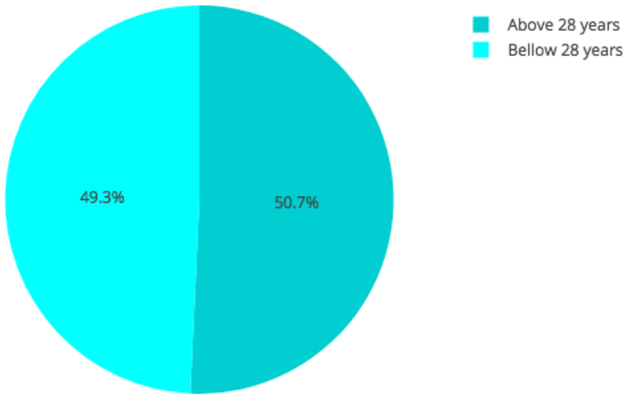

Figure 3: Summary of the mother's age in Tanzania

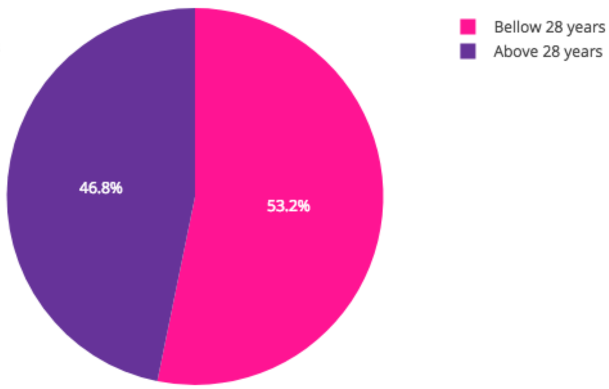

Figure 4: Summary of the mother's age in Kenya

First chi-squared tests were performed to determine whether there is a relation between the maternal age and the child receiving the BCG vaccine. The relation between these variables in Tanzania was not significant, χ^2 (1, N = 1766) = 0.061, p = 0.80. Similarly, in Kenya the relation was not significant as well, χ^2 (1, N = 3556) = 3.2, p = 0.07. Thus, we conclude that there is no association between receiving the BCG vaccine and the mother's age in either country.

Chi-squared tests were conducted for the polio vaccine as well. There was no significant relation between receiving the polio vaccine and the mother's age in Tanzania, χ^2 (3, N = 1766) = 0.74, p = 0.39. However, in Kenya there was a significant association between the polio vaccination rate and the mother's age, χ^2 (3, N = 3556) = 13.12, p < 0.01.

Thus, there is no significant relation between the BCG vaccination and the mother's age in Tanzania and Kenya, and there is no relation between the polio vaccination rate and the mother's age in Tanzania, but there is a significant dependence of polio vaccination on maternal age in Kenya.

3.2.4 Education of the Mother

Next, the study looked at how the education of the mother might affect the vaccination coverage with both vaccines in Tanzania and Kenya. We split the mothers in 4 categories – mothers with no education, primary education, secondary education, or higher education. The data is summarized in Figures 5 & 6.

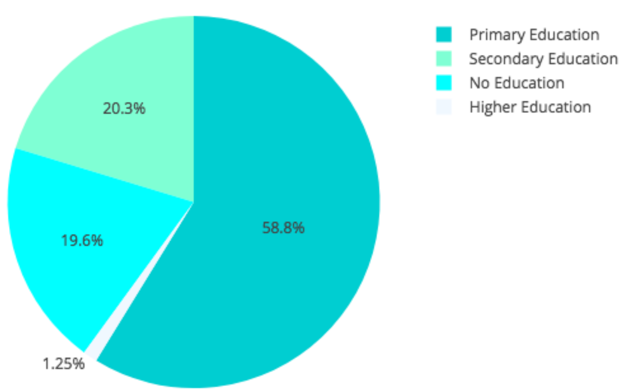

Figure 5: Mother's education in Tanzania

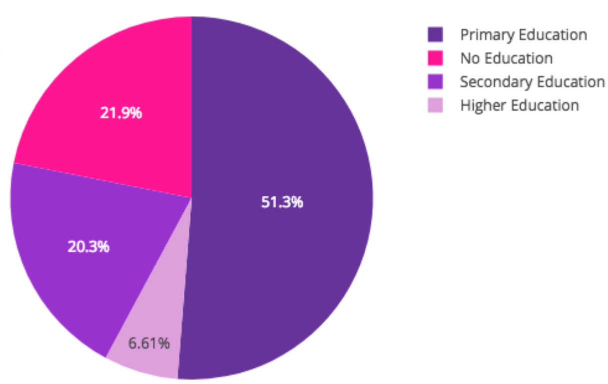

Figure 6: Mother's education in Kenya

For this factor there are also bar charts provided to better indicate the trends that occur with increasing levels of education of the mother.

