# Predictors of Completed Childhood Vaccination in Bolivia

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Abstract
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This research examines how access issues, ethnicity, and geographic region affect under 5 vaccination in Bolivia. Bolivia's rich variation in culture and geography may result in unequal healthcare utilization even for basic interventions such as childhood vaccination. This study utilizes secondary data from the 2008 Demographic and Health Survey for Bolivia to examine predictors of vaccination completion in children by two years of age. Using logistic regression methods, we control for health system variables (difficulty getting to a health center and type of health center as well as demographic and socio-economic covariates). The results indicated that children whose parents reported distance as a problem in obtaining health care were less likely to have completed all vaccinations. Ethnicity was not independently statistically significant, however in a sub-analysis, people from the Quechua ethnic group were more likely to report 'distance as a problem in obtaining healthcare.' Surprisingly, living in a rural environment has a protective effect on completed vaccinations. However, geographic region did predict significant differences in the probability that children would be fully vaccinated; children in the region with the lowest vaccination completion coverage were 80% less likely to have completed vaccination as children in the best performing region, which may indicate demonstrated unequal access and utilization of health services nationally. Further study on regional differences, urbanicity, and distance as a healthcare access problem will help refine implications for the Bolivian health system.

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## INTRODUCTION

Childhood vaccination is a widely accepted public health intervention that is cost effective at reducing child mortality and morbidity.[1] In 2005, the World Health Organization (WHO) and United Nations Children's Fund (UNICEF) developed the Global Immunization Vision and Strategy (GIVS) with the goal of reaching 90% completed vaccination coverage for key childhood vaccinations in all countries by 2010.[2] * The Bolivian Ministry of Health (MOH) adopted the GIVS 90% coverage target , but has not yet been able to achieve the goal . Economic, cultural, and geographic barriers have resulted in differences in healthcare access and utilization across Bolivia, and this study seeks to understand how these aspects predict differences in immunization completion.[3]

## BACKGROUND

The World Bank classifies Bolivia as a low middle-income country, with a per capita GDP of $2576 in 2012.[4] Bolivia is one of the poorest countries in Latin America, but has seen substantial economic growth in the past decade.[5] The majority of the population subsists on small-scale agriculture, mining, and petty trade.[6] Over 50% of the country lives below the national poverty line, and over 20% live in extreme poverty, characterized by insufficient income to buy the basic food

* The vaccinations that are part of the GIVS are the bacille Calmette-Guérin vaccine (BCG), a measles containing vaccine, three doses of diphtheria-tetanus-pertussis vaccine (DTP), and three doses of polio vaccine.

basket in Bolivia.[7] Poverty is most severe in rural areas, which are more likely to lack adequate technology, infrastructure, job opportunities, and access to education and health and sanitation services.[8]

Bolivia has a unique cultural makeup. It has the largest indigenous population in the Americas. In addition to Spanish, the principal cultural and ethnic groups are Quechua and Aimara, along with other smaller indigenous ethnic groups.[9] Indigenous communities are more vulnerable to extreme poverty and food scarcity.[10]

Bolivia is divided into nine sub-administrative territories called departments. Departments have some degree of autonomous power administered by the Departmental Assembly and Governor, and each department is represented in the central government through the bicameral legislature. Population and geography vary across departments. La Paz, the most populous department, has over 2 million inhabitants, while the least populous, Pando, has only 110,000.[11] The departments span very diverse terrains and enormous variation in climates and altitude.[12] The Andean region contains some of the highest points in the Americas and the Altiplano. The Sub-Andean regions have more valleys and are more agriculturally productive. The Llanos (plain) region contains flat lands and extensive rain forests. This regional variation leads to some administrative and developmental challenges due to isolation and limitations of resources.[13]

# LITERATURE REVIEW

## Vaccinations in Low and Middle Income Countries

Vaccination against childhood diseases is widely accepted as one of the most successful and cost effective interventions to reduce childhood morbidity and mortality globally.[14] The World Health Organization estimates that vaccinations prevent 2.5 million deaths annually.[15] Vaccination programs are very cost effective and have economies of scale in both developing and industrialized countries that make them highly sustainable interventions. [16] [17]

