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Determinants of Childhood Immunization in the Philippines

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ABSTRACT AND KEYWORDS

A key method of reducing morbidity and mortality is childhood immunization, yet in 2003 only 69% of Filipino children received all suggested vaccinations.

This study examines three separate outcomes of immunization status: not immunized, partially immunized, and fully immunized. The Andersen Behavioral Model is the conceptual framework that was used. Data were derived from the Women's Questionnaire of the 2003 Philippines National Demographic Health Survey.

Results of the multinomial logistic regression model indicate that the children of mothers with more education, who have attended at least the minimally-recommended four antenatal visits, those living in households with greater wealth and with fewer children under the age of five years, and children with lower birth orders and of the Cebuano ethnicity are significantly more likely to have received their recommended vaccines.

Improving knowledge transfer to mothers is the most effective means by which to increase childhood immunization coverage in the Philippines.

Keywords: Determinants of Immunization, Philippines, Andersen Behavioral Model, Children, Health Policy

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Chapter 1: INTRODUCTION

Statement of problem

Around the world, nearly 10 million children who have not yet reached five years of age die each year.[1] Children are subject to the greatest risk of death in the first month of life, when it is possible for them to succumb to birth asphyxia and a variety of infections, as well as complications due to premature birth. In later years the five main causes of mortality include pneumonia, diarrhea, malaria, measles, and HIV. Additionally, malnutrition, which leaves children vulnerable to both morbidity and early mortality, plays a role in more than half of all child deaths.[1] The World Health Organization (WHO) estimates that two-thirds of child deaths are preventable. In the year 2000, heads of state worldwide agreed to the UN Millennium Declaration, which includes eight "Millennium Development Goals".[2] The fourth goal is to reduce child mortality, and a key method of achieving this objective is by providing immunization against disease.[2]

While mortality rates in young children in the Philippines have declined in recent years, there is still one death for every 25 children under the age of five years.[3] In 2003, only 70% of Filipino children received all suggested vaccinations.[3] In order to increase the rate of fully immunized children and to plan for improved health services utilization, policymakers must have an understanding of the current determinants of immunization.

Vaccine-preventable diseases

The Philippine government addresses childhood immunization via the World Health Organization's Expanded Program on Immunization (EPI).[3] This program seeks to immunize all children against six diseases: diphtheria, pertussis, tetanus, measles, poliomyelitis, and tuberculosis.[3] In order to be fully immunized against all six of these diseases, a child must receive a total of eight vaccinations: three doses of the diphtheria-pertussis-tetanus (DPT) vaccine, one dose of the measles vaccine, three doses of the oral polio vaccine (OPV), and one dose of the Bacille Calmette-Guérin (BCG) vaccine.

The World Health Organization's Expanded Programme on Immunization, established in 1974, has been successful in increasing the number of fully vaccinated children worldwide. Due to a series of immunization initiatives, the Philippines has been deemed polio-free since the year 2000,[4] though it is imperative to continue to immunize against the disease to prevent future outbreaks.

Health services utilization and immunization

A number of studies that are descriptive in nature have examined the determinants of childhood immunizations, but very few use a conceptual model to organize the independent variables. Furthermore, most studies on this

subject are geographically limited, and very few have been undertaken in recent years in the Philippines.

There is an increasing body of knowledge regarding determinants of health services utilization in developing nations. A study in the Philippines used a model-based approach to identify several factors that determine child healthcare service use.[5] Multivariable analysis demonstrated that a high level of maternal education, as well as the presence of co-morbid conditions were significant predictors of health services utilization in this country.[5] Studies from other developing countries have found multiple determinants of child immunization. For example, a study conducted in Turkey found that non-vaccination was influenced by lower levels of parental education, as well as by the parents having migrated to Istanbul less than twenty years prior to the survey.[6] A study that took place in Thailand also identified higher maternal education to be predictive of greater use of health services.[7] Finally, researchers in Brazil identified lower maternal education as a major risk factor for reduced immunization rates.[8] Overall, it seems that parental, and particularly maternal, education plays a consistent role in the decision to seek not only general healthcare for children, but also immunizations, specifically.

Objectives

Increasing the rate of fully immunized children in the Philippines will directly impact the fulfillment of the objectives of the EPI, as well as contribute

to the Millennium Development Goal of reducing child mortality. This study seeks to answer the following question: what are the determinants of immunization status in Filipino children aged 12-23 months?

The dataset analyzed was the 2003 Philippine National Demographic and Health Survey (NDHS), which is a nationally representative sample survey of 13,945 women age 15 - 49.[3] The data pertinent to our study were collected from vaccination cards and mothers' verbal reports for 1,354 children.[3] The Andersen Behavioral Model was used as the conceptual framework of the study to construct regression models predicting immunization status.

Significance of study

This is the first study of which we are aware to use a conceptual model-based approach to analyze a representative sample of the entire Filipino population to identify determinants of childhood immunization in the Philippines. Our results will be important from a health policy point of view, as they provide program managers with the information required to understand vaccination coverage, which will enable changes to be made to policy mutable determinants. Additionally, we are using data from the Demographic and Health Survey, which has been conducted in many developing countries, and thus will allow for our findings to be compared against those in other nations.

Chapter 2: LITERATURE REVIEW

The aim of this section is to provide information that will facilitate the understanding of our results, and place in context the findings of our study. It includes a description of the literature search strategy, and background information on immunizations, vaccine-preventable diseases, and the Philippines. In addition, it includes a review of studies of similar aim that have taken place in developed and developing countries, and an overview of the conceptual model.

Literature Review Methodology

Phase 1 (Initial search strategy): In the beginning, it was necessary to become familiar with the Demographic and Health Survey program and the data it produces. Very basic background information was gathered via an informal search of the Internet using the Google search engine. During the course of this search, a paper written by Rousselle Lavado, a doctoral candidate studying healthcare delivery in the Philippines, was found. Upon contacting her, she was kind enough to suggest resource material concerning the Demographic and Health Survey, which proved to be quite useful.

Phase 2 (Electronic database search): The next step was to delineate the general direction of the thesis in order to provide a basis for the literature search. Four main areas of research were identified: i) the conceptual model

(the Andersen Model); ii) contextual information on the Philippines; iii) immunization in the Philippines; and iv) immunization in other countries. PubMed, EMBASE, Medline, and Google Scholar were used to search the scholarly literature. The following keywords were used: Philippines AND health AND care; Philippines AND healthcare; immunization AND developing; immunization AND beliefs; immunization AND Philippines, factors AND underimmunization; immunization AND coverage AND developed; immunization AND coverage and determinants; Andersen AND model AND health; Andersen AND model AND child; Andersen AND model AND utilization. The titles of all articles were scanned for relevance to the thesis topic. If a paper's title was related to the thesis topic, the abstracts were read. If in turn the abstract proved useful, the article was retrieved. Additionally, each of the electronic databases offers a "Find Similar Articles" function, which was used to obtain supplementary papers. A total of 94 scholarly articles were retrieved in this fashion. Finally, an examination of the selected articles' bibliographies allowed us to identify additional resources.

Phase 3 (Grey literature search): It was also necessary to locate information pertaining to the Philippines and its current immunization practices, as well as immunization programs throughout the world. The Google search engine was used to find websites hosted by the government of the Philippines that outlined relevant contextual information. This strategy also yielded the titles of several books that were beneficial to the process. Finally, the websites for the

World Health Organization (WHO), the United Nations Children's Fund (UNICEF), as well as the World Bank were searched for information.

Background

In the mid-20th century, industrialized countries underwent the 'epidemiological transition' whereby the leading cause of death evolved from infectious and parasitic diseases to chronic and degenerative diseases. This transition, however, has not yet occurred in many developing countries, and therefore the leading cause of death worldwide remains infectious diseases.[9]

Considered one of the 20th century's greatest achievements in public health[10], vaccinations can contribute to a reduction in human suffering and an increase in life expectancy. Immunization has led to the eradication of smallpox, and is associated with a significant reduction in morbidity and mortality resulting from diseases such as diphtheria, pertussis, tetanus, measles, tuberculosis, and poliomyelitis. Moreover, immunization reduces the strain on healthcare systems, and is a highly cost-effective health investment. For example, in the United States, a $1US investment in vaccine doses is estimated to save between $2US and $27US in health expenses.[11] Further, Jamison et al[12] point out that in South Asia, the delivery of all vaccinations within the EPI schedule costs less than $10 per person for each disability adjusted life year (DALY) averted. The only intervention considered in their study which is more cost-

effective in preventing high-burden disease in this region is the training of volunteers in emergency first aid procedures.

Bloom et al[13] add to this argument the fact that cost-effectiveness analyses do not take into account all of the economic benefits derived from immunization. For example, they point out that an impairment to physical functioning, such as paralysis due to polio, may significantly impact an individual's ability to earn an income via manual labour in the future. These researchers also note that a setback in mental development, such as brain damage due to measles, may affect a child's future chances of working. In a study they conducted in the Philippines, they found that immunization was indeed associated with higher IQs, and higher scores in language and mathematics tests at the age of ten. They surmise that this will translate into higher incomes in adulthood.

Notwithstanding the proven benefits of vaccination, there are gaps in coverage. It is estimated that in the absence of vaccinations, approximately five million children would die annually of diseases that are preventable by vaccination.[3] However immunizations currently save the lives of about three million children annually,[14,15] which means that two million children worldwide die each year as a consequence of vaccine-preventable diseases.[11,14]

As a result of sub-optimal immunization coverage, the World Health Organization (WHO) introduced its Expanded Program on Immunization (EPI) in 1974.[11] A priority of the EPI was to create clear guidelines that could be utilized by national health authorities to develop and manage disease prevention

services and immunization practices. The six original vaccinations recommended by the program were against diphtheria, pertussis, tetanus, measles, poliomyelitis, and tuberculosis, and these diseases continue to be the focus of the EPI in the Philippines. Since its inception, the EPI has been successful in increasing vaccination coverage in the Philippines, as well as worldwide[11].

In 1978, the WHO adopted a new approach to the delivery of healthcare services – the primary healthcare approach. This method focuses on the promotion of health and the prevention of illness. At the beginning of the 1980s, on average, developing countries had an immunization coverage rate of 15%. With the 1982 State of the World's Children report, the child survival and development revolution was initiated, which prompted UNICEF to target the reduction of infant and child mortality as a means by which to increase development in non-industrialized countries. Momentum began to build, and during the remainder of the 1980s, developing nations strived to reach a coverage rate of 80% (75% in African countries), via national immunization campaigns and immunization days.[16] By 1997, each of the original six vaccines recommended by the EPI had worldwide coverage rates of at least 80%. However, disparities in coverage exist between countries, and developing countries in particular can improve their rates.[17]

Recently, the WHO and UNICEF have collaborated to create the Global Immunization Vision and Strategy (GIVS). This program is to be implemented from 2006-2015, although efforts began before the official start year of 2006.[18]

GIVS seeks to fortify the health sector in order to increase accessibility to immunization services, and aims to do so via four main strategies: i) increasing the number of eligible individuals who are immunized; ii) introducing new vaccines; iii) linking the delivery of immunizations and other public health interventions (e.g. the distribution of Vitamin A supplements); iv) recognizing the increasing level of global interdependence in immunization programs. One of GIVS' primary goals is to ensure that by 2010, at least 90% of children are vaccinated, with an immunization coverage of at least 80% in each district of every member country.

Vaccine Preventable Diseases

Diphtheria is caused by a bacterium that may cause local infections within the respiratory tract, or may disseminate throughout the body, causing damage to the skin, the heart, and the central nervous system. Pertussis, commonly referred to as 'whooping cough', is a disease of the respiratory tract that can lead to mortality of the affected individuals. Those at greatest risk are those who have not received all recommended vaccines to prevent the infection. Tetanus is a disease caused by a neurotoxin that often leads to the prolonged contraction of skeletal muscle fibers, and may result in death. It is contracted when acquired wounds are infected by contaminated substances (often soil or feces).

The diphtheria-pertussis-tetanus (DPT) vaccine is used to prevent the spread of all three diseases, yet it is administered as a single vaccine to improve the efficiency with which immunization coverage is obtained. The most effective means by which to prevent these infections is to ensure universal vaccination of all individuals within a given community. The immunity conferred by the DPT vaccine against diphtheria and tetanus diminishes over time. It is thus recommended that individuals receive booster vaccines every ten years throughout adulthood in order to ensure continued and effective immunization against the diseases.

Measles is a viral disease which is transmitted via airborne droplets originating from sneezes and coughs. Among other complications, it can cause fever, rash, diarrhea, bronchopneumonia, and encephalitis. Over 95% of children immunized against measles will be protected from contracting measles.[19] In the Philippines, children are immunized against measles via the measles vaccine, while in many developed countries, the measles-mumps-rubella (MMR) vaccine is used. The MMR vaccine is more expensive, and therefore before a country implements its use, the country should have the resources available to sustain such an immunization program, as well as to monitor any new additions to the system.[20]

Poliomyelitis is caused by a virus which is transmitted via the fecal-oral route and infects the gastrointestinal tract. It some cases, it can cause irreversible paralysis. Oral polio vaccine (OPV) is used in the Philippines to provide immunity against the three types of polioviruses. When children receive

all three doses, complete immunity is seen in more than 95% of recipients.[21] This vaccine is often used rather than its alternative, the inactivated poliovirus vaccine (IPV), as it is marked by greater mucosal immunity, it is less costly, and it is easy to administer.[22] However with OPV there is the risk that the attenuated poliovirus reverts to a more virulent form, potentially leading to vaccine-associated paralytic poliomyelitis (VAPP). In countries that have been polio-free for a number of years, the risk of VAPP outweighs the risk of paralysis due to infection with the wild poliovirus, and therefore some countries have begun to use the IPV.