Figure 7 shows how vaccination coverage changes with changing educational levels of the mother. On the x-axis there is the mother's education split in the four categories. For each category there is the percentage of children that had the BCG vaccination reported on their health card, the percentage that didn't have the BCG vaccination on the card but the mother reported the child had it, and the percentage of children that didn't have the BCG vaccine. We notice that with increasing level of the education of the mother the BCG

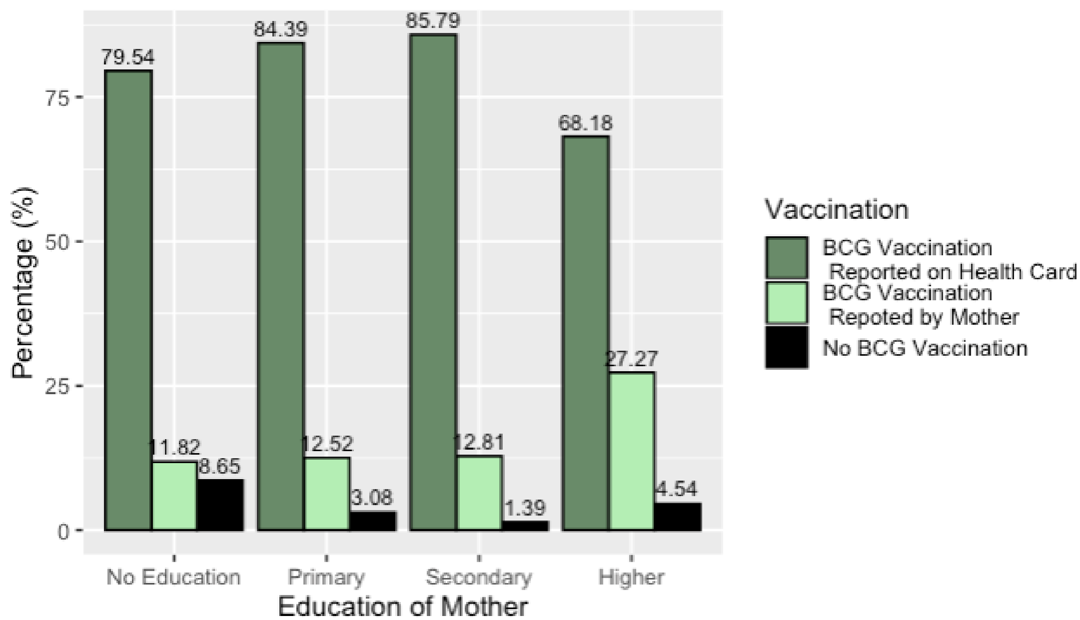

Figure 7: Mother's education vs. BCG vaccination in Tanzania

vaccination rate increases. The only exception is mothers with higher education who had a greater percentage of non-vaccinated children than even mothers with primary education.