Globally, there is a general trend of increasing vaccination completion coverage. However many low and middle income countries are still short of the Global Immunization Vision and Strategy (GIVS) goal of 90% coverage, and there is substantial variation in completion coverage between and within countries.[18] In many low and middle- income countries, there has been a much larger increase in vaccine initiation compared to vaccination completion, so some children are only partially vaccinated.[19] Children who are only partially vaccinated do not have the optimum immune benefit of the vaccinations, so studies increasingly focus on predictors of completed vaccination including the third dose of diphtheria-tetanus-pertussis vaccine (DTP), and the third dose of polio vaccine.[20] [21]

Studies have found that familial level factors have a significant impact on vaccination completion.[22] [23] Urban residence frequently predicts completion, as does higher socioeconomic status, higher maternal age and education.[24]

Studies in other low and middle- income countries have demonstrated that specific aspects of the health system predict under vaccination, including geographic access problems and provider factors such as communication and workload, predict under vaccination. Distance to health centers and poor access is one of the most frequently cited reasons for under vaccination or non-vaccination in low and middle-income countries.[25] [26] [27] [28] Provider type, differentiated as public or private providers, was also a significant predictor in some countries. [29] The predictive effect of provider type was inconsistent across countries based on the public health investment and the importance of private providers in the health system.[30]

## Vaccination in Bolivia

The trend of increased vaccination coverage holds true for Bolivia. Despite this increase, vaccination coverage is still far short of the GIVS goal. In 2008, less than 65% of the children under 5 were fully vaccinated in La Paz, the department with the lowest completion coverage.[31] An understanding of the predictors of completed vaccination specifically for Bolivia will help to identify variation in completion and elements of the health system, individual and population characteristics that allow the variation to persist. In addition to the healthcare delivery features and familial level characteristics brought up from above, Bolivia's unique cultural and geographic makeup may predict differences in completed vaccination.

Health disparities exist across the different ethnic groups in Bolivia, with indigenous groups having worse health outcomes than the Spanish population.[32] Health disparities arise as a result of direct differences in health and nutritional

access, and through mitigating factors such as the influence of culture on socioeconomic status (SES), and education.[33]

Bolivia's geographic variation may also contribute to differences in vaccination. Rural communities are often isolated, resulting in significant difference in access to healthcare between rural and urban populations.[34] Due to the natural environment and a lack of adequate infrastructure, geographic access to healthcare can be particularly challenging, and distance to health centers may be a large problem in receiving health care.[35] Additionally, the decentralized nature of Bolivia's Healthcare system relies on the departments to finance and administer public health programs such as vaccinations.[36] This could result in departmental differences in available vaccination and primary care programs.[37]

Many researchers have explored the impact of economic status, and personal characteristics such as health knowledge, education, and parity are driving forces on healthcare utilization in Bolivia.[38] [39] [40] [41] The health system access issues, and ethnic and regional differences have not been studied in the context of childhood vaccination in Bolivia.

# METHODS

## Research Questions

**$Q_1$:** Do physical access barriers predict completed vaccination among children in Bolivia?

$H_1$: Children whose caregiver reports that distance to health center is "a big problem" are less likely to have completed vaccination than children whose caregivers reported that distance to health center "is not a big problem."

$H_2$: Children in rural areas are less likely to have completed vaccination than children in urban areas.

**$Q_2$**: Does the type of health center predict completed vaccination?

$H_3$: Children vaccinated in private health centers are more likely to have completed vaccinations than in public hospitals and health centers.

**$Q_3$**: Does department predict completed vaccination?

$H_4$: Children in wealthier and smaller departments are more likely to have completed vaccination than children in larger or poorer departments.

