IMPACT ASSESSMENT OF THE 10-VALENT PNEUMOCOCCAL CONJUGATE VACCINE IN PREVENTION OF PNEUMONIA AMONG CHILDREN UNDER FIVE YEARS IN KIJABE MISSION HOSPITAL, KIAMBU COUNTY

BY

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Abstract

This study assessed the impact of the 10 valent pneumococcal conjugate vaccine on pneumonia prevention by determining annual trends of pneumonia, recurrent pneumonia levels as well as establishing the association of other factors, PCV-10 and pneumonia. Using retrospective unmatched case control study design, the study enrolled a total of 190 participants with 130 in the first stratum (0-$2\frac{1}{2}$ years old) and 60 from the second stratum (Above $2\frac{1}{2}$ years old). The total number of cases was 49 and non cases were 141. The first stratum had 37 case patients (28.46%) and 93 (71.54%) control patients. Male gender was represented by a total of 119 patients with 27 case patients (22.69%) and 92 (77.31%) controls. The conduct of this study was necessitated by there being no other impact studies since PCV-10 introduction as well as challenges of serotype replacement witnessed with previous PCVs that is likely to affect the effectiveness of PCV-10. In addition, pneumonia causation is diverse hence its occurrence cannot be stopped by use of only PCV-10 which is effective against 10 of the over 90 serotypes of pneumococcus. Furthermore, the findings of the KEMRI study in Kilifi showed that the nasopharyngeal carriage of common serotypes declined with age while the carriage for uncommon serotypes did not decline. PCV-10 is effective against ten common serotypes thus increasing the chances of the uncommon serotypes causing pneumococcal disease. Data was obtained using interviewer-administered questionnaires. The study findings were that 81.6% of the children had received PCV-10 out of whom 78.1% had received 3 doses within 14 weeks after birth. In spite of these coverage, the proportion of younger children (<2 $\frac{1}{2}$ years) was higher in the cases (75.5%) as compared to the controls (66.0%). However, age was not a significant predictor of pneumonia (p=0.215) as well as gender (p=0.206). Most importantly, PCV-10 was shown to protect against pneumonia, odds ratio 0.683 (p=0.032). This association is supported by the reduction in annual incidences of pneumonia since 2012 by 48.05% to 2013 and 43.75% from 2013 to 2014. Environmental factors were however, significantly associated with pneumonia to include taking the children to events and transmission of colds to children from other family members.

CHAPTER 1

INTRODUCTION

This chapter gives: Background information to the topic; statement of the problem; objectives of the study; significance of the study: outline of the thesis.

1.1 Background Information

Pneumonia is the inflammation of pulmonary parenchyma frequent during infancy and early childhood. There are various classifications of pneumonia based on clinical form, causation and morphology. PCV is a vaccine that protects against pneumonia classified as bacterial pneumonia caused by pneumococcus. Available PCVs include; PCV-7, PCV-9, PCV-10 and PCV-13. In Kenya the leading cause of childhood morbidity and mortality after malaria has been pneumonia of diverse causation with *Streptococcus pneumoniae* being the most common bacterial cause of fatal pneumonia. In Kijabe Hospital, the leading cause of medical admissions in paediatric ward is as a result of pneumonia and this makes pneumonia an important condition.

Kenya was the first country among 19 developing countries in rolling out the 10 valent pneumococcal conjugate vaccine in 2011 February 14th in her routine immunization schedule as per DVI. This was possible through the support from the Global Alliance for vaccines and Immunizations (GAVI) and is hoped to reduce childhood mortality which is the 4th millennium development goal that the government is working towards achieving by the year 2015 through prevention of pneumococcal infections as one of the strategies [15].

In a cross sectional study carried out in Kilifi from 2006-2008 in which a single nasopharyngeal swab from the sample population was obtained and cultured for *Streptococcus pneumoniae*, 53 different serotypes were identified, 42% of which are contained in the 10 valent pneumococcal vaccine. This study also revealed that common serotypes were more in early childhood and carriage declined with age whereas the uncommon serotypes

prevalence did not decline [9]. Other studies on PCV-7 revealed serotype replacement [18]. These findings necessitates the conduct of the current study to ascertain the impact of the vaccine introduction. Additionally, there has been no impact study carried out in Kijabe hospital.

The aim of the current study was to assess the impact that PCV-10 vaccination that was introduced in Kenya and in Kijabe Hospital in the year 2011 has had on the incidence of pneumonia bearing in mind that pneumonia has diverse causes. This therefore means that with introduction of pneumococcal conjugate vaccine, new cases of pneumonia as a result of pneumococcus may be reduced with or without any effect on the pneumonia incidence.