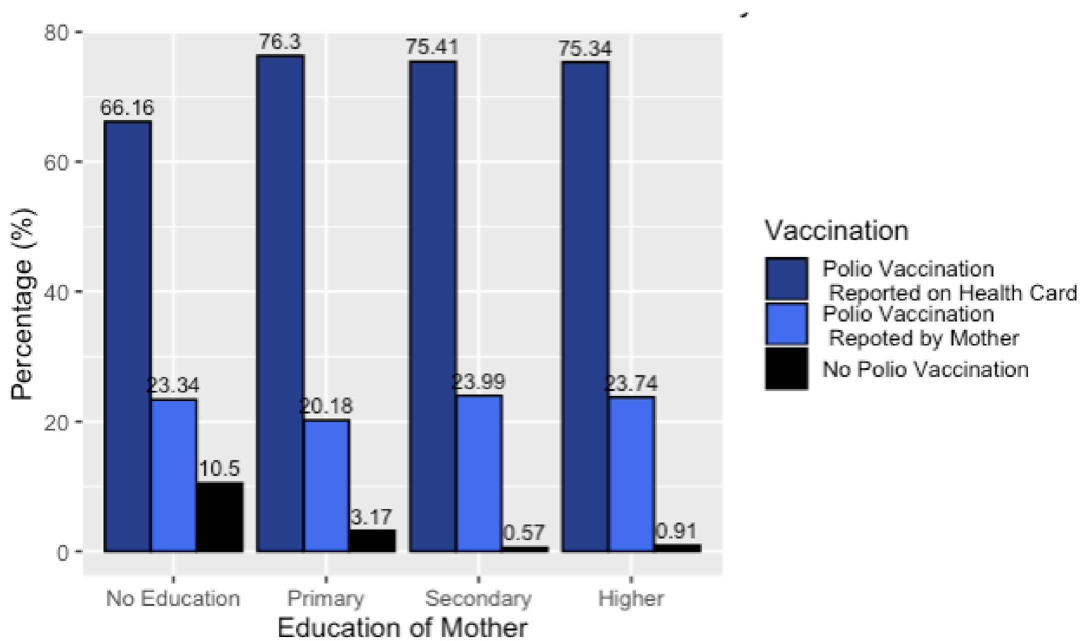

Figure 8: Mother's education vs. BCG vaccination in Kenya

Figure 8 presents the data for Kenya and is structured in a similar manner. We notice the same upward trend of vaccination with increasing level of education. Here, however, there is no large percentage of non-vaccinated children of highly educated mothers, as observed in Tanzania.

To evaluate whether the trend of increasing education causing increasing vaccination is significant, a chi-squared test was performed. The test showed significant relation between the educational level of the mother and the BCG vaccination rate in Tanzania, χ^2 (3, N = 1766) = 29.10, p < 0.01. The results for Kenya were similar – there was a significant association between the mother's education and the BCG vaccination coverage, χ^2 (3, N = 3556) = 108.40, p < 0.01. Thus, increased mother's education leads to increased BCG vaccination rate in both countries.

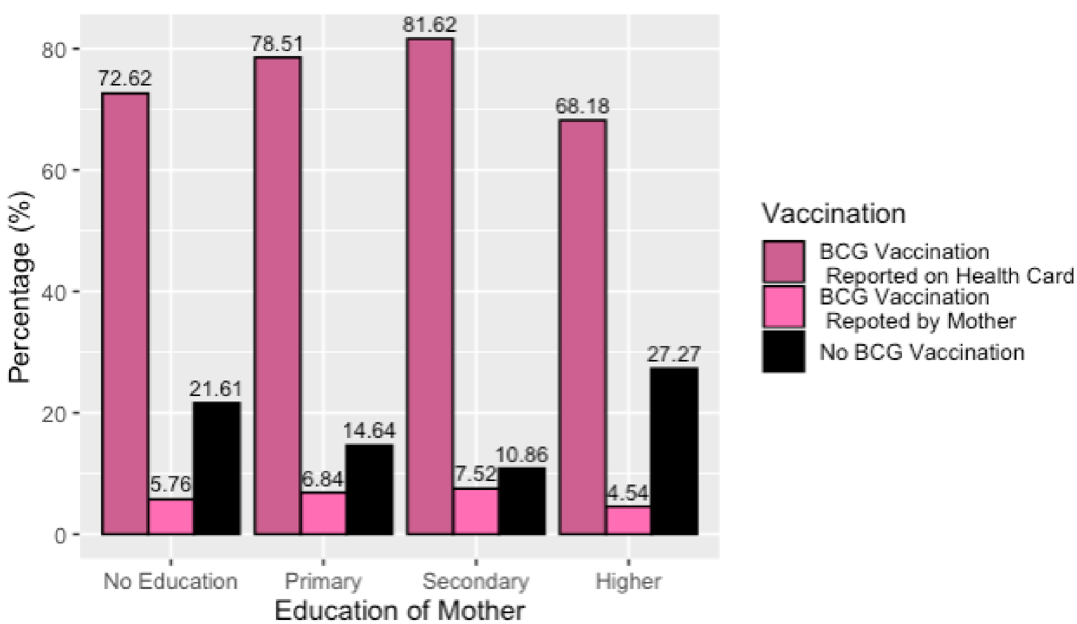

Figure 9: Mother's education vs. polio vaccination in Tanzania

We performed similar data summarizing and analysis for the polio vaccination in both countries.