**$Q_4$**: Does ethnicity predict difference in access barriers?

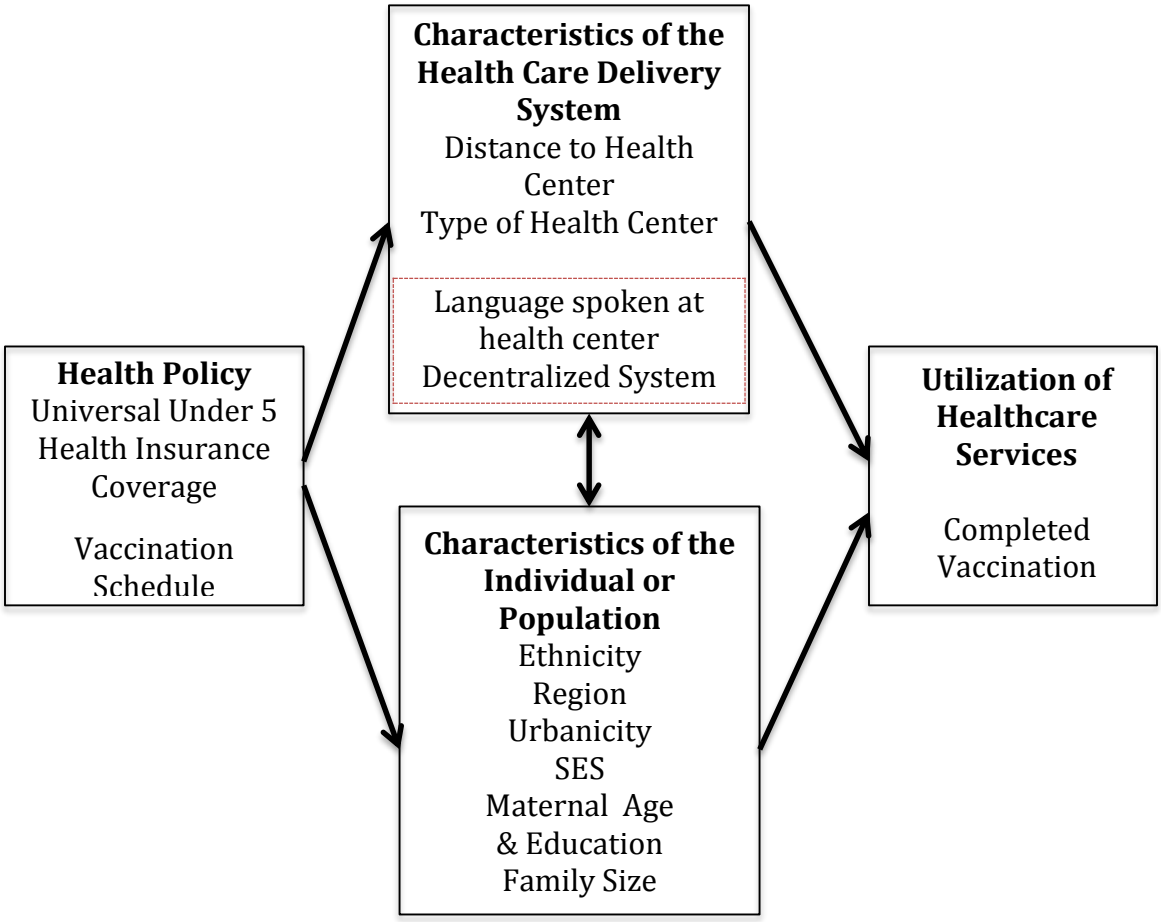
$H_5$: People who identify as Quechua and Aimara are more likely to report that the distance to health center is a big problem than people in the Spanish ethnic group.