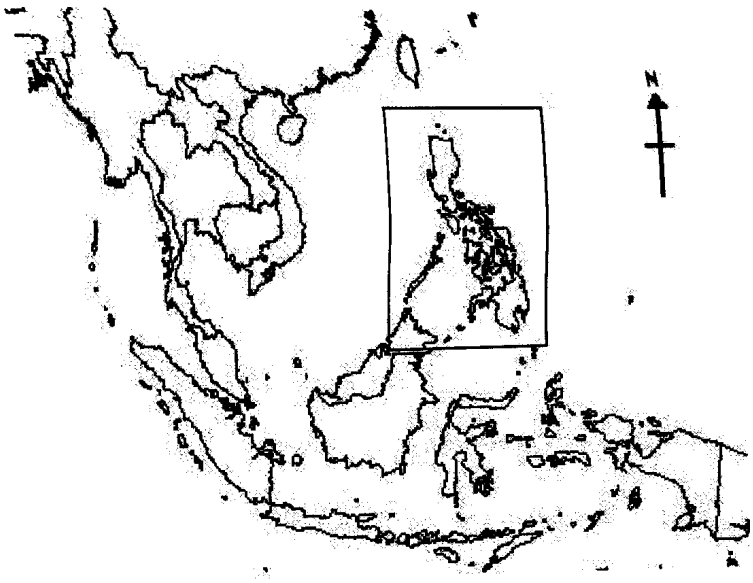
Tuberculosis is caused by a bacterium transmitted by aerosol droplets. Infection is most commonly limited to the lungs, though it can affect many other systems of the body. The Bacille Calmette-Guérin (BCG) vaccine is used to prevent infection resulting from disseminated tuberculosis, however it is not consistently effective in preventing pulmonary infection.[23] While BCG does not necessarily protect against primary infection, it will prevent the spread of the disease within the body.[24] Until more effective preventive measures are developed, countries with high burdens of tuberculosis are encouraged to provide the BCG vaccine to all children.[23] In countries marked by a lower disease burden, selective use of BCG in high-risk communities, along with case detection may be a more effective means of treatment than universal BCG vaccination.[23]

In order for a vaccine to be adequately potent, it must be maintained at a temperature between +2º and +8º C, from the manufacturer to its final

destination. This process and the equipment used are referred to as the 'cold chain'. In temperate climates, the cold chain temperatures are maintained through the use of ice packs, coolers, freezers, generators, and gas-powered refrigerators. Vaccines each have unique temperature thresholds beyond which they lose their potency. For example, while BCG, OPV, and the measles vaccine may be frozen, DPT cannot be frozen without causing damage.[25] Freeze-dried BCG may be safely stored for one year, and freeze-dried measles vaccine for two years, At the recommended cold chain temperatures, DPT may be safely stored for approximately two years, and OPV for 6-12 months.[25] As temperatures rise, the length of time required to diminish vaccine potency is drastically reduced. For example, in temperatures around 20º C, DPT is stable for only four days[26], OPV loses 50% of its potency in one day, and reconstituted BCG and measles vaccines are inactivated within 5-6 hours and one hour, respectively.[25] Preservation of the cold chain is essential, as vaccines that are not maintained at the appropriate temperature are rendered ineffective. This leads not only to financial loss, but also to the inability to supply clinics with the vaccines necessary to prevent disease.

Contextual Information on the Philippines

The Republic of the Philippines is an archipelago composed of over 7,100 islands (Figure 1, p.14). It has a population of approximately 91 million and a birth rate of 24.48 per 1,000 people – one of the highest in the region.[27]



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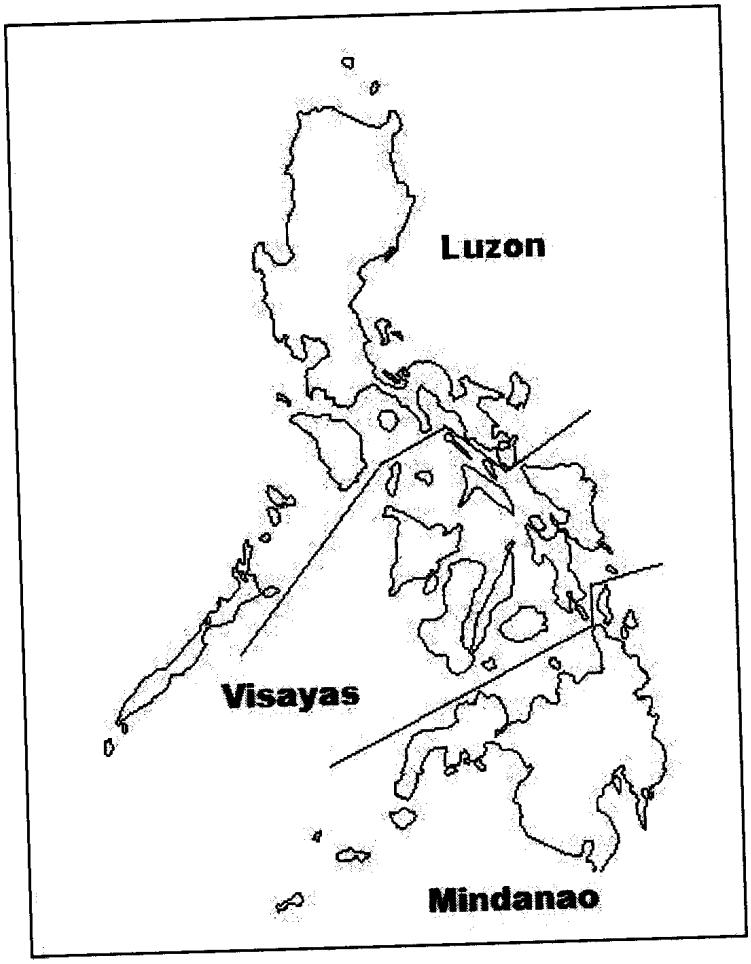


Adapted from:
schools.look4.net.nz/geography/country_information/outline_maps/files_OM/philippines.jpg

Figure 1 *Map of Southeast Asia and of the Philippines, showing the three main island groups Luzon, Visayas, Mindanao*

The majority (80.9%) of Filipino citizens are Roman Catholic, followed by Muslims (5%).[27] Although the Philippines has an overall literacy rate of 92.6%, in 2001 approximately 40% of the population lived below the country's poverty line.[27] Furthermore, with a gini coefficient of 0.46 (0: perfect income equality; 1: perfect income inequality), it has the most unequal wealth distribution of all members of the Association of Southeast Asian Nations (ASEAN).[82]

In the 16th century the islands became a colony of Spain, and remained this way until the Spanish-American war in 1898. In 1935, the islands became a self-governed commonwealth of the United States. During WWII, the Philippines was occupied by the Japanese, however following the war, the Philippines was granted independence. The Philippines is run by a representative democracy, which is modeled after the American political system. The country is divided into 17 administrative regions, which are further subdivided into 79 provinces. For administrative convenience, about 3 to 5 provinces sharing similar cultural characteristics are grouped to form a single region.[28,29]

The Philippine agricultural sector produces sugarcane, a selection of fruits, pork, eggs, beef, and fish. The manufacturing industries primarily export electronic products, garments, petroleum products, coconut oil, and fruits. The country is marked by a good telephone system, and has 233 television stations, but in 1995 there were only 4.6M Internet users.[27] Approximately 0.9% of GDP is reserved for military expenditures. The country was less negatively influenced by the 1998 Asian financial crisis than other surrounding countries. This was due in part to elevated remittances from overseas workers, and also as a result

of relatively low debt prior to the crisis. In spite of this, the poverty existing in the Philippines will be difficult to overcome, due in part to the inequality of wealth distribution.

Health System Financing: Although the Philippines adopted the World Health Organization's (WHO) recommended primary healthcare approach in 1979, a large proportion of the population is marked by poor health. Health outcomes are at less than desirable levels as a consequence of poor service delivery, insufficient health financing, the high cost of medicine, and a 'brain drain' of health care professionals.

Gaps in health status are particularly evident among individuals of different economic groups and geographical regions. The amount of public spending on health, as compared to countries with similar per capita incomes, is relatively low, and thus services are often not obtainable by the poor. In 2002, the total expenditure on health, as a percentage of GDP, was 2.9%, and general expenditure on health accounted for only 4.7% of total government spending.[30] As 60.9% of total spending on health is derived from non-governmental private spending[30], income can play an important role in accessing health services.

Citizens may choose to access healthcare in either public or private facilities. The cost of care in private hospitals must be borne by the individual patients who are accessing such care, or alternatively by their insurance companies. In public facilities, patients are not required to pay for the services

they receive; however they are encouraged to make payments based on their level of income.

Healthcare Delivery: In addition to the disparities caused by wealth, inequalities also arise as a result of location – residents of rural communities are plagued by lower quality and less accessible health services, as well as the emigration of healthcare professionals to urban areas.

Public healthcare in the Philippines is mainly delivered through three distinct services: hospitals, rural health units/urban health centers, and *barangay* (smallest unit of local government) health stations. In the public sector, provincial and district hospitals provide care at the primary, secondary, and tertiary levels. Rural health units and urban health centers are intended to supply primary healthcare services to their local residents, and are designed to provide service to approximately 41,000 patients. They are to be staffed by a primary healthcare physician and nurse, as well as a few midwives and a sanitary inspector. In practice, the rural health units mainly provide preventive services, such as immunizations, as well as first aid in emergency situations. Barangay health stations can be found in approximately 15,000 of the country's 42,000 villages. These health stations provide first aid treatment and family planning services to approximately 3,000 local patients, and are staffed by a midwife and a few volunteer health workers. Healthcare is also delivered privately, through private clinics, and primary, secondary, and tertiary care hospitals.

Prior to 1991, the national Department of Health (DOH) managed and delivered health care services across the country.[28] When the "Local Government Code of 1991" was introduced, the responsibility of health and other services was transferred from the national level to Local Government Units (LGUs).[28] The delivery of Filipino health services underwent many changes, and by 2005, the DOH was responsible for the technical and financial aspects of healthcare, while the LGUs handled the development and implementation of services.[31] Public hospitals are managed by the provincial government, while rural health units and barangay health stations are overseen by the municipal government.

National Health Insurance Program: A number of citizens of the Philippines are eligible for social health insurance coverage by the National Health Insurance Program (NHIP). This program was implemented in accordance with the "National Health Insurance Act of 1995", which sought to expand on the former medicare program that covered only government and private sector employees.

The NHIP membership includes four main groups: i) individuals formally employed by the government or in the private sector; ii) indigents; iii) retirees and legal dependents of working members; and iv) individual paying members.[32,33] PhilHealth, the government corporation charged with running the NHIP, estimates that its program has 68M beneficiaries, which is a national coverage rate of approximately 75%.[27,32] A possible reason for the coverage rate not being higher is that individual paying members are not forced to

participate in the insurance program. As these people either cannot afford, or simply choose not to pay the insurance premiums, they are not covered by the NHIP.

The NHIP compensates its members for the costs of a variety of services, including professionals' fees, diagnostic tests, prescription drugs, and room and board for hospital stays. It also covers the vaccines recommended by the EPI, according to the Philippine immunization schedule, which was introduced in 2004[17] (Table 1, p.20). Despite the availability of this compensation, the insurance program is marked by low utilization rates by its members, and further, it is estimated that only 10% of the indigent population is currently enrolled in the program.[34] The program is designed to deliver equitable service, on the basis of need as opposed to a person's ability to pay. With so few low-income individuals utilizing the service, however, the overall benefit of the program is questionable.

Current Philippine Immunization Efforts: The Philippines finds itself among the 42 countries which account for 90% of child (under five years) deaths worldwide, and it has the second highest infant (under one year) mortality rate in Southeast Asia.[17] Morbidity and mortality in the population may be reduced by ensuring that children receive all of the vaccines outlined by the Expanded Programme on Immunization. Achieving greater immunization coverage is important to the Filipino administration, which is evidenced in monetary terms by the President increasing the DOH's "Immunization Project" budget to Philippine pesos 485 million in 2008, from Philippine pesos 455

TABLE 1 *Philippine Immunization Schedule*

Vaccine	Schedule
BCG (Bacille Calmette Guérin for TB)	Birth
DPT (Diphtheria, Pertussis, Tetanus)	6, 10, 14 weeks
Measles	9 months
OPV (Oral Polio Vaccine)	6, 10, 14 weeks

(Adapted from the WHO vaccine preventable disease monitoring system database.[38] *Available from:* http://www.who.int/vaccines/globalsummary/immunization/countryprofileselect.cfm*)*

million in 2007 [1 Canadian Dollar (CAD) = 44.62 Philippine Peso (PHP)].[35] Additionally, the DOH is responsible for several immunization promotional campaigns, such as "National Immunization Days", "Knock Out Polio", and "Garantisadong Pambata".[36] As a result of such efforts, the Philippines has been polio-free since 2000[37], though it is imperative to continue vaccinations against this disease, as re-entry of the virus into the country via neighbouring countries may occur.[37]

Notwithstanding some level of success, the national immunization coverage rate for vaccinations suggested by the EPI still falls short of WHO's goals – approximately 70% of children nationwide are fully immunized (Table 2, p.22), though coverage rates vary according to geographic region. Furthermore, tuberculosis remains the third leading cause of death in Filipinos, while measles is among the top five causes of death in children under 5 years of age.[39]

Determinants of Immunization Status in Developed Countries

Childhood vaccination programs are a cost-effective means by which to reduce morbidity and mortality due to vaccine-preventable diseases. The WHO estimates that in the United States, a $1 USD investment in vaccinations accounts for $2 - $27 USD in savings for prevented future healthcare costs.[11] Despite this evidence, worldwide immunization coverage remains at suboptimal levels. Recent studies examining reasons for undervaccination in developed countries are limited in that they tend to focus on specific geographic regions.