Figure 9 shows the findings about mother's education effect on polio vaccination rates in Tanzania. There is a similar trend as the BCG vaccination in Tanzania – the vaccination rate increases with increasing educational level of the mother, but there is a high percentage of mothers with higher education who don't have their children vaccinated.

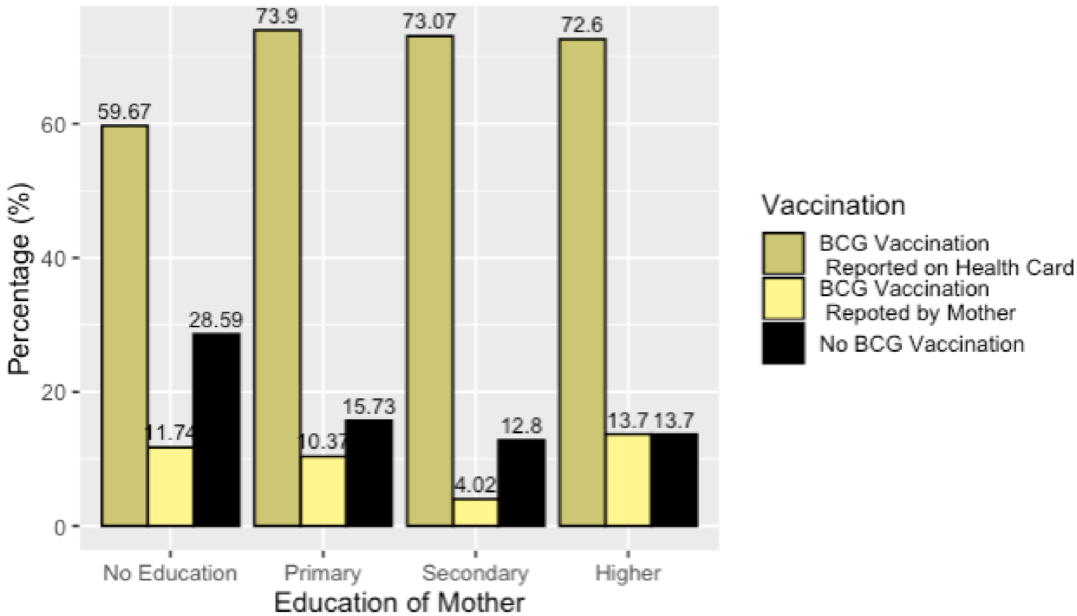

Figure 10: Mother's education vs. polio vaccination in Kenya

Also, Figure 10 contains the summarized results about polio vaccination and mother's education in Kenya. Similar to the trend in Figure 8, the polio vaccination rate increases with increasement of the mother's education and the percentage of children that didn't get the polio vaccine decreases as mothers get more educated.

Once again, chi-squared tests were ran to determine if the relationship observed was statistically significant. There indeed is a significant association between mother's education and polio vaccination coverage both in Tanzania, χ^2 (3, N = 1766) = 16.54, p < 0.01 and Kenya, χ^2 (3, N = 3556) = 76.54, p < 0.01.

Thus, as the maternal educational level in Tanzania and Kenya increases, the BCG and polio vaccination coverage increases as well.

3.2.5 Access to Health Facilities

The next factor this study concentrates on is access to health facilities. The interviewed people were separated in three groups – people with no problems accessing a health facility, people for who accessing a health facility is not a big problem, and people for who accessing a health facility is a big problem. We summarized the result for Tanzania and Kenya in Figure 11 and Figure 12 respectively. An interesting observation is that no citizen in either country said that they have no problem accessing health facilities. Also, a larger number of people reported that it is not a big problem for them to access health facilities compared to the number of people saying it is a big problem.