## Data

Data came from the 2008 Monitoring and Evaluation to Assess and Use Results Demographic and Health Surveys (MEASURE DHS) from Bolivia. MEASURE DHS is funded by the U.S. Agency for International Development (USAID) and provides nationally representative survey data on fertility, family planning, maternal and child health, gender, HIV/AIDS, malaria, and nutrition in over 90 countries. It is a publically available data set collected approximately every 5 years via home surveys. Children's health status and history was reported by their caregiver, typically their mother, as part of the survey administered to women. Data was collected through multilevel cluster randomization, clustering on villages or neighborhoods in large cities, and randomized the households interviewed within the clusters to ensure a nationally representative sample. [42]

The study sample was limited to children from 24 months old to less than 5 years (N= 4833). The sample was restricted to children from 24 months old and older because Bolivia's childhood vaccination schedule is complete by 24 months.

**Theoretical Framework**




The theoretical framework was an adapted version of the Aday/Anderson Access Model.[43] It traced the health policy of the national vaccination schedule through characteristics of the population and health service delivery system to the resulting variable of interest: utilization of health care services. All children under the age of 5 have health insurance, so cost of vaccination was not accounted in this study but should be noted for the sake of the model. The principal characteristics of the health service delivery system that other studies have shown to influence completion were physical access and health provider type. Physical access was

measured through the proxy "distance to health center is a big problem", and provider type was categorized as public or private. Language spoken at the health center and the decentralization of Bolivia's healthcare system are elements of the healthcare delivery system that may influence vaccination completion, but they were not explored in this study due to data limitations, which is why they are in a light red box above. Characteristics of the individual and population were also expected to effect vaccination completion. Geographic location, categorized by department, and ethnicity are important covariates that may have substantial theoretical meaning in Bolivia. Additional aspects that were considered based off of prior literature on vaccination completion are familial factors and living in an urban environment.

## Dependent Variable

The dependent variable was a binary categorical variable. The categories were: complete vaccinations and incomplete vaccination. Bolivia's vaccination schedule was adopted from World Health Organization (WHO) recommendations, and is completed by 24 months. Complete vaccination were defined as having completed Yellow Fever vaccine, three rounds of Polio vaccine, three rounds of Diphtheria, Tetanus Toxoid, and Pertussis vaccine (DTP), a Measles Mumps and Rubella vaccine (MMR) and a Bacille Calmette-Guérin vaccine (BCG). The sample included children up to 5 years, so completed vaccination is not timely vaccination because they could have had delayed but still completed by the time of the survey. The category "incomplete vaccination" was used if a child had no vaccinations, or

some but not all vaccinations in Bolivia's vaccination schedule by 24 months. These categories have previously been used to assess vaccination coverage in low and middle income countries, and the WHO.[44] Vaccination status in the data comes from vaccination records card or parental recall. Vaccination records included dates of the vaccine but parental recall did not. Both records have potential bias, since parental recall tends to over report vaccination, and using only vaccination records in low and middle income countries frequently underreport vaccination. Using them in combination helps limit the effect of the bias.[45]

### Key Independent Variables

This research investigated the effect of two key independent variables on vaccination. The first was a self-reported measure for difficulty in getting to the health center due to distance. The binary variable categorized the difficulty getting to the health center due to distance as "a big problem" or "not a big problem" according to the child's caretaker who completed the survey. This variable was a proxy for geographic access to health centers. The second key independent variable was type of health center. This binary variable was divided into public or private health center. Private health center included private providers, non-governmental organizations (NGOs), and other church run medical centers. It did not include traditional healers.

### Covariates

Covariates account for further differences in completed vaccination. The four ethnic categories were defined by language: Spanish, Quechua, Aimara, and Other.

Other included individuals from indigenous groups with smaller populations, and those whose ethnicity was recorded as "foreigner" in the survey. The geographic categories were defined by the nine departments: Beni, Chuquisaca, Cochabamba, La Paz, Oruro, Pando, Potosí, Santa Cruz, and Tarija. There was no collinearity between the departments and ethnicity. Urbanicity was a binomial variable wherein urban location of residence was defined as large cities, small cities, and towns. All other locations of residence were considered rural. A wealth index was created by MEASURE DHS to accurately measure socioeconomic status in Bolivia accounting for purchasing power and standard of living. Maternal age, maternal education, and family size were family level factors that affect vaccination.