Table 2 *Percentage of children 12-23 months old who obtained each vaccine, Philippines 1993, 1998, and 2003.*

	1993	1998	2003
	% vaccinated	% vaccinated	% vaccinated
BCG	91.2	90.8	90.8
DPT 1 (first dose)	91.1	90.3	89.9
DPT 2 (second dose)	87.9	87.0	85.9
DPT 3 (third dose)	79.9	80.9	78.9
Polio 1 (first dose)	90.9	91.7	91.3
Polio 2 (second dose)	86.2	88.1	87.3
Polio 3 (third dose)	78.2	81.7	79.8
Measles	81.4	78.9	79.7
Fully Vaccinated	71.5	72.8	69.8
Partially Vaccinated	21.7	19.5	22.9
Not Vaccinated	6.8	7.7	7.3

(Adapted from the Philippine DHS Final Reports, 1993[3], 1998[41], 2003[42]. Available from: www.measuredhs.com/pubs/search/search_results.cfm?Type=5&srchTp=type&newSrch=1*)*

Developed countries, as defined by the World Bank, are those whose gross national income per capita classifies them as "high income" (greater than $11,115).[115] Examples of research on determinants of immunization coverage in developed countries are listed below.

A study[40] conducted in the province of Ontario, Canada examined a series of databases to determine the determinants of immunization status of infants who were two years old, and born between July 1, 1997, and June 30, 1998. Of the 96,526 children in the sample, 66.3% were considered fully immunized. As administrative data were used for this study, individual socio-demographic information was not available. Household income quintile was therefore estimated using postal code of residence.

Logistic regression was used to examine the independent effects of several predictors on immunization status. The results indicate that children from low income households, those with less than a "high" continuity of care, those who attend a physician who has been in practice less than five years or more than twenty five years, and a physician who has less than a "high" volume of primary care billings for children aged 0 – 6 years are more likely to be partially immunized.

A strength of this study is the large sample size that was utilized to evaluate the determining factors. Additionally, this study provides different insight than many of its kind as it is focused on determinants at different (patient and provider) levels. On the other hand, a limitation of this study is the fact that the researchers chose to not to include infants living in rural areas of the

province (nearly 12% of total sample), as well as infants who had not received any immunizations (nearly 5% of final cohort). Reasons for undervaccination and non-vaccination can vary greatly between groups, and by eliminating these portions of the sample, the researchers may not have identified all factors contributing to the observed outcomes.

In the US, the Centers for Disease Control and Prevention conducted a study[43] to identify reasons for underimmunization at 3 months of age. They chose to study this age-group as prior research has demonstrated that children whose vaccines are not up-to-date at this age are more likely to be underimmunized later in life. The study examined four geographic areas within the US which are federally designated as "Health Professional Shortage Areas", and had coverage rates between 70% - 84%, depending on the site: northern Manhattan (n=847), Detroit (n=843), San Diego (n=771), and a rural area of Colorado (n=1,091). The researchers employed a two-stage cluster design for household selection, and in-person interviews were conducted using a survey instrument designed by the researchers. Immunization status was determined using vaccination cards and provider records.

Chi-square tests and multivariable logistic regression was used to identify risk factors for underimmunization. While there was not a single independent variable associated with underimmunization at all four geographic sites, at three of the four sites households with 2 or more preschool-aged children, and participation in a Food Stamp program were significantly more likely to have children who are underimmunized. Other significant factors

associated with underimmunization included not being the first-born child, having unmarried parents, having a mother with a lower level of education, living in an impoverished household, having no insurance or public insurance (vs. private), and not participating in the Women, Infant, and Children (WIC) Nutrition Program.

This study did not include children whose immunization dates could not be confirmed by provider reports (5% - 12% of respondents, depending on site), or by vaccination cards, which may have led to nonsampling bias due to noncoverage. Furthermore, it is limited to only four communities, which makes its results difficult to generalize across a larger population. Additionally, the questionnaire did not seek to identify reasons for which children missed opportunities for vaccination (i.e. attended a health facility but was not administered the required vaccine). Such information would be highly beneficial in attempting to fully comprehend reasons for underimmunization.

In another study[44] conducted in the US, in three counties of the state of California, investigators sought to identify risk factors for low immunization coverage among private practices. Practices were randomly selected, and data were collected from the medical charts of 1,719 children aged 24 months at the beginning of the project. The median immunization coverage rate for all practices was 54%.

Multivariable logistic regression was used to identify the independent variables which were associated with children being up-to-date in the vaccination schedule. Factors predictive of children being partially immunized

included attending a practice in which fewer than 50% of child patients are considered "active" (i.e. have attended the office more than twice since reaching 1 month of age), making less than 14 visits to the practice before 2 years of age, residing in San Bernardino and San Joaquin (vs. Contra Costa) counties, attending a practice which is composed of 10%-50% (vs. <10%) Medicaid patients, and a practice in which 50% or more of patients received their DPT and their *Haemophilus Influenzae* Type b (Hib) boosters on separate visits (vs. concurrently).

One of the strengths of this paper is the fact that the researchers very clearly delineated the different predisposing characteristics in terms of those attributable to the healthcare provider as opposed to the consumer (parent/child). This facilitated a more comprehensive understanding of the issues facing underimmunized children in California.

In an Australian study, researchers combined socio-demographic data derived from perinatal and congenital anomaly databases with information regarding immunization status from the Australian Immunisation Register (ACIR) in order to identify risk factors for incomplete immunization.[45] Records were obtained on 60,491 children born in Victoria in the year 1998, and the outcomes of interest were immunization status at 12 and 24 months of age. At each of these time periods, the immunization coverage rate was approximately 90%.

Multivariable logistic regression was used to identify the predictors of incomplete immunization. The results showed that non-complete vaccination

status in children aged 12 months was associated with having a mother less than 25 years of age, not having private health insurance, being born at home (vs. hospital), being born in an urban (vs. rural) setting, being in the lowest and highest socio-economic quintiles, having a single parent, and having parents born overseas or being of Aboriginal or Torres Strait Islander descent. Also playing a role were parity (a linear trend existed whereby more children lead to a greater proportion of partially immunized children), time between pregnancies (12-23 months vs. no previous pregnancies was predictive of incomplete immunization status), birth weight less than 2500g, and singleton births. All of these same factors were also predictive of incomplete immunization status at the age of 24 months, with the exception of birth weight, which was only significant at less than 1500g.

In the UK, a study[46] was undertaken to determine whether there was a difference in the reasons for children being partially immunized versus not immunized. These two groups of children compose 4.4% of the infants in the UK. Data were derived from the Millennium Cohort study, which is a sample of children born between September 2000 and January 2002 in the United Kingdom. The immunization status of 18,488 9-month-old infants was analyzed. In the case of multiple births, only the first born child was included in the analysis to avoid the potential dependence between siblings. Maternal recall was used to determine children's vaccination status, and multivariable analyses were used to identify independent variables which were associated with the outcomes.

Factors associated with both partial immunization and non-immunization include single parenthood, being part of a family with more than 1 child, and residing in disadvantaged and ethnic wards. Underimmunization was also associated with mothers being less than 20 years old, mothers smoking during pregnancy, and infants having a history of at least one prior hospital admission. Non-immunization was additionally associated with mothers being 40 or more years old, having more educational qualifications, and being of black Caribbean (vs. white) descent.

A strength of this paper is that the researchers sought reasons for underimmunization and non-immunization. The most common reason for being partially immunized was medical factors relating to the child or family, and the most predominant reason for non-immunization was maternal beliefs or attitudes towards immunization.

In Italy, a convenience sample was used to collect immunization data on children across the country in early 1997.[47] A total of 1,035 mothers of pre-school children were interviewed using a survey developed and pre-tested by the researchers. The survey results indicated that 59% of children had received the measles-mumps-rubella vaccine, while only 54% of children had been immunized against pertussis. Bivariate analysis was followed by multivariable logistic regression to identify the independent predictors of child immunization status.

Children born after 1994, whose families resided in urban areas, and whose mothers resided in northern Italy, had positive attitudes toward

immunization, were high school or university-educated, and had received a satisfactory level of information on immunization were more likely to be immunized. This study was extremely thorough in its treatment of the possible independent variables; however it is unfortunate they used non-probability sampling, as this may have caused bias due to noncoverage.

In another study[48], determinants of immunization in children aged 18 – 24 months in Flanders, Belgium were identified. The coverage rate for receiving all recommended vaccines was approximately 92%. A two-stage cluster design was used, and the families of 1,354 children born in 2003 were surveyed. Results of the logistic regression analysis demonstrated that children who were vaccinated at a well baby clinic or day-care, whose mothers were employed on a full time basis, and whose family income was between €2000 – €3000 per month were significantly more likely to be vaccinated compared to children who visited family physicians and pediatricians, whose mothers were unemployed, and whose family income was less than €1500 per month [1Canadian Dollar (CAD) = 0.68 Euro (EUR)]. What is interesting about the results of this paper is the researchers found both employment status and socioeconomic status to be predictive of immunization coverage, despite the fact that the vaccines were offered free of charge. The researchers therefore concluded that reaching families of low socioeconomic status in Flanders, Belgium remains a challenge.

In conclusion, the determinants of immunization status tend to vary a great deal according to which developed country is being studied. Common predictors across countries include socioeconomic status, attending the offices

of experienced physicians, and maternal educational level. Interestingly, the study by Samad et al[46] found that a high level of education in women of the UK can lead to non-immunization in children. This is a curious result, contrary to the majority of other literature, which forces one to consider the mechanisms at play. For example, is it possible that mothers with a high level of education are more likely to have concerns regarding the safety of vaccines and their potential side effects, and therefore choose to not have their children immunized? There exists research that examines the role of resistance to vaccinations in developed countries.[49,50] It would be worthwhile to investigate the potential association between resistance and education. Increasing maternal education is often seen as one of the primary means by which to improve the delivery of child healthcare services, yet such an investigation may indicate that there is the potential for 'too much of a good thing', if in some instances education is indeed leading to less children being immunized.

Determinants of Immunization Status in the Philippines

Research has been undertaken in a number of developing countries to identify the determinants of childhood immunization coverage. However, the vast majority of the literature pertaining to immunization in developing countries is descriptive in nature. For example, a study by Streefland et al[51] examines patterns of vaccination acceptance, and notes that in the Philippines, one bad

experience with vaccination will not tend to deter parents from pursuing further immunization for their children.

In another study by Streefland and colleagues[52], the researchers sought to identify and describe impediments to proper immunization in several countries, including the Philippines. The paper explained that two significant problems contributing to undervaccination were a lack of supplies (e.g. needles and syringes), in addition to insufficient knowledge transfer between healthcare workers and mothers. On a positive note, mothers indicated that waiting times, proximity to healthcare centers, and clinic hours of operation did not pose problems when attempting to access immunization for their children.

There are a number of studies that use more rigorous methods to identify determinants of childhood immunization coverage in the Philippines and other developing countries, and are discussed below. A study by Friede et al[53] sought to evaluate immunization program participation in the province of Cavite in the Philippines. The researchers interviewed families residing within five villages of the province for whom written immunization records were available. Interviewees were asked to confirm the immunization registers' records. In certain instances, the caretaker remembered the child having received more immunizations than were recorded. In cases such as these, the caretaker's version of vaccination status was assumed to be correct, provided he/she could supply details regarding the specific vaccination. Children were deemed "immunized" if they had received two doses of the DPT vaccine, and "non-

immunized" if they had either received one dose, or had not received a single dose.

The authors elected to use the Andersen Behavioral Model (See Page 47) to understand the factors predictive of under-utilization of the immunization services. Pearson chi-squares were used for bivariate analyses, and logistic regression was used to evaluate the independent effect of each variable on the outcome. Variables identified as being independently predictive of complete immunization included living within 0.5km of the site of immunization, having vaccines offered at an "appropriate" time of day, not visiting a "hilot" (women of the village who act as midwives and specialize in pediatric problems), having a parent on the town council, and having a parent who believed the pain involved in being vaccinated is not an important reason to remain unimmunized.

The authors pointed out their surprise at the fact that demographic variables (which are typically associated with undervaccination in developing countries (e.g. household wealth, education, etc.)) were not identified as being associated with the outcome in this study. They felt this was reflective of the study site, which consisted of small rural villages. The researchers thus concluded that it may be more important to consider factors relating to the ability to physically access services (e.g. distance to facility, time of day that immunizations are received, etc.) than socio-demographic factors when attempting to improve immunization coverage in rural areas. A weakness of this study is the small size of the sample, as well as its limited geographic scope. While their research uncovered interesting results, it is difficult to assess

whether their observations could be extrapolated to explain reasons for underimmunization in other rural areas of the Philippines. Further, it would be very difficult to generalize such results to the country's population as a whole.

The second Philippine study was conducted by Nurman et al.[17] The main purpose of this study was to determine whether immunization-specific education would improve compliance in immunizing children. Researchers provided immunization-specific education to mothers of 89 newborns delivered at the University of Santo Tomas Hospital, and used 77 mothers who frequented the hospital's out-patient department as a control group. After giving birth, mothers in the experimental group were provided with a lecture on immunization. Before being discharged, they were given the immunization schedule, instructions regarding immunization, and a vaccination monitoring card. The control group was composed of mothers of children aged 6 – 24 months, who did not receive immunization education.

The researchers used the Kruskal-Wallis and Chi-square tests to evaluate non-parametric data, and Pearson Correlation Coefficients to test for correlations. The results indicated that there was a weak positive correlation between immunization education and status, and that parents who received education regarding vaccines were more likely to follow the Philippine immunization schedule. Marital status, educational attainment, occupation, income, and total number of children did not impact whether immunization-educated mothers followed an immunization schedule. Mothers who did not follow the proper immunization schedule indicated several reasons for not doing

so. These included illness of the child, cost, unavailability of the vaccine, and distance to the health center.