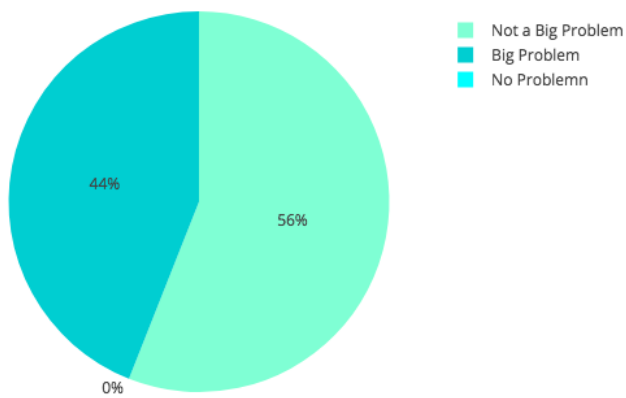

Figure 11: Health facilities access in Tanzania

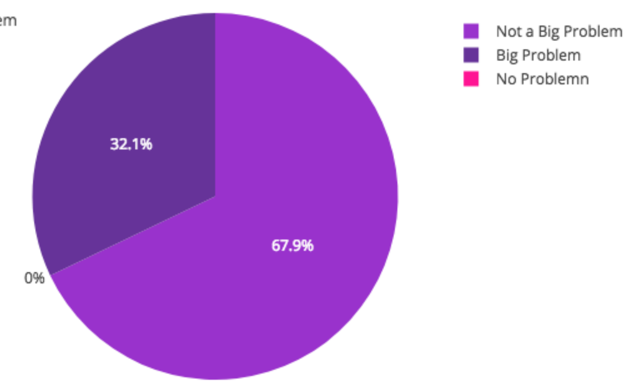

Figure 12: Health facilities access in Kenya

Chi-squared tests were used to test if the number of BCG vaccinated children depends on the access to health facilities. We concluded that there is a significant relation between access to health facilities and BCG vaccination in Tanzania, χ^2 (1, N = 1766) = 4.57, p = 0.03 and Kenya, χ^2 (1, N = 3556) = 4.53, p = 0.03.

Chi-squared tests were performed to see whether the polio vaccination depends on the access to health facilities as well. We got a significant association of access to health facilities to polio vaccination in Tanzania, χ^2 (1, N = 1766) = 18.10, p =< 0.01 but we got no statistical significance for Kenya, χ^2 (1, N = 3556) = 3.13, p = 0.08.

Thus,access to health facilities and BCG vaccination rates are related in both countries, but access to health facilities and polio vaccination rates are related just in Tanzania.

3.2.6 Availability of Electricity

This study also examined how the access to electricity in the household affected the vaccination rate with both vaccines in Tanzania and Kenya. People were split in two groups – those with permanent access to electricity and those who don't have access. The data for the BCG vaccine is summarized in Tables 6 & 7.

Table 6: Contingency table for vaccination with the BCG vaccine and availability of electricity in Tanzania.

	Electricity	No Electricity
Vaccinated with BCG in Tz	288	1351
Not Vaccinated with BCG in Tz	2	64

Most of the people in Tanzania have no permanent access to electricity (80.12 %). However, still most of the people are vaccinated with the BCG vaccine. The data for Kenya looks similar. A total of 80.78 % of the Kenyan citizens reported no permanent access to electricity. However, still most of the Kenyans reported that their children had the BCG vaccine.

Table 7: Contingency table for vaccination with the BCG vaccine and availability of electricity in Kenya.

	Electricity	No Electricity
Vaccinated with BCG in KE	613	2499
Not Vaccinated with BCG in KE	11	123

The data for the polio vaccine are summarized in a similar manner. Table 8 presents the number of polio vaccinated children that live in households that either have electricity or don't have access to electricity. We see a significant increase in the number of non-vaccinated children which is in accordance with the trend of less children getting the polio vaccine compared to the BCG vaccine.

Table 9 presents the data for Kenya as well. We observe a similar trend – less children

Table 8: Contingency table for vaccination with the polio vaccine and availability of electricity in Tanzania.

	Electricity	No Electricity
Vaccinated with polio in Tz	253	1195
Not Vaccinated with polio in Tz	37	220

get vaccinated with the polio vaccine and the majority of children live in households that don't have electricity, but they still receive the polio vaccine.