**Analysis**

To assess the impact of these key issues on vaccination, we preformed binary logistic regression accounting for survey weights clustered at the strata of neighborhood or village, with a primary sampling unit of households. The following equation was used to address $Q_1$ and $Q_2$ and $Q_3$

Model 1: $\gamma Completed_i = \beta_0 + \beta_1 Distance_i + \beta_2 Type_i + \beta_3 Ethnicity_i + \beta_4 Department_i + \beta_5 Demographic\ Covariates_i + \varepsilon_i$

Some further analysis allowed us to examine the effect of ethnicity and geography on the probability that caregivers will report distance "is a big problem" in obtaining health care ($Q_4$). The equations also use binomial logistic regression accounting for survey weights.

Model 2: $\gamma Distance_i = \beta 0_j + \beta_1 Ethnicity_i + \beta_2 Department_i + \beta_3 Demographic\ Covariates_i + \varepsilon_i$

# Results

## Descriptive Statistics

Table 1 provides the demographic characteristics of the study sample used in the regression analysis for the sample population adjusted for survey weights. The sample consisted of 4,883 children ages 2-5 years. The caregivers in than half the sample (56.56%) reported that distance "is a big problem" in receiving healthcare. Most of the total sample received medical care at a Public Health Center or Hospital (78%). Ethnic and Departmental representation approximately reflect the population distribution because the survey was weighted to be nationally representative. The average maternal age is 30 years old (SD=0.12 years). The highest level of education completed by the child's mother is primary education for over half the sample (54.7%), but only 6.23% had no education. Approximately 55% of the sample lived in urban environments.

**Table 1:** Demographic Characteristics of the Study Sample N=4,883[a]

| Variable | n M | % | Variable | n M | % |
|---|---|---|---|---|---|
| Distance is a Problem | 2,759 | 56.56% | Wealth Index | | |
| Public Health Center | 3, 827 | 78.36% | poorest | 1,206 | 24.68% |
| Ethnicity | | | poorer | 1,018 | 20.84% |
| Spanish | 2,876 | 58.89% | middle | 1,086 | 22.24% |
| Quechua | 1,041 | 21.32% | richer | 893.2 | 18.29% |
| Aimara | 469.2 | 9.61% | richest | 681.5 | 13.95% |
| Other | 497.7 | 10.19% | Highest Maternal Education | | |
| Department | | | none | 304.4 | 6.23% |
| Chuquisaca | 318.4 | 6.52% | primary | 2,672 | 54.70% |
| La Paz | 1368 | 28% | secondary | 1,328 | 27.19% |
| Cochabamba | 877 | 17.96% | higher | 580.3 | 11.88% |
| Oruro | 241 | 4.93% | Maternal Age | 30.05 | (0.12) |
| Potosí | 625.1 | 12.59% | Family Size | 5.579 | (0.035) |
| Tarija | 176 | 3.60% | Urban | 2,669 | 54.65% |
| Santa Cruz | 1080 | 22.11% | | | |
| Beni | 176.5 | 3.61% | | | |
| Pando | 32.66 | 0.67% | | | |

[a]Weighted to be nationally representative

**Model 1: Research Questions 1-3 Completed Vaccination**

Bivariate logistic regression was used to answer the question '*Does the distance and the type of health center predict completion of childhood vaccination?*' and indicated the odds ratios and 95% CI for completion of vaccination schedule across the independent variables. Controlling for all other covariates, children whose caregivers reported that distance "is a big problem" in obtaining healthcare were 25% less likely to complete the recommended vaccines than those for whose caregivers reported that distance "was not a big problem" (see table 2). There was no statistically significant difference in completion rates for children receiving healthcare from private health centers or public health centers. There was also no statistically significant difference in completion rates across ethnicities. Almost every regional department had statistically significant lower odds of completion relative to the omitted reference department of Chuquisaca. Chuquisaca is a smaller department with the historical capital city of Sucre, which may lend it a protective effect, but there was no systematic difference in wealth or resources as collected by DHS that explained this difference. Urbanicity was also a significant predictor of under completion, as children in urban areas are 48% less likely to receive completed vaccinations as children in rural areas.