One limitation of this study is that it is not made clear whether the evaluated socio-demographic factors (e.g. educational attainment) influenced the decision to seek care in mothers who were not educated on immunizations upon the birth of their children. Furthermore, as multivariable analyses were not conducted, it is difficult to assess the independent role of each of the explanatory variables. Additionally, the paper discusses the fact that the distance to health facilities and parental beliefs regarding vaccines may negatively influence a child becoming fully immunized. Despite this discussion, the researchers failed to include relevant questions in their surveys, and thus they cannot definitively comment on the impact of either of these factors on the outcome.

The third study conducted in the Philippines, by Auer[54], sought to assess immunization coverage among children 12 – 24 months old in a squatter area of north-west Manila. At the time of the study, the population of this area was approximately 12,000 individuals, 99.7% of whom were living below the national poverty line. The study employed a variation of the WHO's '30 X 7' cluster sampling design (30 clusters, 7 houses per cluster). Owing to local geography, they were unable to identify 30 clusters, and rather divided the area into 19 clusters. Eleven to twelve children were then randomly selected from each cluster, for a total sample size of 216 infants. The vaccination status of these

children were assessed with the use of vaccination cards (35% of children) and mother's verbal reports.

The results indicated that at the time of the survey (1988), only 24% of surveyed children were fully immunized, 57% were partially immunized, and 19% of surveyed children had not received a single vaccination. Approximately two thirds of the study area is reached by Youth With A Mission (YWAM), a mission group that travels door-to-door spreading immunization knowledge, and delivers free vaccinations once a month. The proportion of fully immunized children residing in the areas covered by YWAM (28%) is larger than in children outside of these areas (15%). The authors point out that their results conflict with governmental reports of vaccination coverage which place full coverage at a rate of about 50%. This is an interesting point, however the researchers fail to provide an explanation for this apparent discrepancy. Finally, the paper's descriptive analyses demonstrate that children who have received their vaccines through governmental agencies are more likely to be underimmunized (vs. fully immunized) than children immunized in non-governmental facilities.

The researchers present the following reasons for the low occurrence of full immunization in this sample: i) the perception of time in the Philippine culture is different than that seen elsewhere, which means mothers may more easily forget about 'appointments and fixed dates'; ii) a lack of knowledge and awareness regarding vaccinations in general; and iii) a lack of importance placed on the benefits of immunization.

The authors indicate that the validity of their study may be influenced by the fact that some of the mothers who provided a verbal report could not clearly recall the vaccination status of their children. This study contributes to the literature in that it provides a new and different perspective than that delivered by the Philippine government. The study is mainly descriptive in nature, and builds a foundation in which future research may be rooted.

Other Developing Countries

Developing countries, as defined by the World Bank, are those whose gross national income per capita classifies them as "low income" ($905 or less) or "middle income" ($906 - $11,115).[115]

In Kazakhstan, researchers[55] sought to identify the determinants of immunization in a country which is of lower economic status than most developed countries, yet has a vaccination program which is considered superior to those in developing countries. The 1999 Demographic and Health Survey (DHS) was utilized to study children 12-60 months old. The researchers noted the times at which children were immunized, and subjects were considered fully immunized if they had received all recommended vaccinations by the time outlined by the National Immunization Schedule, or up to one month later. Overall vaccination coverage in this country is relatively high (~85%), which can be attributed to the history of the strong public health system in the former Soviet Union. Multiple logistic regression was used to identify the factors

associated with lower vaccination coverage. Children residing in the former capital region, those with unmarried mothers, and those who are Muslim were less likely to be fully vaccinated.

In the selection of independent variables, the researchers were limited to those which were present in the DHS survey. Certain independent variables were selected based on previous research, while the reasoning behind the inclusion of others was unexplained. A further limitation of this study is its sampling frame - analysis was restricted to children for whom health cards could be produced (91% of total). Compared to children who possess health cards, those who do not may be different in terms of socio-demographic factors. Therefore by simply excluding children who did not possess health cards without first comparing the two groups, the sample may have been subjected to nonsampling bias due to noncoverage.

In Buenos Aires, Argentina, the Secretariat of Health typically determines vaccination coverage by dividing the number of administered vaccine doses by the target population. A study[56] in this region was therefore undertaken to provide a population-based independent assessment of immunization coverage.

The immunization status of children from 13 to 24 months old and 25 to 59 months old was determined in this study. Three children from each age bracket were selected per block in each of the city's census tracts. In order to be included in the survey, a written record of the child's vaccinations was required. It was discovered that 76% of the 1391 children surveyed had received all required vaccines (BCG, polio, DPT, measles). Risk factors which

were significantly associated with incomplete immunization included child's age, zone of residence, birth order, and vaccination provider (public versus private). The three most commonly provided reasons for undervaccination were: i) shortage of money; ii) unavailability of the vaccine; and iii) child was ill at the scheduled time of vaccination.

This survey excluded all children who did not have vaccination cards (approximately 10%), which may have influenced the determined predictors of undervaccination. Furthermore, this study's analysis failed to take into consideration errors in the time a vaccine was received (e.g. if a vaccine was received before or after the suggested age). Therefore, the results fail to take into account the adherence to the suggested timing of the immunization schedule. Proceeding in this manner is not uncommon in studies of immunization coverage, as it can be difficult to ascertain the dates of childhood immunization. Therefore while this is not the most ideal manner in which to study immunization status, it is not uncommon, and therefore the results are likely still comparable across studies.

In India, a cross sectional study[57] of children 24 - 47 months old was undertaken in the urbanized villages of East Delhi, India to identify determinants of immunization. Information was collected by door-to-door interviews of households selected using systematic random sampling, to obtain information on a total of 693 children in total. In order to ensure the validity of maternal recall of immunization, mothers were asked when and where the vaccines were received. It is unclear how the socio-demographic variables were selected for

use in the initial bivariate analysis. In total, 82.7% of children were immunized with BCG, 70.7% with DPT and OPV, and 65.3% with the measles vaccine. Children of literate mothers, those born in a hospital setting, and children who possessed immunization cards were more likely to be completely immunized than children of mothers who cannot read, who were born at home, and who did not have written proof of vaccination.

While this study claims to be one of the first population-based studies to evaluate factors associated with immunization status in India, it is limited to individuals residing in East Delhi. As immunization coverage varies greatly across regions, it is difficult to extrapolate the results of this study to other regions of India.

Data from the 1993-94 Bangladesh DHS were used to evaluate immunization coverage among children 12 - 23 months old in rural areas of the country. This study by Jamil et al[58] specifically sought to identify modifiable factors that are associated with immunization so that health programs may be improved. Both vaccination cards and maternal recall were used to determine the immunization status of the child. The results indicate that characteristics of the health program (e.g. proximity to healthcare clinics) are less likely to affect immunization status than are socio-demographic and economic factors of the individual and/or household. Children of mothers who had completed at least primary school, males, and those residing in Khulna region and in economically advantaged households were more likely to be fully immunized than children of mothers who have not completed primary school, females, and those residing in

Dhaka, Chittagong, and Rajshahi and in economically disadvantaged households.

In another study[59] undertaken in Bangladesh, a convenience sample of 113 children aged 6 weeks to 23 months who were patients of the International Centre for Diarrheal Disease Research was selected for inclusion in the study. When these children were brought to the clinic to receive their DPT1 vaccine, their caretakers were interviewed about their education, their marital status, etc., as well as to ascertain their knowledge regarding immunizations. At this meeting they were informed that their children would require a second dose (DPT2) in four weeks. Six weeks later, parents were once again interviewed to determine whether their children had received DPT2.

A higher level of parental education, greater household wealth, and more knowledge concerning the DPT vaccine were found to be associated with children receiving the follow-up DPT2 vaccine. One of the strengths of this study is that the researchers were able to assess knowledge regarding vaccinations before the desired event had occurred; the gathered information was therefore unlikely to be affected by recall bias. The study is also unique in that it identifies the determinants of receiving (or not receiving) a single follow-up vaccination, as opposed to full (versus incomplete) immunization.

In a study[6] of rural and urban sections of Istanbul, Turkey, the '30 X 7' cluster sampling method was used to evaluate immunization coverage in 221 children from 9 months to 6 years of age. Immunization status was determined based on record cards and mother's verbal report. Children were considered

fully immunized if they had received one dose of BCG and measles vaccine, and three doses of OPV, DPT, and Hepatitis B vaccines by the age of 18 months. Children older than 18 months were deemed fully immunized if they had additionally received booster doses for OPV and DPT. This study found that the overall vaccination coverage rate was 84.5%. Determinants of full immunization in children included higher levels of maternal and paternal education, and a greater amount of time since the immigration of the parents to Istanbul. Reasons for non-vaccination included not being able to access healthcare services, being unaware of vaccinations, disallowance by the child's father, and illness of the child at the scheduled time of vaccination.

The study included in the analyses all children of the appropriate age living in the surveyed households. As siblings and other children living within the same household are subjected to the same external environment, they cannot be considered to be independent observations. Accordingly, it would have been preferable to exclude all but one child from each household, so as to ensure the independence of observations, and eliminate the potential for sampling frame bias.

In another Turkish study[114], researchers sought to identify the determinants of immunization coverage in the South-East Anatolian Project (SEAP) region. This is an area inhabited by individuals with lower levels of education and socio-economic status than other regions of Turkey. Data on the immunization status of 734 children between the ages of 2 – 59 months old

were collected from their parents or caregivers, using a questionnaire that was administered in face-to-face interviews.

Variables found to be associated with having up-to-date vaccinations included living in an urban (versus rural) setting, having a lesser number of siblings, having greater birth intervals between siblings, the mother being visited by a midwife after giving birth, and higher levels of maternal education.

A possible limitation of this study was the fact that 17.2% of the respondents did not know whether their children had been vaccinated. This may have led to nonsampling bias due to nonresponse.

A study conducted by Mashal et al[60] assessed variations in immunization coverage across 331 districts of Afghanistan, over a period of four years (2000-2003). Data were derived from immunization coverage reports which were produced using the combined efforts of UNICEF, the WHO, and the Afghanistan Ministry of Public Health. These data were utilized to assess the differences in immunization coverage across the varying districts and regions of the country.

Owing to the ongoing social unrest in the country, the researchers considered the level of security (occasionally insecure; insecure; highly insecure) within each region of the country and its effect on immunization coverage. It is not surprising that children residing in more secure regions are significantly more likely to have been vaccinated than children living in unstable areas.

This study did not use a survey to ascertain immunization coverage. Rather than using information from vaccination cards and mothers verbal

reports, vaccination statistics were derived from national databases. It was then possible to estimate coverage rates by dividing the reported number of children under the age of 12 months of age who had been vaccinated by the estimated total population under 12 months of age. The latter was derived by taking 2002 census data, and making an assumption regarding the general level of population growth that occurred over the course of the four years examined by the study. A limitation of using this method to determine immunization coverage is that not all children under the age of 12 months would have reached the age to have received all required vaccines, which would therefore underestimate the number of fully vaccinated children.

One of the major strengths of this study is that it estimates immunization coverage in each district and region of the country. The results could therefore be utilized in a future study to assess and compare the predictors of full immunization status in different geographical areas of the country, and how they change over time (provided information related to potential independent variables could be obtained).

In a study[61] undertaken in Pakistan, information pertaining to 107 districts, within 4 major provinces of Pakistan, was derived from reports published by the Pakistan Census Bureau and the UNICEF "third party evaluation" household surveys. These utilized the WHO's '30 X 7' cluster sample, which is typical for use in evaluating the Expanded Programme on Immunization.

There was only one variable associated with individuals being immunized, and that was the possession of a television set. Though this variable was originally included as one of several indicators of economic status, the results led the researchers to use the face value of the variable in order to interpret the association between it and the outcome. In Pakistan, a large portion of immunization promotion occurs via television advertisements. The researchers therefore concluded that it was not wealth that was related to immunization status, but rather the acquirement of knowledge regarding vaccines.

As information on full immunization status was not available to the researchers, they used the presence or absence of DPT3 as a proxy indicator for all other immunizations. The underlying assumption was that children who had received DPT3 are likely to have received all other vaccines recommended by the EPI. This definition of "fully immunized" is different than that employed in most other studies, and thus the results may be difficult to compare across studies. A further limitation is that due to political instability, data were not collected from all of the country's provinces. This could lead to nonsampling bias due to noncoverage.

In conclusion, the determinants of immunization in developing countries can vary greatly according to the country and region within a country that is being studied. Maternal/parental education, household wealth, parental marital status, and total number of children in a family are factors about which there exists conflicting results as to their association with immunization

outcome.[6,17,53,57,58,59,114] Factors that have been identified as determinants of immunization include birth order[56], religion[55], and region of residence within a country[55,56,58,114]. In the Afghanistan study[60], political stability was also shown to impact vaccination coverage. When parents were given the opportunity to explain the reason(s) for which their children were not vaccinated, common responses included: a lack of vaccine supplies[17,52,56], the cost[17,56], the child being ill on the scheduled vaccination date[6,17,56], and an extended distance to the health facility[17,53]. These conflicting data make it difficult to generalize the results of studies across countries. In addition, given the contextual differences across countries, it is imperative to undertake country specific analyses of determinants of immunization status.