The study variables comprised of various explanatory variables; the 10 valent pneumococcal vaccine, other factors influencing pneumonia majoring on home environment and selected practices with one response variable; pneumonia.

1.2 Statement of the Problem

Pneumonia has been among the most prevalent childhood conditions in Kenya and a fatal paediatric condition managed in paediatric ward in Kijabe Hospital. In February 2011 PCV-10 (pneumococcal conjugate vaccine 10) was introduced in Kenya as part of the immunization schedule by the Division of Vaccine and Immunization (DVI). Since then, children in their infancy have been the main beneficiaries with no catch up vaccination in the hospital.

There have been various strategies to improve child survival and with pneumonia having diverse causation, synergy of these strategies and PCV-10 would produce a great impact in pneumonia prevention. However, PCV-10 is only effective against 10 serotypes of pneumococcus whose nasopharyngeal carriage declines with age from infancy according to KEMRI cross sectional study in Kilifi, whereas the carriage for the rare serotypes does not decline. Challenges of serotype replacement witnessed with PCV-7 introduction in other countries affected the effectiveness of vaccine use. PCV-10 is likely to experience similar challenge limiting its effectiveness. It is worth noting that PCV-10 and *Haemophilus Influenza* type B vaccines in the immunization schedule are only effective against some

1.3 Objectives of the Study

(i) To determine the extent primary school teachers use ICT in lessons preparations and acquiring new information relevant in their subject areas.

(ii) To investigate how primary school teachers use ICT in content delivery and exams preparations.

(iii) To determine the extent primary school teachers use ICT in results analysis and keeping learning related records.

1.4 Hypotheses

The null hypothesis:-

H_0: There is no difference in teaching efficiency between teachers with ICT skills and teachers without ICT skills.

$H_0 : \beta_1 = 0, \beta_2 = 0, \beta_3 = 0, \beta_4 = 0$

H_1: Teachers with ICT skills are efficient than teachers without ICT skills.

$H_1 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq 0$

1.5 Significance of the Study

The study aimed to show the relationship between using ICT skills and teaching delivery by primary school teachers. The results from the analysis of variables were used to produce a binomial regression model,which could be used in future to predict the outcome of using ICT skills at various levels in teaching.

1.6 Overview of the Chapters

In **Chapter 1**, essential elements of the study are given. These include background information to the problem investigated and the statement of the problem, significance of the study, the objectives of the study, hypotheses and significance of the study.

In **Chapter 2**, the literature about the findings and reports on previous studies on ICT integration in education sector from various countries are highlighted. The pieces

etiquette, children still suffered pneumonia. The current study also identified that viral pneumonia prevention is not adequately addressed therefore recommending that viral vaccine prevention be considered. Kijabe hospital benefits from these findings by not only providing adequate health education but also giving the education in a timely manner, that is before the disease occurs as well as giving quality care to the communities served by Kijabe Hospital. Overall countrywide reduction in the cases of pneumonia will be witnessed if the Ministry of Health utilizes the findings of this study to conduct a survey on viral pneumonia and its prevention.

The current study found that PCV-10 has a positive impact in reduction of the incidence of pneumonia therefore adding to the body of knowledge useful in further researches utilizing designs to enable determination of actual prevention conferred by PCV-10 vis-a-vis other causes of pneumonia.

1.5 Justification

PCV-10 is a vaccine that is administered to prevent occurrence of a disease (pneumonia). This makes pneumonia an outcome that PCV-10 intends to impact on by its use/ introduction. Considering that human subjects are the study participants, the children's health is a priority that cannot be compromised by denying the vaccine for study purposes. Therefore, the researcher employed the use of epidemiologic study design that is observational; a retrospective unmatched case control design. This design utilizes subjects who have already developed a disease which is the desired study outcome and determines exposure.

This study design uses logistic regression useful as a predictive analysis and it is used to describe data and to explain the relationship between one dependent binary variable (pneumonia) and one or more metric (interval/ ratio scale) independent variable (PCV-10, environmental factors). Binary logistic regression was appropriate for this study because the dependent variable pneumonia is binary in nature; present or absent.

This is why the current study recruited pneumonia patients as cases as well as the impact of PCV-10 can only be measured through reduction in pneumonia infections. The study was also assessing other pneumonia risk factors making pneumonia a dependent variable

hence cases could not be recruited on the basis of vaccination rather than the dependent state which is pneumonia.

1.6 Outline of the Thesis

This thesis is organized as follows; **Chapter One** is the introductory chapter, **Chapter Two** addresses literature that is relevant in the study of PCV-10 impact on pneumonia prevention. Research methodology is presented in **Chapter Three** while results are presented in **Chapter Four**. **Chapter Five** which contains the summary, general conclusion and recommendations for further research come after chapter four.