**Table 2:** Analysis of the Predicting Factors of Completed Vaccination (N=4501)

| | OR | 95% CI | P>\|t\| |
|---|---|---|---|
| Distance Is A Problem | 0.751 | (0.607 – 0.930) | 0.009** |
| Public Health Center | 1.181 | (0.857 – 1.628) | 0.308 |
| Ethnicity | | | |
| Spanish | Ref | - | - |
| Quechua | 1.090 | (0.784 – 1.514) | 0.609 |
| Aimara | 0.732 | (0.496 – 1.080) | 0.116 |
| Other Ethnicity | 1.181 | (0.814 – 1.714) | 0.381 |
| Department | | | |
| Chuquisaca | Ref | - | - |
| La Paz | 0.199 | (0.119 – 0.334) | <0.001 *** |
| Cochabamba | 0.203 | (0.119 – 0.346) | <0.001 *** |
| Oruro | 0.274 | (0.152 – 0.492) | <0.001 *** |
| Potosi | 0.423 | (0.250 – 0.714) | <0.001 *** |
| Tarija | 0.773 | (0.399 – 1.497) | 0.444 |
| Santa Cruz | 0.305 | (0.173 – 0.539) | <0.001 *** |
| Beni | 0.397 | (0.198 – 0.749) | 0.009** |
| Pando | 0.332 | (0.166 – 0.663) | 0.002** |
| Urban | 0.507 | (0.317 – 0.814) | 0.005** |
| Wealth Index | | | |
| Poorest | Ref | - | - |
| Poor | 1.133 | (0.814 – 1.577) | 0.458 |
| Middle | 1.330 | (0.810 – 2.184) | 0.259 |
| Richer | 1.514 | (0.815 – 2.810) | 0.189 |
| Richest | 1.792 | (0.865 – 3.713) | 0.116 |
| Maternal Education | | | |
| None | Ref | - | - |
| Primary | 0.887 | (0.587 – 1.340) | 0.569 |
| Secondary | 1.518 | (0.931 – 2.476) | 0.094 |
| Higher | 1.456 | (0.801 – 2.647) | 0.218 |
| Maternal Age | 0.999 | (0.800 – 1.015) | 0.875 |
| Family Size | 0.995 | (0.943 – 1.050) | 0.856 |

* P>0.1 **P>0.05 ***P>0.001

## Model 2: Research Question 4 Distance

Table 3 shows the results for the logistic regression that was used to answer the question *'Does ethnicity predict a difference in access barriers?'* The outcome variable was "distance to health center is a big problem." In this model, people of the Quechua ethnic group were 25% more likely to report that distance was "a big problem" in accessing healthcare at a significance level of P=0.06. Departmental

differences were also apparent in this model. People in the departments of La Paz are approximately 2.5 times as likely as people in the department of Chuquisaca to report distance as a problem in accessing healthcare, and people in Chochabamba nearly 2 times as likely. Wealth significantly predicted difference in the odds that distance "is a big problem" in accessing healthcare. Compared to the poorest quintile, each subsequently increased wealth quintile indicated lowered odds that the caretaker will report that distance "is a big problem" in obtaining healthcare.