Limitations of Current Research

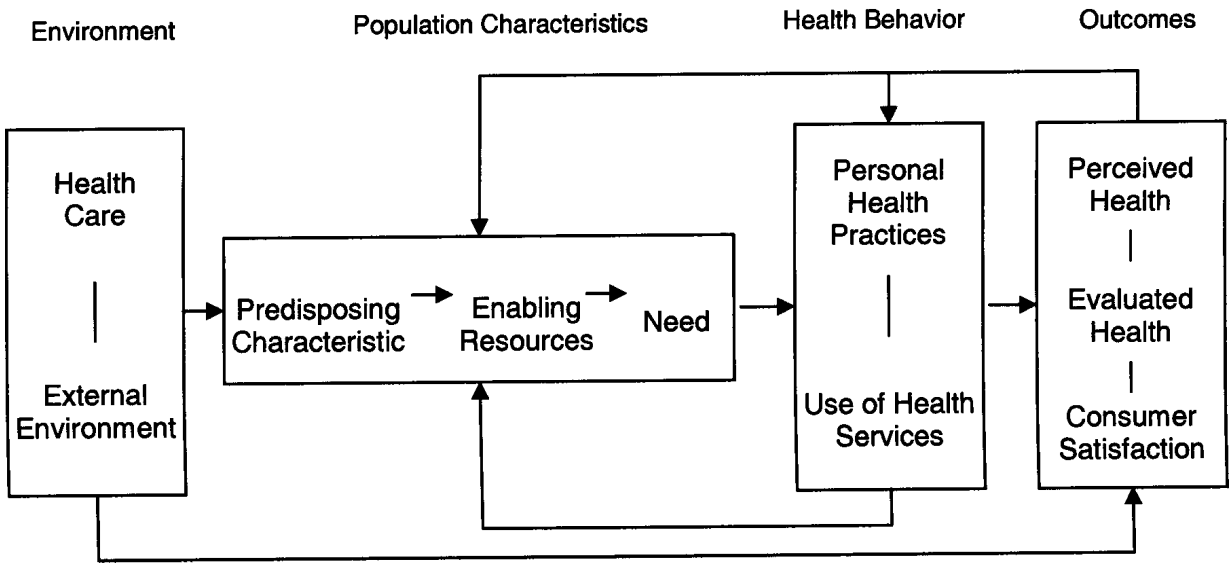
Literature pertaining to childhood immunization coverage levels varies according to ages studied, the employed definitions of full and partial immunization, the use of single vs. multiple vaccinations, and the method of validation of the receipt of immunizations. There exists varying levels of coverage within and among countries, as characteristics of the individual/household, such as maternal education, household wealth, number of siblings, and region of residence can all impact immunization rates.

The majority of information pertaining to immunization coverage in developing countries is descriptive in nature. There exists a small body of

literature which has utilized rigorous models to assess the determinants of immunization status. Those that do exist are typically marked by small sample sizes, and are geographically limited (i.e. they evaluate immunization coverage within regions of a country, as opposed to within the nation as a whole). Studies relating to determinants of immunization in the Philippines are no exception. The one study of which we are aware that has utilized a conceptual model to identify determinants of immunization was conducted by Friede et al.[53] Though this study is methodologically sound, and makes note of some interesting points, it was limited to a sample of 145 children, in a single province of the Philippines, and was published in 1985, using data from 1980.

Conceptual Model

The Andersen Behavioral Model[62] provides a conceptual framework by which to study factors which determine an individual's access to and utilization of healthcare (see Figure 2, p. 47). This model has been successfully used to identify child health service use in developing countries.[5,63,64,65,66] There are a variety of predictive models in existence which measure health-related behaviours (e.g. Fabrega[67], Kosa and Robertson[68], Suchman[69]). However there are but a handful which would be best suited to measure the outcome of our study (e.g. Kasl and Cobb[70], Kar[71], Rosenstock[72]). Of these, there are fewer still which have a wide enough breadth to take into account all potential



Adapted from Andersen[62]

Figure 2: *The Andersen Behavioral Model*

predictive factors. It is for this reason that we selected for use the Andersen Behavioral Model.The Andersen Behavioral Model suggests that individual health services utilization is determined by characteristics of the individual, his/her milieu, and

health behaviours. Characteristics of the population affect the group as a whole, and may consequently have an impact on individual care-seeking behaviour. It is possible that the type of health care system found in a particular country or region and an area's environment may affect an individual's decision to seek care. These may be further broken down into the demographic composition of the population, as well as its social norms and beliefs.[73] Health policies, finances, and the physical environment of the region may also affect the group.[73,74]

Individual characteristics describe traits that may predispose, enable, or contribute to an individual's need for care. Among the predisposing characteristics are demography (e.g. age and gender)[73,74,75,76], social traits (e.g. level of education)[73,74,75,76], and beliefs (e.g. religion)[73,74,75]. Enabling resources may be divided into finances (e.g. household wealth)[73,74,75,76], and organization of health care services (e.g. location of residence)[75]. Finally, need may be measured as it is perceived by the individual, or as it is evaluated by a healthcare professional. In the case of the former, an opinion may be given by the individual or by a family caregiver with respect to health status, as well as number and type of symptoms experienced in a given period of time.[75,76,77] Alternatively, when examined by a healthcare professional, need may be

evaluated in a variety of manners, including with the use of an instrument which has been developed to evaluate the severity of an illness.[73,75,77]

The 'Health Behaviors' component of the model includes personal health practices (e.g. how an individual seeks a particular form of care), as well as the decision to use health services.[74] To evaluate the use of health services, the Andersen Behavioral Model examines consumer satisfaction[76], as well as both the perceived and evaluated health of the individual[73,75].

Research objectives

Our study will utilize a widely accepted conceptual model to examine the determinants of immunization status in children 12 – 23 months old who reside in the Philippines. The current study has been undertaken, in part, due to the paucity of relevant literature and information, especially as it pertains to the Philippines. The first step in attempting to increase vaccination coverage is to identify factors that are predictive of immunization. This study seeks to answer the following question: what are the determinants of immunization status in children in the Philippines aged 12-23 months?

METHODS*

Data Source

The "Measure DHS" (Demographic and Health Survey) project contributes to the collection and distribution of data relating to health and population trends in developing nations.[3] DHS surveys are implemented in such a way as to ensure that the results may be compared across countries. The project is funded by the United States Agency for International Development (USAID), and is implemented by Macro International Inc., along with Johns Hopkins University Bloomberg School of Public Health, Program for Appropriate Technology in Health, Casals and Associates, and Jorge Scientific Corporation. The DHS program has conducted National Demographic and Health Surveys (NDHS) in over 75 countries, and these surveys typically take place every five years. The 2003 Philippines NDHS is the eighth demographic survey to be carried out in this country since 1968.

The dataset analyzed for this research project was the 2003 Philippines NDHS. The results from this demographic survey outline the state of the Filipino population and its health. Such vital information may be utilized by health authorities to enhance the health services currently available in the Philippines. One of the survey's five main goals was to "collect high-quality data on family

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* 'Data Source', 'Data Collection', 'Subject Recruitment', 'Enrollment Criteria', and 'Creation of Thesis Data Set' are sections based heavily on information retrieved from the Measure DHS website[78], and the introduction of the Philippine National Demographic and Health Survey 2003[3].

health, including immunizations".[3] The survey was conducted by the Philippines National Statistics Office (NSO), and the financial costs associated with the implementation of the survey were covered by the United States Agency for International Development (USAID).

Data Collection

Forty-four interviewing teams collected data from June 16 to September 3, 2003. Each of these was composed of a team supervisor, a field editor, three or four female interviewers, and one male interviewer.

Upon completion, questionnaires were returned to the NSO Central Office in Manila. Data editing, entry and verification were conducted by the Demographic and Social Statistics Division of the NSO. The manual editing began on July 15, 2003, and the data entry began on July 21, 2003. The census and Survey Processing System (a computer package program) was utilized for data entry, editing, and tabulation. All data processing was completed by October 29, 2003.

Subject Recruitment

A Filipino master sample was designed and approved in 2003, and was based on the 2000 Census of Population and Housing. The sample utilized in

the Philippines' 2003 NHDS was a replicate of the new master sample that was designed in such a way as to ensure representation from both urban and rural areas, as well as from each of the country's 17 administrative regions. A three-stage cluster sampling design was employed in each of the 17 regions. The first stage of sampling saw 819 primary sampling units (PSUs) selected, with a probability proportional to the number of households identified in the 2000 census. Each PSU was composed of a *barangay* (the smallest unit of local government in the Philippines) or a group of adjacent *barangays*. In each PSU, enumeration areas (EAs) were selected with probability proportional to the number of EAs in the second stage of sampling. For the purpose of this survey, an EA was defined as an area that was distinct in its geographical boundaries – each EA consisted of approximately 150 adjacent households. From May 7 to 21, 2003, all households in the selected EAs were listed. In the third and final stage of sampling, approximately 17 households were selected from each EA, using a systematic sampling approach. In total, 13,914 households were selected, 12,694 of which were occupied, and 12,586 of which responded (response rate of 99% in both rural and urban areas).

As a result of the methods used to select the sample for the NDHS, the findings are likely to apply to all Philippine children between 12 and 23 months old who have lived in the Philippines since their birth (the target population).

Enrollment Criteria

The four questionnaires utilized in the 2003 NDHS included a Household Questionnaire, a Health Module, a Women's Questionnaire, and a Men's Questionnaire. The Women's Questionnaire collected information from women aged 15-49 years (these cut-offs were chosen in order to reach the majority of women of reproductive age). This questionnaire gathered information on a variety of topics, including reproductive behaviours, antenatal care, children's health, breastfeeding and nutrition, and sexually transmitted infections. Information on immunization was gathered via vaccination record cards and mother's verbal reports. Research indicates that maternal recall can be relied upon to assess the level of immunization coverage across the population.[79,80] Among the interviewed households, there were 13,945 eligible female respondents, of which 13,633 completed the questionnaire (response rate of 98% in both rural and urban areas).

Creation of Thesis Data Set

For the purposes of our research question, our study looked at women who had given birth to at least one child in the preceding 5 years (since the time of the 1998 NDHS), who was between the ages of 12 and 23 months old. We limited our study to this age bracket, as those children less than one year of age

would not have had the opportunity to be fully immunized, as per the country's immunization schedule (see Table 1, p. 20 – Immunization Schedule). The Demographic and Health Survey uses maternal recall to determine the immunization status of children lacking immunization cards. Over the course of the years since a child's birth, the recall bias introduced by a mother may increase, and we therefore reasoned that by limiting our study to those children under the age of two years we would reduce the possibility of such a survey error.

Among the women who responded to the survey, there were 1,354 respondents who fit this description, and these women had given birth to a total of 1,362 children. If a woman had given birth to more than one child in that time period, only one child from each woman was randomly selected and included in our sample, which meant the sample was of 1,354 children. There were 30 women who failed to provide an answer to every question pertaining to immunization status. Children for whom data were missing, or whose mothers answered "don't know" to any of these questions were eliminated from the sample, leaving us with a total sample size of 1,324 children.

There was very little missing data with regards to the independent variables. For example, survey questions regarding the following variables were answered in complete: maternal age, maternal education, number of household members, number of children 5 and under, ethnicity, birth order, region of residence, type of place of residence, and wealth index. Therefore the only two variables for which there were missing data was paternal education and

antenatal visits for pregnancy. These variables were missing only 25 and 142 units of their data, respectively.

Selection and Definition of Variables

Dependent Variable: The dependent variable in this study was the immunization status of Filipino children aged 12 - 23 months. Written immunization records, as well as mothers' verbal reports were used to determine children's vaccination status. In Section 4B "Immunization, Health and Nutrition" of the Women's Questionnaire, mothers were asked whether their children had vaccination cards, and approximately 39% of respondents were able to produce the card. Interviewers transcribed the information from the cards, which included whether children had received the BCG, polio 1, polio 2, polio 3, DPT 1, DPT 2, DPT 3, and measles vaccines. In the majority of cases, the date of immunization was also obtained from the vaccination card. Mothers who were unable to produce vaccination cards for their children were asked whether their children had received the vaccines for each disease. If they answered yes, they were asked how many doses of each vaccine were received, and when each of these events took place. From this information, we created a single variable, "immuniz", whereby children were categorized as being "fully vaccinated" if they had received all eight doses of the vaccines recommended by the EPI (BCG, 3 Polio, 3 DPT, Measles); "partially vaccinated"

if they had received some of these vaccinations; and "not vaccinated" if they had not received any of these vaccinations.

Independent Variables (see Table 3, p.57): The predisposing variables included maternal age, which was measured continuously in years, and maternal and paternal education, which were each divided into four categories – No Education/Incomplete Primary; Complete Primary/Incomplete Secondary; Complete Secondary; Higher Education.[6] These categories were used to ensure comparability of our results with other studies. Binary variables were created for number of household members and birth order (2-5 and 6-22; 1-2 and 3+, respectively), while number of children in the house 5 years and under was coded as 1, 2, or 3-5, again, categories were selected in this manner for the purpose of comparison with other studies.[6,55] Finally, ethnicity was defined as either Tagalog, Cebuano, Ilocano, Ilonggo, or Other. In its original form, this variable had 23 different ethnicity response categories, in addition to an "Other" category. We reduced the number of response categories to five, based on the criterion of having at least 100 respondents per ethnicity grouping.

There were three enabling variables assessed in this study: type of place of residence (urban or rural), region of residence (National Capital Region, Luzon, Visayas, or Mindanao), and wealth index quintile. We maintained the original questionnaire response categories for the variables 'type of place of residence' and 'wealth index quintile'. The region of residence variable was originally subdivided into 17 response categories. For policy relevant purposes,

TABLE 3 *Predisposing, Enabling, and Need Factor Variables Used in the Analyses*

Predisposing Characteristics	**Enabling Factors**	**Need Factors**
Maternal Age	Region of Residence	Antenatal visits for pregnancy
Maternal Education	Type of Place of Residence (Urban or Rural)	
Paternal Education	Wealth Index	
Number of Household Members		
Number of Children 5 and Under		
Ethnicity		
Birth Order		

we chose to combine the smaller regions into larger geographical categories, and maintained the National Capital Region as a separate entity.