Table 9: Contingency table for vaccination with the polio vaccine and availability of electricity in Kenya.

	Electricity	No Electricity
Vaccinated with polio in Tz	518	2154
Not Vaccinated with polio in Tz	105	468

To determine whether these trends are statistically significant chi-squared tests were conducted. According to the tests, there is a significant relation between BCG vaccination and availability of electricity in the household in both Tanzania, χ^2 (1, N = 1766) = 8.50, p = 0.004, and Kenya, χ^2 (1, N = 3556) = 10.19, p = 0.001.

However, the chi-squared tests show a different picture for the dependance of polio vaccination on electricity in the household. There is no significant association between availability of electricity and polio vaccination coverage in either Tanzania χ^2 (1, N = 1766) = 1.25, p = 0.26, or Kenya χ^2 (1, N = 3556) = 0.28, p = 0.60.

Thus, availability of electricity significantly affects BCG vaccination coverage in both countries but it doesn't affect the polio vaccination in either country.

3.2.7 Birth Order

Last but not least, this study looked at birth order and how it might affect vaccination coverage. The children were split in 4 groups – the firstborns (birth order of 1), the ones with birth order of 2 and 3, birth order 4 and 5, and the ones with birth order of 6 or more. The data are summarized in two pie charts – one for Tanzania (Figure 13) and one for Kenya (Figure 14). We notice that in both countries most children had a birth order of 2 or 3, but there was still a significant number of families that had 6 or more children, namely 20.6 % of the families in Tanzania and 18.2 % of the families of Kenya.

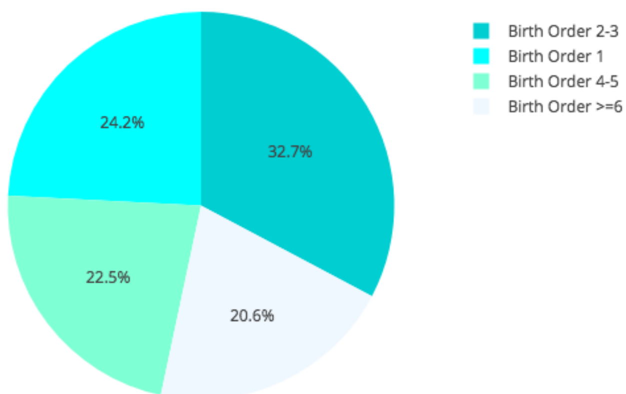

Figure 13: Distribution of birth order of children in Tanzania

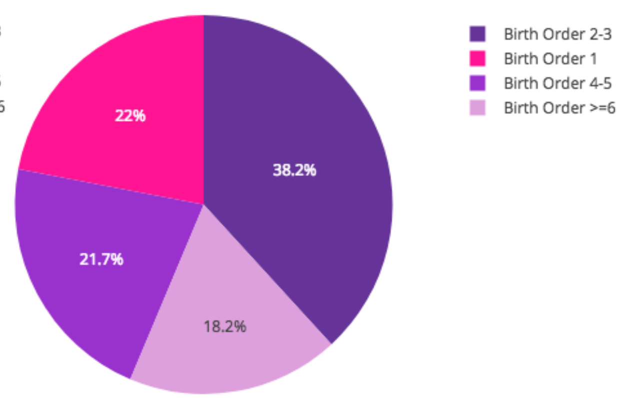

Figure 14: Distribution of birth order of children in Kenya

Pearson's chi-squared test was ran and showed that there was no significant relationship in Tanzania between the birth order and BCG vaccination coverage, χ^2 (3, N = 1766) = 6.29, p = 0.10 and polio vaccination coverage, χ^2 (3, N = 1766) = 7.13, p = 0.07. However, the results for Kenya were significant both for the BCG vaccine, χ^2 (3, N = 3556) = 24.37, $p < 0.01$, and the polio vaccine, χ^2 (3, N = 3556) = 33.92, $p < 0.01$

4 Discussion

4.1 Tanzanian and Kenyan Vaccination Coverage

After analyzing the data for the Tanzanian and Kenyan BCG and polio vaccination coverage, we can see that there are many similarities but also striking differences between the two countries. We initially suspected that Kenya would be doing better with the vaccination coverage, as the country is praised as one of the best countries in the whole continent of Africa in terms of public health practices, but it turned out that Tanzania's results were much better.