CHAPTER 2

LITERATURE REVIEW

This chapter reviews literature related to PCV-10 and pneumonia for children under the age of five years and its prevention. The literature review is presented beginning with pneumonia as a condition and preventive strategies. It further explains in detail the PCV-10 use in Kenya since February 2011 and finally critical review expounding on the areas of gaps.

2.1 Pneumonia

Pneumonia is defined as the inflammation of pulmonary parenchyma frequent during infancy and early childhood [1].

There are various classifications of pneumonia based on clinical form, causation and morphology. The current study was limited to classification according to causation that include; bacterial pneumonia which accounts for 50% of cases and causes approximately 70% of deaths with *Streptococcus pneumoniae* being the most common bacterial cause across all age groups [1]. On the other hand, *Haemophilus influenzae* accounts for half of all deaths due to bacterial pneumonia in children aged five years and below. Majority of these morbidity and mortality occur in marginalized communities of developing countries [2].

The other causes of pneumonia include; various other bacterial species both gram-negative and gram-positive, viruses and *Mycoplasma pneumoniae* common during cold seasons and in crowded places. Another cause of pneumonia usually during neonatal period is *Chlamydia trachomatis* whose mode of transmission is sexual contact [1].

The worldwide WHO estimates of pneumococcal disease among under-fives in 2005 is 0.7-1 million children with a majority of cases occurring in developing countries and Kenya is one of these countries. In Kenya the leading cause of childhood morbidity and mortality after malaria has been pneumonia of diverse causation with *Streptococcus pneumoniae*

being the most common bacterial cause of fatal pneumonia [3, 4, 5, 6]. The mortality rate has been 1 in every 5 children under the age of five years in Kenya, contributing a 20% under-five mortality rate [5, 6]. Pneumonia is prevalent in Kijabe Hospital. However, malaria is not prevalent in Kijabe owing to its location in a region where malaria is not endemic given that malaria is the leading fatal paediatric disease in Kenya.

Pneumonia therefore being the leading cause of mortality among children, its prevention is paramount. There have been various proven strategies for its prevention worldwide by the World Health Organization and UNICEF whose implementation is especially important in developing countries where the disease burden is high. Some of these strategies are as follows:

To begin with, vaccination has played a big role in preventing vaccine preventable pneumonia: with pneumococcal conjugate vaccine preventing against pneumococcal pneumonia, the heamophilus influenza type B (Hib) vaccine against *Haemophilus influenzae* and palivizumab which is effective against RSV, the most common cause of viral pneumonia [7]. In the Kenyan immunization schedule, Hib vaccine has been in routine immunization since the year 2001 [8] with PCV-10 introduction in the year 2011. On the other hand, palivizumab is not yet available thus viral pneumonia prevention relies on other preventive strategies for instance hand hygiene.

Secondly, effective hand washing with soap and water and/or alcohol based sanitizers prevents transmission of pneumonia causing microbes [10]. Transmission of some of these microbes is airborne through coughing and sneezing and droplets with high carriage of *Streptococcus pneumoniae* in children with coryza and cough [9], whereas viral transmission is through contact on hands and surfaces [1] commonly Respiratory Syncytial Virus. In addition, appropriate and prompt use of antibiotics for upper respiratory tract infections is a mode of prevention that reduces streptococcal pharyngeal carriage [9] thus reducing transmission rates and eventual pneumococcal pneumonia.

Another preventive strategy is through case management of pneumonia in the community and hospitals [2]. Kenya having adopted the use of Integrated Management of Childhood Illnesses (IMCI) that offers the best opportunity for case management at all levels for over the past five years, has generally realized an improved child survival. This is evident from

reports of the Kenya Demographic and Health Survey 2008-09 that showed a reduction in childhood mortality rate from 115/1000 in 2003 to 77/1000 and a further reduction was seen in KDHS 2014 to 52/1000 live births [13, 28]. In the United States, community based case management reduced neonatal mortality by 42% and both infant mortality and childhood mortality each by 36% [2].

Infant and young child feeding is yet another important strategy in prevention of pneumonia and other causes of death in children. The WHO recommends exclusive breastfeeding for the first 6 completed months of infancy which has been shown to reduce childhood mortality by 13% and adequate complimentary feeding from 6-23 months of life reduces mortality by 6% [2]. Reduction in mortality is achieved through improved immunity from proper nutrition. On average worldwide exclusive breastfeeding rates are estimated at 35% [11, 12] with Kenya's rates being 61% in 2014 [28], a marked improvement from the 32% KDHS 2008-09[13]. In Kenya, 21% of children between age 6-23 months receive acceptable recommended diet as per KDHS 2014 survey. The rates of malnutrition are; stunting 26%, wasting 4% and underweight 11% overall among the under-fives [28]. These values indicate the susceptibility to infections during early childhood with pneumococcal disease being one of these infections. However, consistent decrease in malnutrition rates has been observed over time from previous KDHS done.