With respect to the wealth index, it is difficult to assess household income in developing countries, as many individuals are engaged in seasonal employment, which can be unpredictable in terms of money earned. As such, wealth was evaluated by indexing all household assets (e.g. telephone, personal computer, car, etc.) and utility services (i.e. connection to water supply and telephone, and type of water source), as per the method developed by Filmer & Pritchett.[81,82] Using principal component analysis, this method assigns weights to each indicator. The assets and utilities are multiplied by their respective weights, and are then summed, thus creating a wealth index which can be ranked to compare household wealth. This method has been validated and utilized by a number of studies.[83,84,85,86] The wealth index was included in the DHS dataset, and was calculated by ORC Macro.

Need is a key component of the Andersen Behavioral Model, and can be of two types – evaluated and perceived. Evaluated need, as referenced in the Andersen Model, is determined by clinicians and researchers in the healthcare field who study, establish, and evaluate standards of care. In the case of immunizations, it is important for children to receive all those that are recommended by the EPI, and therefore the evaluated need for immunizations is 100%. As such, we cannot include evaluated need in our model, as it is the same for all children. The Andersen Model also expresses need as it is perceived by the individual or his/her caregiver. Different mothers are likely to

have different opinions as to the need for vaccinations, and therefore perceived need varies between subjects. Our model therefore makes use of perceived need in order to assess the role of need in obtaining vaccines.

As no specific question within the survey specifically discussed the perception of need, it was necessary to use a proxy. Number of maternal antenatal visits (0-3, or 4+) was selected as the proxy as we hypothesized that having attended at least the minimally-recommended number of antenatal visits (four) would increase the likelihood of mothers been informed about child healthcare in general, as well as the need for vaccination, specifically. The variable was originally coded continuously, however we dichotomized it so that our results would be more meaningful from a policy standpoint.

Data Analysis[*]

The data were analyzed using Stata version 9.0.[87] The unit of analysis was a child between the age of 12 – 23 months old. After running the model both with and without the survey weights, we elected to use the unweighted data as the weighting did not influence the results (See Appendix). An additional reason to not use the weights is because they were not calculated for our unit of analysis, the children, but rather for the surveyed women.

Bivariate analyses were conducted in order to assess the association between immunization status and the predisposing, enabling, and need factors.

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[*] Information on the statistical model is taken from the Stata 9 Reference Manual.[88]

A one-way ANOVA was used to assess the difference in mean age of mothers of children in the three immunization status groups. Pearson chi-square tests were used to evaluate the relationship between the explanatory categorical variables and the three immunization status groups.

Multinomial logistic regression was utilized to determine the independent effect of each of the predisposing, enabling and need variables on immunization status. Multinomial logistic regression is used when the dependent variable (immunization status) has k ($k > 2$) classes; in this case, 1 = not vaccinated; 2 = partially vaccinated; and 3 = fully vaccinated. We arbitrarily selected two separate bases (1 and 2) and ran two models. This enabled us to compute the relative odds of three novel contrasts (e.g. 1 vs. 2 and 1 vs. 3 in the first model, and 2 vs. 3 in the second model). In this model, coefficients corresponding to each outcome are calculated (e.g. $\beta^{(1)}$, $\beta^{(2)}$, $\beta^{(3)}$). The model is as follows[88]:

$$\Pr(y=1) = e^{X\beta(1)} / (e^{X\beta(1)} + e^{X\beta(2)} + e^{X\beta(3)})$$

$$\Pr(y=2) = e^{X\beta(2)} / (e^{X\beta(1)} + e^{X\beta(2)} + e^{X\beta(3)})$$

$$\Pr(y=3) = e^{X\beta(3)} / (e^{X\beta(1)} + e^{X\beta(2)} + e^{X\beta(3)})$$

Say we select $\beta^{(1)}$ as the base. Then $\beta^{(1)} = 0$, and the equations become:

$$\Pr(y=1) = 1 / 1 + e^{X\beta(2)} + e^{X\beta(3)})$$

$$\Pr(y=2) = e^{X\beta(2)} / (1 + e^{X\beta(2)} + e^{X\beta(3)})$$

$$\Pr(y=3) = e^{X\beta(3)} / (1 + e^{X\beta(2)} + e^{X\beta(3)})$$

Then the relative probability of y = 2 and y = 3 to the base outcome is:

$$\Pr(y=2) / \Pr(y=1) = e^{X\beta(2)}$$

$$\Pr(y=3) / \Pr(y=1) = e^{X\beta(3)}$$

Let us call this ratio the conditional odds. The exponentiated value of a coefficient is the conditional odds ratio for a one-unit change in the corresponding variable X.

Variance inflation factors were computed using linear regression in order to exclude the possibility of multicollinearity between the independent variables. None of these exceeded 2.50, which is the level proposed by Allison[89] to be potentially indicative of multicollinearity. To ensure the independence of irrelevant alternatives (IIA), the Hausman[90] and Small-Hsiao[91] tests of IIA assumption were utilized. Neither of these produced significant results, indicating that the odds of each outcome are indeed independent of other alternatives.

The possibility of antenatal visits differentially affecting immunization status depending on the level of maternal education and household wealth was considered by testing for significant interactions between these variables. The interaction terms were not found to be statistically significant, and therefore it was concluded that it is unlikely that interactions are playing a role in the association between the independent and dependent variables.

RESULTS

Description of Sample

A description of the sample of 1,324 children and their mothers can be found in Table 4 (p.63), which outlines how many individuals make up the categories of each of the predisposing, enabling, and need factors. With respect to the predisposing characteristics, the mean age of mothers who had responded to the survey was 29 years old. The majority of parents had completed at least a primary education, with the greatest number of mothers and fathers falling into the "compete primary/incomplete secondary" category. The majority of households were composed of more than six people; only about 20% of mothers had more than two children under the age of five in their homes; and the number of first and second-borns vs. later-born children was split about evenly. The two dominant ethnic groups in our sample were Tagalog and Cebuano, which together accounted for nearly half of all respondents. Regarding the enabling resources, nearly two fifths of the women resided in the Luzon island grouping, while the rural/urban divide was about even. Over half of respondents were classified in the "Lowest" and "Lower Middle" wealth groupings. Finally, with respect to the need factor, approximately two thirds of women had received the minimally-recommended four antenatal visits.

TABLE 4 *Description of sample*

Characteristic	**Description** N (% of total)
Predisposing Factors	
Mother's Age (mean)	29.0 years
Maternal Education	
No Education/Incomplete Primary	216 (16.3)
Complete Primary/Incomplete Secondary	439 (33.2)
Complete Secondary	327 (24.7)
Higher	342 (25.8)
Paternal Education	
No Education/Incomplete Primary	269 (20.7)
Complete Primary/Incomplete Secondary	408 (31.4)
Complete Secondary	289 (22.3)
Higher	333 (25.6)
Number of Household Members	
2-5	623 (47.1)
6-22	701 (52.9)
Number of children 5 and under	
1	490 (37.0)
2	573 (43.3)
3-5	261 (19.7)
Ethnicity	
Tagalog	295 (22.3)
Cebuano	351 (26.5)
Ilocano	125 (9.4)
Ilonggo	109 (8.2)
Other	444 (33.6)

TABLE 4 (continued) *Description of sample*

Characteristic	Description N (% of total)
Birth Order	
1-2	666 (50.3)
3 or more	658 (49.7)
Enabling Factors	
Region	
National Capital Region	183 (13.8)
Luzon	503 (38.0)
Visayas	245 (18.5)
Mindanao	393 (29.7)
Type of place of residence	
Urban	612 (46.2)
Rural	712 (53.8)
Wealth Index	
Lowest	398 (30.0)
Lower Middle	298 (22.5)
Middle	243 (18.3)
Upper Middle	218 (16.5)
Highest	169 (12.7)
Need	
Antenatal visits for pregnancy	
Less than 4	379 (32.1)
4 or more	803 (67.9)

Bivariate Analyses

Of the 1,324 children whose mothers were surveyed, a total of 916 (69.2%) had been fully vaccinated (see Table 5, p.66 for a list of all variables). Children with lower birth orders, and those residing in households with less than 6 members and with fewer children under 5 years of age were more likely to be fully vaccinated. A child's likelihood of being fully immunized increased with his/her mother's and father's level of education, the number of antenatal visits for pregnancy, and household wealth. Mothers whose families resided both in urban areas, as well as within the National Capital region were more likely to have fully immunized children than people who resided in rural areas and in other regions of the country. Ethnicity was also a significant variable at the bivariate level. Maternal age was not a statistically significant predictor of full immunization status in children, though there was a trend approaching significance ($p = 0.053$). We used the results of the bivariate analysis as a screening tool for variable inclusion in the multivariable model, and therefore included all independent variables in the multinomial model.

Multinomial Regression Analyses

A multinomial multivariable logistic regression model was utilized in order to identify independent predictors of immunization status.

TABLE 5 *Vaccination status as related to child and/or household characteristics*

Characteristic	Row Total	Vaccination Status: Not Vaccinated (n = 103)	Partially Vaccinated (n = 305)	Fully Vaccinated (n = 916)	X^2 (df) *p*-value
Predisposing Factors					
Continuous Variables			mean ± SD		
Mother's Age	1,324	30.4 ± 7.5	28.9 ± 6.7	28.8 ± 6.3	F=3.76 (2, 1321) =0.053
Categorical Variables			*n* (row %)		
Maternal Education					
No Education/ Incomplete Primary	216	42 (19.4)	64 (29.7)	110 (50.9)	103.3 (6) <0.001
Complete Primary/ Incomplete Secondary	439	40 (9.1)	125 (28.5)	274 (62.4)	
Complete Secondary	327	11 (3.4)	71 (21.7)	245 (74.9)	
Higher	342	10 (2.9)	45 (13.2)	287 (83.9)	
Paternal Education					
No Education/ Incomplete Primary	269	46 (17.1)	85 (31.6)	138 (51.3)	77.8 (6) <0.001
Complete Primary/ Incomplete Secondary	408	32 (7.8)	98 (24.1)	278 (68.1)	
Complete Secondary	289	15 (5.2)	60 (20.7)	214 (74.1)	
Higher	333	9 (2.7)	56 (16.8)	268 (80.5)	
Number of Household Members					
2-5	623	37 (5.9)	138 (22.2)	448 (71.9)	7.0 (2) =0.029
6-22	701	66 (9.4)	167 (23.8)	468 (66.8)	
Number of children 5 and under					
1	490	25 (5.1)	89 (18.2)	376 (76.7)	25.5 (4) <0.001
2	573	48 (8.3)	143 (25.0)	382 (66.7)	
3-5	261	30 (11.5)	73 (28.0)	158 (60.5)	

TABLE 5 (continued) *Vaccination status as related to child and/or household characteristics*

Characteristic	Row Total	Vaccination Status: Not Vaccinated (n = 103)	Partially Vaccinated (n = 305)	Fully Vaccinated (n = 916)	X^2 (df) *p*-value
Ethnicity					
Tagalog	295	15 (5.1)	64 (21.7)	216 (73.2)	
Cebuano	351	19 (5.4)	86 (24.5)	246 (70.1)	28.3 (8)
Ilocano	125	7 (5.6)	28 (22.4)	90 (72.0)	<0.001
Ilonggo	109	8 (7.3)	17 (15.6)	84 (77.1)	
Other	444	54 (12.2)	110 (24.7)	280 (63.1)	
Birth Order					
1-2	666	31 (4.6)	125 (18.8)	510 (76.6)	36.2 (2)
3 or more	658	72 (11.0)	180 (27.3)	406 (61.7)	<0.001
Enabling Factors					
Region					
National Capital Region	183	10 (5.5)	33 (18.0)	140 (76.5)	
Luzon	503	25 (5.0)	124 (24.6)	354 (70.4)	25.8 (6)
Visayas	245	18 (7.4)	51 (20.8)	1876 (71.8)	<0.001
Mindanao	393	50 (12.7)	97 (24.7)	246 (62.6)	
Type of place of residence					
Urban	612	37 (6.0)	118 (19.3)	457 (74.7)	16.1 (2)
Rural	712	66 (9.3)	187 (26.2)	459 (64.5)	<0.001
Wealth Index					
Lowest	398	64 (16.1)	117 (29.4)	217 (54.5)	
Lower Middle	298	16 (5.4)	73 (24.7)	207 (69.9)	88.9 (8)
Middle	243	10 (4.1)	45 (18.5)	188 (77.4)	<0.001
Upper Middle	218	9 (4.1)	48 (22.0)	161 (73.9)	
Highest	169	4 (2.4)	22 (13.0)	143 (84.6)	
Need					
Antenatal visits for pregnancy					
Less than 4	379	66 (17.4)	109 (28.8)	204 (53.8)	92.6 (2)
4 or more	803	25 (3.1)	162 (20.2)	616 (76.7)	<0.001

Table 6 (p. 69) outlines the unadjusted results while Table 7 (p.71) provides the results adjusted for the other covariates in the model.

Not vaccinated versus partially vaccinated: Children of mothers who had received at least the four recommended antenatal visits were more than three times as likely to receive some, versus no, vaccinations (OR = 3.29, $p<0.001$). Maternal age, maternal or parental educational attainment, number of household members, number of children under five years, ethnicity, birth order, household wealth, type of place of residence, and region were not significant determinants in this model.