**Table 3:** Analysis of the Predicting Factors of "Distance is a big problem in obtaining healthcare" (N=4826)

| | OR | 95% CI | P>\|t\| |
|---|---|---|---|
| Ethnicity | | | |
| Spanish | Ref | - | |
| Quechua | 1.255 | (0.990 – 1.590) | 0.060* |
| Aimara | 1.010 | (0.747 – 1.364) | 0.950 |
| Other Ethnicity | 0.955 | (0.725 – 1.259) | 0.743 |
| Department | | | |
| Chuquisaca | Ref | - | - |
| La Paz | 2.475 | (1.706 – 3.591) | <0.001*** |
| Cochabamba | 1.959 | (1.343 – 2.857) | <0.001*** |
| Oruro | 1.234 | (0.787 – 1.936) | 0.359 |
| Potosi | 1.142 | (0.733 – 1.781) | 0.557 |
| Tarija | 1.792 | (1.155 – 2.781) | 0.009 |
| Santa Cruz | 1.786 | (1.213 – 2.631) | 0.003 |
| Beni | 1.090 | (0.666 – 2.784) | 0.731 |
| Pando | 1.471 | (0.928 – 2.332) | 0.100 |
| Urban | 0.877 | (0.632 – 2.332) | 0.430 |
| Wealth Index | | | |
| Poorest | Ref | - | - |
| Poor | 0.452 | (0.333 – 0.613) | <0.001*** |
| Middle | 0.397 | (0.266 – 0.593) | <0.001*** |
| Richer | 0.278 | (0.183 – 0.424) | <0.001*** |
| Richest | 0.188 | (0.110 – 0.321) | <0.001*** |
| Maternal Education | | | |
| None | Ref | - | - |
| Primary | 0.945 | (0.649 – 1.378) | 0.770 |
| Secondary | 0.779 | (0.502 – 1.210) | 0.267 |
| Higher | 0.858 | (0.539 – 1.367) | 0.519 |
| Maternal Age | 1.016 | (1.001 – 1.030) | 0.18 |
| Family Size | 1.013 | (0.970 – 1.057) | 0.544 |

* P>0.1 **P>0.05 ***P>0.001

## Discussion

Despite growth in Bolivia's health sector and increasing vaccination coverage, Bolivia has been unable to meet its goal of 90% immunization coverage.[46]

This investigation utilized nationally representative survey data to study predictors of the binary outcome for completed vaccination by two years of age. After controlling for covariates, children whose caregiver reported distance "is a big problem" in obtaining health care were less likely to have completed vaccinations compared to children whose caregivers reported that distance "is not a big problem." Interestingly, living in a rural environment actually has a protective effect on completed vaccinations. There were significant differences in outcomes of interest across departments.

In the primary model focusing on the outcome of completed vaccination, almost every department showed significant differences. Children in La Paz, the department with the lowest vaccination completion, are 80% less likely to have complete vaccination compared to Chuquisaca, the department with the highest completion. The variation across departments may have important implications for the health system. In 1996 Bolivia enacted decentralization health reforms as part of the country's financial decentralization.[47] The 2003 the Universal Mother and Child Insurance Scheme called the SUMI program worked to further decentralize the health sector because financing occurred at municipal, departmental, and national levels.[48] The goal of these reforms is to allow departmental governments to focus on local priorities and deliver more effective service. The substantial differences in completion of immunization programs across departments could be related to the

decentralization. Departments determine which human development programs to develop and fund including health services. Local priorities and available resources drive investment in different programs, and may result in unequal access to health services nationally despite the cost effectiveness of vaccination programs.[49]

Another important result was the lack of significance in ethnicity on the odds of completed vaccination in Model 1. There has been an effort to improve access to health services for the indigenous population, and this finding suggests that there are not systematic cultural differences external to controlled covariates for income, urbanity, education, and department. However, the odds that distance "is a big" problem in obtaining health care are statistically higher for Quechua people compared to Spanish Bolivians. So even though there is not a Quechua specific risk for lowered odds of completed vaccination when accounting for covariates, being Quechua puts you at a higher risk of having trouble obtaining healthcare due to distance. Having trouble obtaining healthcare due to distance may only apply to other health services, or it could in turn increases the risk of not completing vaccination. Distance as a problem in obtaining healthcare may be a result of several factors including the health system, infrastructure, and individual travel capacity. Further study of the reasons that distance would be beneficial to address this significant barrier to completed vaccination in order to create policy recommendations that are culturally appropriate.