First, we notice that in both countries a higher percentage of the population is vaccinated with the BCG vaccination compared to the polio vaccine. We had just 4.11% of the children who didn't receive the BCG vaccine in Kenya and 3.85% in Tanzania compared to 17.81% of the children not receiving the polio vaccine in Kenya and 15.40% in Tanzania. This striking increase of more than 10% could be due to several factors. First and foremost, the BCG vaccine is given to the babies just once – at birth. In contrast, we used data about the third and last polio vaccine needed, which completes the child's vaccination and is given at 14 months of age according to the Tanzanian and Kenyan immunization programmes.

Thus, in the period of 14 months many things could occur that would prevent the child of getting the 3rd final shot of the vaccine. The parents could have no access to health facilities where the child can receive the vaccine (subsection 3.2.5). Also, it might be the fact that some parents do not care and do not believe in the vaccination of their child, so they do not initiate steps for the child to get the final dose. The child might also be the 5th or 6th in the family (section 3.2.7) and thus the parents might not think about the vaccination of their later children.

Similar results were obtained by Mirembe et al. in a polio vaccination study in Uganda [13]. They concluded that many factors affect the polio vaccination coverage such as distance to the immunization point, caregiver's education level, and encouragement by health workers. Many of these factors don't play a role in BCG vaccination, so a gap is created between the percentage coverage with the two vaccines.

Therefore, we can say that the vaccination coverage for the BCG vaccine is better compared to the polio vaccine in both Tanzania and Kenya due to a multitude of factors.

Now, we focus our discussion to a comparison between the two countries. It turned out that Tanzania had a greater percentage of vaccinated children with both the polio and the BCG vaccines. Tanzanian citizens also did better in the three rankings we assigned, namely the possession of health cards, the BCG vaccination coverage, and the polio vaccination coverage. This is contrary to what we expected because Tanzania is considered a less economically developed country compared to Kenya, and Tanzanians had harder access to health facilities than Kenyans. According to Canavan et al. [12], vaccination policies depend greatly on the location of the country we are studying and the type of vaccines. They concluded that less than 50% of Tanzanian children received the full vaccination course including the measles, pentavalent, rotavirus and other vaccines. Thus, even though we conclude that Tanzania is doing better with BCG and polio vaccines, we also need to consider the bigger picture with all the vaccines needed.

We think these results might be due to better implementation of the immunization calendar by government officials in Tanzania than Kenya. It might also be due to the mindset of the locals in each country. Tanzanian people might believe more in the effects of vaccinations, which is contrary to the current situation with the COVID-19 vaccines. Thus, people in Tanzania might trust long-existing vaccines which were proven in time to work. Kenya, as a more developed country, might suffer from believes currently present in some European countries and the US that vaccination might be dangerous for the children and that they might affect the health of the whole nation negatively.

No matter what the reason is, it is very interesting that the results we obtained were contrary to what we expected and examining why this happened would be a good topic for further research.

4.2 Factors Affecting the Vaccination Coverage

We tested the effect of seven factors on BCG and polio vaccination. We got some mixed results, and now, we will go through each factor separately in our discussion.

First, we examined the effect of getting one of the vaccines on receiving the other. The results definitely met our expectation and proved that receiving one of the vaccines affects the child's chances of receiving the other vaccine. This makes sense because parents that believe in the importance of the vaccines would try to provide their child with both the BCG and the polio vaccines, as they are both essential. Also, after receiving the BCG vaccine in the hospital after birth, parents might observe that it doesn't affect the child in any negative way and have enough trust to provide the child with a polio vaccine too. Similar results were obtained by Peter Ntenda in Malawi [9]. He found that children with at least one vaccine are more probable to be fully vaccinated.

Second, the sex of the child proved to be of no significance for either vaccine in Tanzania and Kenya. This matches our hypothesis again, as we believed parents and health workers wouldn't discriminate children based on their gender while providing them with vaccination. Although the gender norms are different in Eastern Africa compared to Europe and the US, it is good to see that children's health and safety are not affected because of stereotypes and cultural believes. This matches research that has been done on the same topic by Bbalee in Uganda [14]. They found out that sex is not a significant factor is getting vaccinated but many other factors might affect the vaccination coverage such as maternal education (especially at post-secondary level), exposure to media, maternal healthcare utilization, occupation type, and immunization plan.