Not vaccinated versus fully vaccinated: Children of mothers who had completed secondary school were approximately three-and-a-half times more likely than children whose mothers had not completed primary school to have received all, as opposed to no, vaccinations (complete secondary: OR = 3.54, $p = 0.006$; higher: OR = 3.66, $p = 0.013$). As maternal educational level increased, the odds ratio also increased, indicating children of more educated mothers were more likely to be fully immunized. Children whose mothers identified themselves as Cebuano were three-and-a-half times more likely to be fully vaccinated than children of Tagalog mothers (OR = 3.60, $p = 0.013$). Children residing in households that are categorized as lower middle, middle, and highest wealth index quintiles were two-and-a-half, more than three, and more than four times more likely, respectively, to have received all recommended vaccines (lower middle: OR = 2.48, $p = 0.010$; middle: OR = 3.33, $p = 0.016$; highest: OR = 4.39, $p = 0.048$). As is the case with education,

TABLE 6 *Unadjusted multinomial logistic regression results of models predicting non vaccination vs. partial vaccination, non vaccination vs. full vaccination, and partial vaccination vs. full vaccination*

Characteristic	Conditional Odds Ratio Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Predisposing Factors			
Mother's Age	0.96**	0.96**	1.00
Maternal Education			
No Education/Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	2.05**	2.62**	1.28
Complete Secondary	4.24**	8.50**	2.01**
Higher	2.95**	10.96**	3.71**
Paternal Education			
No Education/Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	1.66	2.90**	1.75**
Complete Secondary	2.16**	4.76**	2.20**
Higher	3.37**	9.93**	2.95**
Number of Household Members			
2-5	--	--	--
6-22	0.68	0.59**	0.86
Number of children 5 and under			
1	--	--	--
2	0.84	0.53**	0.63**
3-5	0.68	0.35**	0.51**
Ethnicity			
Tagalog	--	--	--
Cebuano	1.06	0.90	0.85
Ilocano	0.94	0.89	0.95
Ilonggo	0.50	0.73	1.46
Other	0.48	0.36**	0.75

** *p*-value < 0.05

TABLE 6 (continued) *Unadjusted multinomial logistic regression results of models predicting non vaccination vs. partial vaccination, non vaccination vs. full vaccination, and partial vaccination vs. full vaccination*

Characteristic	Conditional Odds Ratio Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Birth Order			
1-2	--	--	--
3 or more	0.62	0.34**	0.55**
Enabling Factors			
Region			
National Capital Region	--	--	--
Luzon	1.50	1.01	0.67
Visayas	0.86	0.70	0.81
Mindanao	0.59	0.35**	0.60**
Type of place of residence			
Urban	--	--	--
Rural	0.89	0.56**	0.63**
Wealth Index			
Lowest	--	--	--
Lower Middle	2.50**	3.82**	1.53**
Middle	2.46**	5.54**	2.25**
Upper Middle	2.92**	5.28**	1.8**
Highest	3.01	10.54**	3.50**
Need			
Antenatal visits for pregnancy			
Less than 4	--	--	--
4 or more	3.92**	7.97**	2.03**

** *p*-value < 0.05

TABLE 7 *Multinomial logistic regression results of models predicting non vaccination vs. partial vaccination, non vaccination vs. full vaccination, and partial vaccination vs. full vaccination, n = 1158*

Characteristic	Conditional Odds Ratio Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Predisposing Factors			
Mother's Age	1.0	1.0	1.0
Maternal Education			
No Education/Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	1.3	1.4	1.1
Complete Secondary	2.4	3.5**	1.5
Higher	1.6	3.7**	2.3**
Paternal Education			
No Education/Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	1.0	1.5	1.5
Complete Secondary	0.9	1.1	1.2
Higher	1.3	1.4	1.1
Number of Household Members			
2-5	--	--	--
6-22	0.8	0.9	1.1
Number of children 5 and under			
1	--	--	--
2	1.1	0.7	0.7**
3-5	1.0	0.6	0.6**
Ethnicity			
Tagalog	--	--	--
Cebuano	2.5	3.6**	1.4
Ilocano	1.2	1.4	1.2
Ilonggo	1.2	2.0	1.7
Other	1.3	1.9	1.4

** p-value < 0.05

TABLE 7 (continued) *Multinomial logistic regression results of models predicting non vaccination vs. partial vaccination, non vaccination vs. full vaccination, and partial vaccination vs. full vaccination, n = 1158*

Characteristic	Conditional Odds Ratio Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Birth Order			
1-2	--	--	--
3 or more	1.4	0.9	0.7**
Enabling Factors			
Region			
National Capital Region	--	--	--
Luzon	2.2	2.5	1.2
Visayas	1.0	1.4	1.4
Mindanao	0.8	0.7	0.9
Type of place of residence			
Urban	--	--	--
Rural	1.8	1.6	0.9
Wealth Index			
Lowest	--	--	--
Lower Middle	1.9	2.5**	1.3
Middle	2.2	3.3**	1.5
Upper Middle	1.8	1.9	1.0
Highest	2.1	4.4**	2.1**
Need			
Antenatal visits for pregnancy			
Less than 4	--	--	--
4 or more	3.3**	5.0**	1.5**

** *p*-value < 0.05

with an increase in wealth comes an increase in the likelihood of full immunization status. Children of mothers who had received at least the four recommended antenatal visits were five times more likely to receive some, as opposed to no, vaccinations (OR = 4.94, $p<0.001$). Maternal age, paternal education, number of household members, number of children under five years, birth order, type of place of residence, and region were not significant determinants in this model.

Partially vaccinated versus fully vaccinated: The children of mothers who attended post-secondary education were greater than two times more likely to receive all, as opposed to some, of their recommended vaccines, as compared to the children of mothers with less education (OR = 2.27, $p = 0.007$). As the level of maternal education increased, so too did the likelihood of the child being fully vaccinated. Children living in households in which there was more than one child under the age of five years were about two thirds as likely to receive all of their vaccinations once they have received at least some of them, as compared to children in households inhabited by only one child in this age bracket (2 children: OR = 0.66, $p = 0.018$; 3-5 children OR = 0.62, $p = 0.044$). As the number of children increased, the odds ratio decreased, indicating that full immunization became less likely. Children who are not first or second-born were two thirds as likely to be fully, rather than partially, immunized (OR = 0.65, $p = 0.044$). Households in the highest wealth quintile were twice as likely to have children that were fully versus partially immunized, as compared to the lowest wealth quintile (OR = 2.07, $p = 0.049$). Once again, as wealth increased, the

odds ratios increased, meaning that children were more likely to be fully immunized. Children of mothers who received at least the four recommended antenatal visits were one-and-a-half times more likely to receive all, versus some, of their vaccinations (OR = 1.50, p = 0.013). Maternal age, number of household members, ethnicity, type of place of residence, and region were not significant determinants of children receiving all, rather than some, of their recommended vaccines.

DISCUSSION

Overall Immunization Rates

According to the 2003 Philippine Demographic and Health Survey, the overall immunization rate of children in this country aged 12 – 23 months old is 69.2%. Measure DHS conducts surveys in over 75 developing countries. In comparing the immunization rate in the Philippines to that in other recently surveyed developing countries, its coverage seems about average. For instance, the immunization rates in other countries are as follows: Tanzania: 71.1%[92], India: 43.5%[93], Ghana: 69.4%[94], Egypt: 88.7%[95], Bangladesh: 73.1%[96], Indonesia: 52.0%[97], and Malawi: 64.4%[98]. To date, the Philippines' success in attaining a relatively high immunization coverage rate is rather impressive. Yet, the country still falls short of the WHO and UNICEF's Global Immunization Vision and Strategy goal of 80% coverage in the country. As such, there remains room for improvement.

The number of children in the Philippines who have received all recommended vaccines has decreased slightly since the 1998 and 1993 Demographic and Health Surveys, at which respective points 72.8% and 71.5% of children were fully covered (Table 2, p. 22).[41,42] Despite the slight decrease in the proportion of children who have completed the recommended immunization schedule, the percentage of infants who have not received any vaccines has remained at 7.7% since 1998.[42] It therefore stands to reason that the number of

children partially immunized rose in that five year period. If the historical trends had continued, we would have expected 3.6% more of the population to be fully immunized, however this was not the case, and these children instead slipped into the 'partially immunized' category. This is an example of why it is important to study not only the reasons for non-vaccination, but also the determinants of underimmunization. Additionally, the rate of fully immunized children in the Philippines has plateaued at approximately 70%, which falls short of the GIVS' goal of at least 80% coverage in each country. The determinants of immunization must be identified before they can be addressed in an effort to improve overall coverage rates.

Determinants of Immunization

Our results indicate that immunization status in children in the Philippines is determined by a combination of predisposing, enabling, and need characteristics. The one factor found to significantly improve the odds of receiving greater immunization coverage in all three outcome groups was pregnant mothers attending at least the minimally-recommended four antenatal visits. Factors found to improve the odds of a child being fully vaccinated (vs. not vaccinated or partially vaccinated) included higher maternal education, and greater household wealth. When comparing children who are not vaccinated to those who are fully immunized, the Cebuano ethnicity was also predictive of compliance with the immunization schedule. Finally, children who have gone on

to become fully immunized versus children who remain only partially immunized are more likely to have a lower birth order (i.e. eldest vs. youngest), and to live in households with fewer children under the age of 5 years.

Consistent with our study, maternal education has been identified as a common determinant of access to child healthcare services in general, as well as access to immunization coverage in children.[5,7,8,58,114] While there are two studies from the Philippines which do not support with this finding,[17,53] the study by Nurman et al[17] uses only bivariate statistics in its analysis, and further, both studies are geographically limited and thus not necessarily representative of the population as a whole. It is hypothesized that maternal education may influence outcomes by increasing women's knowledge regarding disease causation, prevention, and cures. This may be due to the direct influence of lessons learned in school, or may also be an indirect result of educated women's subsequent abilities to comprehend health-related messages.[99] Cleland and van Ginneken[99] further explain that more highly educated women may be more receptive to novel and modern ideas, and may have more confidence in dealing with unfamiliar individuals. Among children who are not vaccinated, the presence of disease may be an impediment to a child's ability to attend school and learn.[13] If children, particularly young girls, were not educated due to illness, they will become caregivers who are not well educated. This in turn will propagate the cycle of future children remaining underimmunized as a consequence of lack of education.

Household wealth has been identified in other studies as a determinant of immunization status[17,59,61], though this is inconsistent with Friede et al[53] who did not find it to have any bearing on the attainment of greater immunization coverage in a rural area of the Philippines. In healthcare centers across the country, vaccinations are offered free-of-charge[82], however despite this, according to our results wealth is still a strong determinant of immunization status. Jamil[58] explains this by noting that while the vaccinations may be offered for free, the time and financial cost of reaching a healthcare facility may present a great enough burden to dissuade individuals from accessing care.

Dayan et al[56] found that not being the first born was associated with lower vaccination coverage. Ozcirpici et al[114] indicated that having a greater number of siblings residing in the household is associated with a lower rate of immunization, though Nurman et al[17] did not come to this conclusion. Our results corroborate the findings of the first two studies. It has been suggested that a possible reason for this finding is that it may be challenging for parents who care for multiple children to find the time to have all of their children immunized.[100]

Previous work[55,56,58] identified region of residence as being associated with immunization status, though we did not find this to be the case. One study demonstrated that type of place of residence (i.e. urban vs. rural) also had an influence on vaccination status.[144] While our results indicate that there was an association between these two variables, it is not at a statistically significant level.

The ethnicity variable included in our study was based on individuals' self-described ethnicities. In the Philippines, ethnicities are determined based on a combination of factors. Categorization is based largely on language, though "homeland" and current region of residence also play a role in ethnic determination.[101] Although "Filipino" was declared in the constitution to be the national language, the general population recognize Filipino and Tagalog as essentially the same language with different names. Cebuanos see the adoption of the Tagalog language as the national language as a direct threat to their ethnic group, and in an attempt to increase ethnic solidarity, have revolted against this decision. There does not seem to be similar opposition from other ethnic groups to the national language being Tagalog. Our results indicated that Cebuano mothers were more likely than Tagalog mothers to have fully immunized children. It is possible that one ethnic group was more inclined than another to have their children immunized. However it is also possible that mothers of Cebuano ethnicity were more likely to correctly identify their ethnicities than women of other ethnicities. This could lead to bias in the categorization of ethnicities, as these mothers may have been more adamant in their responses to certain questions. As such, there may have been other factors at play in the association between ethnicity and immunization.

The Andersen Behavioral Model has been utilized extensively in studies both in Canada and internationally to predict and explain the use of healthcare services.[64,65,66,102,103,104] However, it is not typically utilized to identify determinants of preventive care. One reason for this may be that many forms of

preventive medicine, such as immunizations, have an evaluated need of 100%. As such, this limits the 'need' variable within the Behavioral Model to perceived need of care. In spite of this, the Andersen Behavioral Model could be very useful in this context, as it provides a framework to assess the combination of contextual and individual characteristics which may play a role in immunization.

Trinh and colleagues have attempted to use the model to identify determinants of a preventive service, specifically antenatal care utilization, in Vietnam.[105] In this study, need was measured by the number of children, and the number of sons in the family of each woman. In 1980, Friede et al[53] conducted a study that applied this model to immunization coverage of 145 children in the Philippines. These researchers limited the independent variables to a combination of background characteristics of survey respondents, as well as predisposing and enabling factors, and did not address the component of need.

In the conceptualization of need, we wished to examine perceived need, however there was no such direct information available to us as we were limited by the variables within the DHS dataset. We therefore chose to use a proxy for perceived need. Previous research has demonstrated that knowledge regarding vaccinations is linked to an improvement in coverage[106], and that consistent contact with a healthcare provider can lead to improved immunization coverage.[107] We hypothesized that an increase in contact with the healthcare system leads to an increase in knowledge translation regarding vaccinations. Specifically, mothers who speak with healthcare professionals will be more

likely to learn about the importance of immunization, and will in turn act on this information. As a result, we considered using the number of antenatal visits by pregnant mothers, as well as contact with the healthcare system within the last two weeks due to child fever, cough, or diarrhea. We elected not to use the latter variables, as any information that may have been received during the medical visits would have been delivered after the point where the immunization schedule was slated to begin. Conversely, antenatal visits, by definition, occur prior to the birth of the child, and hence prior to the start date of immunizations. This variable was therefore selected as the proxy for perceived need. As with immunizations, antenatal care is offered for free, or for a nominal cost at public healthcare facilities.[82] It is therefore noteworthy that not all women are receiving the recommended number of care visits. However the cost of actually accessing care may prevent some women from benefiting from the free healthcare services.