The protective effect of living in a rural area remains significant even when removing wealth index and education from the equation (data not shown), though the magnitude was slightly reduced. Many other studies on health services in Bolivia

suggest that rural areas have reduced access to more health services.[50] [51] This might contribute to a greater perceived need which might result in additional resources funneled to vaccination campaigns in rural areas. Urban areas have resources for more complex health services, which may cause lower completed vaccination rates through two ways. It may result in reduced investment of preventative health services, such as childhood vaccination in the areas as the funds are allocated to strengthening larger hospital systems. If larger hospitals are the primary available healthcare center, people seeking non-emergent, preventative services may be lower service priorities, which can result in lower receipt of vaccinations. The data set does not include variables such as size of health center, or insight into health services investment priorities on the village or city level, so the specific cause should be explored in further study.

**Limitations**

The data which made up the immunization report came from both maternal report and health card records. While prior studies have shown that utilizing a mixed report does not alter the validity or significantly bias the result, this does provide some limitations.[52] Maternal reports did not include dates, so studying the timeliness of individual vaccinations could have produced inaccurate results. Since all vaccinations in the program were to be completed by 24 months, that became the cutoff to easily identify complete immunization by the scheduled time. As a result this study does not include children who died before their second birthday. That

does present another limitation because children who died before their second birthday could have died of vaccine preventable disease as a result of not being vaccinated.

The second limitation is the variable *distance as a big problem in accessing healthcare* is a subjective measure, and can be influenced by unmeasured aspects such as the quality of the road, the mode of transportation, and the overall distance. It is a good proxy for understanding the impact of access problems on vaccination completion, but the subjective nature requires further study to understand what is driving the access problems.

A third limitation is that the data comes from self reported survey data; therefore, information about the health services utilization was limited to personal experience and knowledge, as well as by the questions asked. As a result, there is inadequate data on health system specifics to explain the increased risk of not completing vaccinations for urban residents as discussed above, and the protective effect of some departments.

The strengths of this paper are that it is a nationally representative data set, questions are policy and culturally relevant, and incorporates characteristics of the individual and health system in the analysis. A nationally representative data set allows for analysis on the national level. The policy focus for both GIVS and Bolivia is completed vaccination, so limited the the observations to children who should have had completed vaccination focuses the analysis on a policy relevant group. Secondly, the question “is distance a big problem in accessing healthcare” is a culturally relevant way of assessing physical barriers to access to healthcare. The challenges of

geography and infrastructure, as well as individual's perceptions of distance, could lead to an inaccurate characterization of the individual caregivers perception of their healthcare access barriers if this study used a different method for categorizing distance to health center as an access issue. Finally, we studied characteristics of the healthcare system and the individual, which presents a more holistic picture of the predictors of childhood vaccination than if we had focused solely on individual factors or health system elements.

## Policy and Practice Implications

Despite the limitations, the results suggest that departmental differences remain substantial and should be addressed to achieve national immunization goals. The national scenario of decentralization in both the financial and health sectors may contribute to these differences in completion across departments. While decentralization may be more efficient, the significant departmental differences in odds of completed childhood vaccination suggest that the result is neither an equitable distribution of resources nor an effective method to achieve the national health goals.

Future research should focus on the extent decentralization policies result in lower vaccination completion rates including comparing department level programs and health structures to determine what policies are associated with better access to health services and improved health outcomes.

The results raise many questions that require further study, but they illustrate important gaps in the health system of Bolivia, most significantly differences across departments, and the surprisingly protective effect of rural areas on immunization completion. The gaps should be explored in further study to provide specific and actionable areas of improvements in the health system to bring vaccination rates to the national goal.

## Conclusion

Vaccination is both cost effective and provides a substantial public benefit. Bolivia is committed to achieving the GIVS goal of 90% completed vaccination, however they still fall short. The results of this papers show that access problems, urbanicity, and some departments all predict lower odds of vaccination completion. In order to close the gap between the current coverage and the goal, further studies should explore the reasons why these issues and differences persist, and what steps can be made to ameliorate them.

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