Third, we examined how the age of the mother might affect the vaccination coverage. We found out that there was only one significant association in Kenya with the polio vaccination, and the other 3 cases proved to be of no significance. We would conclude that overall this is not a significant factor, as 3 of the 4 cases were not significant. This differs from what we initially hypothesized because we thought that older mothers would prefer to vaccinate their children. However, apparently living longer and gaining more life experience doesn't affect mother's believes about vaccination. This is also different from what Ntenda found in Malawi [9], so the effect of mother's age in different countries might need further research.

Fourth, we proved that increasing the educational level of the mother increases the chances of both BCG and polio vaccination in the child. This makes sense and matches our hypothesis, as more educated mothers will understand the dangers of diseases such as Tuberculosis and Poliomyelitis better and will try to protect their children. However, we noticed an interesting trend of decrease in vaccination coverage in children of mothers with higher education. This might be again due to doubts in government reliability and speculations in manipulation.

Fifth, access to health facilities and receiving the BCG and polio vaccines proved to be significantly related in 3 out of the 4 cases – vaccination with the BCG vaccine in both countries, and polio vaccination in Tanzania. Thus, overall we consider this factor significant. This matches our hypothesis as access to health facilities would be crucial for a child to receive a vaccine. Children of mothers that give birth not in a health facility might not receive the BCG vaccine as it is administered the day after birth. Thus, our hypothesis that the BCG vaccination and the access to health facilities were significantly related was not rejected. In terms of the polio vaccine, we looked at the third dose that is administered 14 months after birth by a health official, so the presence of a health facility nearby would be crucial again.

Sixth, access to electricity significantly affected only the BCG vaccination coverage and didn't affect the polio vaccination coverage. This is probably due to similar facts as in the previous factor – the BCG vaccine is administered after birth in hospitals. People without electricity probably have less finances and live in more rural areas, and thus, have no access to hospitals for giving birth, and therefore, the children don't receive the BCG vaccine.

Seventh, we examined how the birth order might affect the polio and BCG vaccination coverage. We found out that birth order proved to be significant in Kenya but not in Tanzania. This is contrary to our expectations – we hypothesized that birth order would be significant in both countries and children with greater birth order would be less vaccinated. We think the significance for Kenya comes from the more abundant data for that country – we had 1766 observations for Tanzania and 3556 observations for Kenya. The greater sample size allows for more precision and might affect the significance of the results. We also obtained very low p-values for Tanzania – namely 0.10 for the BCG vaccine and 0.07

for the polio vaccine which indicate almost significant results.

5 Conclusion and Recommendations

This study proved to be successful in evaluating the factors affecting the BCG and polio vaccination coverage in Tanzanian and Kenyan children aged 12 to 23 months. Several factors proved to play an important role in the vaccination campaigns, namely the child receiving at least one of the vaccines, the educational level of the mother, the access to health facilities, and the birth order for Kenya. Policy-makers can draw important insights from this study and improve the vaccination campaigns.

For instance, we will recommend that health officials try to provide at least the basic vaccines necessary for the child, as in this way parents might be persuaded to vaccinate their child with every vaccine necessary for a long and healthy life. Also, expanding the health network, and opening health facilities in more rural regions would be essential for expanding the vaccination efforts. Many times even though people want to vaccinate their children, they can't afford to go to the nearest health facility. Another factor that would increase the vaccination coverage is providing mothers with the necessary education so that they can make better informed decisions. Providing workshops would be essential, but also, increasing the level of school education mothers receive will greatly affect the vaccination coverage.

As for further research, I will recommend that people look at the factors that affect other vaccination campaigns such as the pentavalent and the rotavirus vaccines, which prove to be equally as important as the BCG and the polio vaccines. Also, the topic of factors affecting BCG and polio vaccination can be expanded, adding factors such as father's education and age, family amount of media exposure, family wealth index, maternal and fraternal employment status, and geographical region of residence. Further studies can also concentrate on the whole region of Eastern Africa and compare more countries, not just Tanzania and Kenya.

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