Unfortunately, respondents of the DHS Women's Questionnaire were not provided with the opportunity to give an explanation for their children being under- or non-vaccinated. Research in developing countries, including the Philippines, has demonstrated that parents will avoid having their children immunized if the children are ill at the time that they are supposed to receive the vaccine.[6,17,56] This finding highlights the importance of educating parents on immunizations, and ensuring that they properly understand the contraindications of childhood vaccinations.

Recent studies in the Philippines have identified a lack of supplies as a reason for non-compliance with the immunization schedule.[17,52] Also, both Nurmam et al[17] and Friede et al[53] identified an association between lengthier distances to healthcare facilities and undervaccination, though this directly contradicts the findings of Streefland et al[52]. While there was a question within our survey which addressed this issue, the variable was marked by a low response rate and thus was not included in our analysis. It would be of benefit to accord more attention to this potential determinant in future research.

What is encouraging is the fact that parents in the Philippines do not seem to be easily dissuaded from having their children vaccinated solely on account of being subjected to a prior bad or painful immunization experience.[51,53]

Policy Implications

In 1988, the Western Pacific Regional Committee of the WHO embarked on the mission of eradicating poliomyelitis in the region. To facilitate this goal, the Philippine president committed in 1993 to conducting National Immunization Days on an annual basis. On these days, all children between the ages of 0 – 59 months can receive the OPV vaccine at vaccination posts. Additionally, the other vaccinations recommended by the EPI are available for those children who are not yet fully immunized. Also, all children aged 12 – 59 months may receive doses of vitamin A. A study by Reichler et al[108] which examined

National Immunization Days in Egypt found that the most common reason for non-vaccination during these days was that parents were not informed of their existence. This information further supports the notion that knowledge translation is a key component of attaining superior immunization coverage, irrespective of the approach used in the delivery of the vaccination services.

In 1990, a nationwide communication campaign was launched that aimed to support the country's immunization program. One strategy of the program was to increase mothers' knowledge regarding immunization by utilizing the mass media. In an attempt to increase immunization coverage, "vaccination days" were developed, which allowed mothers to bring their children to healthcare centers every Wednesday to receive free vaccinations. A second strategy of the program was to draw mothers to the health facilities to have their children vaccinated for measles. This disease was selected as the target for the campaign as its symptoms are easily recognizable by mothers, and it is the final vaccine to be received according to the immunization schedule. Children who arrived to be immunized against measles but who had not received their other vaccines were provided with all required immunizations. Full immunization coverage across the country rose from 54% in 1989 to 65% in 1990[106], following the campaign, and it was therefore regarded as a great success.

More recently, a variety of efforts have been implemented in an attempt to improve routine immunization coverage. For instance, a new program called Reaching Every District (RED) aimed to increase the number of fully vaccinated

children by increasing community involvement and efficiency of delivery at the district level, and has been successful thus far. The Department of Health has also launched the "Knock-out Tigdas 2007", which is a follow-up to the 1998 and 2004 "Ligtas Tigdas" measles immunization campaign. For a month in the fall of 2007, vaccination providers traveled door-to-door to immunize all children aged 9 – 48 months against measles. Children also received a vitamin A capsule, as well as a deworming tablet. Additionally, regular healthcare facilities, as well as places such as basketball courts and town plazas were set up to deliver these services to all eligible children. The ultimate goal of this campaign is to eliminate measles in the Philippines by 2008.

The Philippines is the only country within the WHO's Western Pacific Region to not provide immunization against hepatitis B on a national scale. Only 38.5% of children in the Philippines receive all three doses of the hepatitis B vaccine [36], and one in ten people are afflicted by hepatitis B[109], which can lead to liver disease and cancer of the liver. Interestingly, coverage in the Philippines is not much lower than in India, where vaccination against hepatitis B is now being received routinely with other immunizations.[57,110] In the delivery of immunization against hepatitis B, it is advised that the vaccine be administered at the same time as DPT.[15] Unfortunately the reason for which hepatitis B is not routinely administered in the Philippines is due to the fact that it is more expensive than the other vaccines offered in the EPI. As the government has but limited financial resources, universal immunization against hepatitis B may not be implemented for some time.

In the interest of improving children's health, governments in developing countries have considered tactics such as visits to vulnerable households as a means by which to increase immunization coverage.[58,111] However the most efficient and beneficial method for the Philippines may be to re-implement an informational campaign like that from 1990. Research indicates that a lack of knowledge transfer between mothers and healthcare providers is one of the primary reasons for undervaccination in the Philippines.[52] A recent study in the Philippines found that over a third of surveyed women received information about immunizations from their relatives.[17] The problem with this type of information transfer is that it may not be accurate and up-to-date. Nurman et al[17] found that adults in this country who are provided with education regarding vaccines will follow the correct immunization schedule. However, they caution that in order for such an education program to be successful, it must take into account the socio-demographic factors of the target group.

While nearly 70% of children 12 – 23 months old in the Philippines have received all recommended vaccines, there are still one in five who are only partially immunized. BCG is the most common vaccine for children to have received, while coverage is quite low for OPV 3, DPT 3, and the measles vaccine (Table 2, p.22). What is more, from the time of the first vaccine to the third vaccine, both OPV and DPT suffer drop-out rates of over 10% of the target population.

If policy efforts focused on ensuring that partially vaccinated children became fully immunized, the country could potentially be marked by a total

immunization coverage of over 90% of the target population. To attain such a goal, it would be crucial to distribute accurate information regarding immunizations. A newly launched program could ensure the education of women by healthcare professionals and would focus on those women whose children are at greatest risk of being only partially immunized. Therefore based on our results the provision of knowledge should specifically be targeted towards mothers who have little formal education, who do not receive the recommended number of antenatal visits, who have many children, and who reside in households with low levels of wealth.

Limitations

It is important to note the limitations of this analysis. One factor that affects many facets of the study is that we used a secondary dataset. Consequently, we were limited to the use of variables which are found in the Philippine Demographic and Health Survey. For example, contextual factors, such as public perception regarding vaccines, would have been an interesting variable to study, however its inclusion was not possible on account of the lack of relevant questioning in the survey. Another topic on which it would have been beneficial to have more information is the subject of health insurance. There was a question within the survey which dealt with this subject, however there was a large number of missing values, and it therefore could not be included in our analysis. Despite the fact that the NHIP offers healthcare benefits to the

least wealthy of individuals and households, higher levels of household wealth are associated with greater immunization coverage. It would have been interesting to include in the model an independent variable assessing health insurance coverage and its effect on the outcome.

A second area from which our analysis could have benefited from more information is that of beliefs regarding vaccinations. There are studies[6,53] which included open-ended questions in their surveys to try and assess attitudes regarding vaccinations, as well as stated reasons for non-vaccination. Having such information available would have enhanced our analysis, as well as our understanding of the determinants of immunization.

Another weakness of the study is the use of maternal recall in the determination of immunization status. While there are studies[79,80] that confirm the validity of this source of information, it less likely for a written record of immunization than a mother's oral recall to be fallible. Unfortunately we were unable to evaluate the potential effect of the possession of a vaccination card on children's immunization status. This is owing to the fact that the survey only provided the source of information (i.e. vaccination card or verbal report) for vaccines that had been received. For example, if a child had received 7 of the 8 required vaccines, it was possible to determine the source of information for the 7 received vaccines, but not for the 8th vaccine, which was not received. As a result, we only had access to complete data for those children who were fully immunized, and therefore could not include the source of information in our statistical model.

Additionally, in our study we did not take into account the point in time at which a child received his/her vaccines. The Philippine immunization schedule states that all children should receive all recommended vaccines before the age of one year in order to be considered "fully immunized". To answer our question of interest, we elected to consider a child "fully immunized" if he/she had received all recommended vaccines by the time the survey was conducted. This may have influenced the outcome by overestimating the proportion of children who are "fully immunized", according to the definition established by the Philippines.

Finally, it is noteworthy to mention that the gold standard to confirm reported immunization coverage may be to use blood samples to assess the presence of antibodies of the specified disease antigens, which has been done in studies examining Hepatitis B coverage.[112,113] This method, however, would not be practical for assessing immunization coverage on a large-scale, as it requires a great deal of resources and is inefficient in comparison to using immunization cards.

Future Research

This project may be expanded on in the future by following a variety of different courses of action. One option would be to compare the results of this analysis to the results from previous and forthcoming Philippine Demographic and Health Surveys, which would allow for an analysis of trends over time.

Additionally, many studies assessing EPI coverage rates utilize the '30 X 7' WHO cluster sampling technique to identify households for surveying. It may be worthwhile to undertake such a project in order to deliver a survey which could include open-ended questions addressing beliefs regarding vaccinations, as well as use/non-use of the National Health Insurance Program benefits. Combining the answers to such a survey with the results from a DHS survey would provide a wealth of quantitative and qualitative information regarding determinants of immunization in the Philippines.

There are studies[79,80] that confirm the validity of the use of maternal recall in describing childhood vaccination status. However there is also research[54] that suggests that women cannot always clearly recall the vaccination status of their children, and thus questions the interchangeable nature of the source of information. Unfortunately we were not able to assess this issue in our study owing to the lack of information which was previously explained. In the future it would be interesting to examine this factor, to determine whether there is any difference in the determinants of immunization according to the possession of vaccination card.

It would also be worthwhile to investigate the determinants of access to antenatal visits, so as to better understand why certain women are not accessing services which are highly encouraged, and offered at minimal cost. The sum of this information could likely aid in the development of methods to reach those children who are not currently receiving all of their vaccinations.

If the Philippine Department of Health were able to achieve a higher national immunization rate (e.g. 90%), future research on the subject would shift in focus. For example, it would be interesting to see whether this increased use of immunization services would lead to a decrease in child mortality and morbidity due to vaccine-preventable diseases. Building on this idea, if mortality rates did not decrease as much as expected, the reason why could be investigated. For example is there a problem with the efficacy in the delivery of the vaccines (i.e. the cold chain)? Alternatively, does the increased focus on immunization lead to a decrease in focus on the prevention of other important causes of childhood disease, such as diarrhea and respiratory ailments? These would be interesting questions for investigation in the long-run.

Conclusions

Two million children worldwide die each year as a consequence of vaccine-preventable diseases.[14] The results of our study indicate that in 2003, 69.2% of Filipino children aged 12 - 23 months were fully vaccinated, 23.0% were partially vaccinated, and 7.8% were not vaccinated. Multinomial logistic regression results indicate that the odds of a child having a higher immunization status were significantly greater when pregnant mothers had attended at least the minimally-recommended four antenatal visits, when mothers had achieved higher levels of education, and for the children of mothers who identified as Cebuano. This was also true of children who lived in households with greater

wealth, with fewer children under the age of five years, and who had lower birth orders.

If policy efforts were to focus on ensuring that partially vaccinated children became fully immunized, the country could potentially be marked by a total immunization coverage of over 90% of the target population. To make this happen, knowledge translation regarding immunizations should become a priority. The delivery of this information should specifically target mothers who have little formal education, who do not receive the recommended number of antenatal visits, who have many children, and who reside in households with low levels of wealth.

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APPENDICES

Multinomial logistic regression results using survey weighting

Characteristic	Conditional Odds Ratio: Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Predisposing Factors			
Mother's Age	1.0	1.0	1.0
Maternal Education			
No Education/ Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	1.1	1.4	1.2
Complete Secondary	2.0	3.2**	1.6
Higher	2.1	4.9**	2.3**
Paternal Education			
No Education/ Incomplete Primary	--	--	--
Complete Primary/ Incomplete Secondary	1.0	1.3	1.4
Complete Secondary	0.7	0.9	1.2
Higher	1.5	1.5	1.0
Number of Household Members			
2-5	--	--	--
6-22	0.9	0.9	1.0
Number of children 5 and under			
1	--	--	--
2	1.1	0.7	0.6**
3-5	1.3	0.7	0.5**

** p-value < 0.05

Multinomial logistic regression results using survey weighting (continued)

Characteristic	Conditional Odds Ratio		
	Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Ethnicity			
Tagalog	--	--	--
Cebuano	2.2	2.8**	1.3
Ilocano	1.3	1.5	1.1
Ilonggo	1.1	1.6	1.5
Other	1.1	1.5	1.4
Birth Order			
1-2	--	--	--
3 or more	1.1	0.7	0.6**
Enabling Factors			
Region			
National Capital Region	--	--	--
Luzon	2.3	2.3	1.0
Visayas	0.9	1.2	1.3
Mindanao	0.7	0.6	0.9
Type of place of residence			
Urban	--	--	--
Rural	1.8	1.6	0.8
Wealth Index			
Lowest	--	--	--
Lower Middle	1.7	2.1**	1.3
Middle	1.7	2.7**	1.6
Upper Middle	1.3	1.4	1.1
Highest	1.4	2.8	2.0

** *p*-value < 0.05

Multinomial logistic regression results using survey weighting (continued)

Characteristic	Conditional Odds Ratio Not vaccinated vs. Partially Vaccinated	Not vaccinated vs. Fully Vaccinated	Partially Vaccinated vs. Fully Vaccinated
Need			
Antenatal visits for pregnancy			
Less than 4	--	--	--
4 or more	3.7**	5.2**	1.4**

** *p*-value < 0.05