Other strategies include control of indoor pollution through smoking and firewood as a source of fuel in poorly ventilated rooms that offer unhealthy environment and also prevention and management of HIV [2] through elimination of mother to child transmission (eMTCT) program. In these program, recommendations include breastfeeding of exposed infants up to the age of 12 months, strategies focusing on improving coverage of pregnant mothers with efficacious ART and prevention of unplanned pregnancies among HIV infected population [14]. Currently the NASCOP ART guidelines recommends that, as a criteria for initiation of ART, all HIV infected pregnant and lactating women should be initiated on ART regardless of WHO clinical stage nor CD4 count [29].

Hospital practices that are useful in prevention of pneumonia is through reducing the length of mechanical ventilation and appropriate use of antibiotics, elevating the head of the bed to 30^0-45^0 to prevent aspiration pneumonia and health workers with respira-

tory tract infections should use masks or avoid contact with patients. In addition, strict hand hygiene before and after any procedure on every patient plays an important role in prevention of nosocomial pneumonia[7].

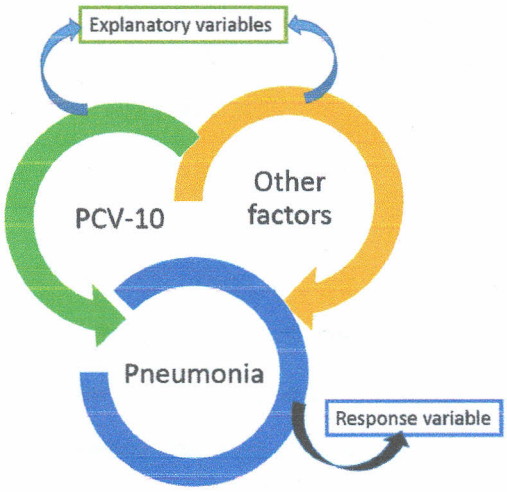

Figure 2.1: Conceptual Framework

2.2 Pneumococcal conjugate vaccine

Pneumococcal conjugate vaccine comprises of PCV-7, PCV-9, PCV-10 and PCV-13 with the numerical value indicating the number of serotypes of pneumococcus the PCV is active against[3] some of which will be discussed later on. The only other type of pneumococcal vaccine approved by the World Health Organization for use among the elderly and not yet available in Kenya is PPV-23; a polysaccharide pneumococcal vaccine. This study is limited to the 10 valent pneumococcal conjugate vaccine which is the only pneumococcal vaccine in Kenya.

On February 14th 2011, PCV-10 was launched in Nairobi by the former Head of State, Mwai Kibaki and Beth Mugo the Minister in the then Ministry of Public Health and Sanitation. This followed extensive pre-vaccination surveillance studies, rigorous social mobilization and creation of awareness on pneumonia as one of the killer diseases in children [8, 15].

Figure 2.2: The National Launch of PCV-10 in Kenya, 2011

Adapted from GAVI alliance, 2011

Through the support of the Global Alliance for Vaccines and Immunization that committed to provide the vaccine for the next 5 years with the Kenyan government financing an annual Kshs.72 million, PCV-10 became available in Kenya [6].

In addition to the awareness efforts, the tools for monitoring and evaluation e.g. the mother and child booklet MOH 216, were revised to include provision for PCV-10 vaccine dosage, duration, route of administration, date given and return date for the next dose for the three primary doses like the other vaccines on schedule.

Conjugation is necessary because the immunogenic components of bacteria polysaccharide are T-independent antigens that trigger B-cell proliferation without T-cell activation thus poor immunogens in children below 2 years [7].Conjugation enhances the immunity conferred by PCV-10 and it is done by conjugating its respective polysaccharide serotype antigens with various protein carriers [3] thus inducing T-cell activation in infants hence improved immunogenicity [7].

PCV-10 is administered intramuscularly at anterolateral left thigh and it is contraindicated in allergy to vaccine-products and in acute, moderate or severe illness with or without fevers [1].

Streptococcus pneumoniae is a gram-positive encapsulated diplococcus whose polysaccharide capsule is responsible for causation of pneumococcal disease [4]. The fatal pneumococcal diseases in children include pneumonia, the main focus of this study, meningitis and bacteremia with less serious conditions being otitis media, sinusitis and bronchitis [3]. The composition of the capsule are varied giving rise to about 90 identified serotypes of *Streptococcus pneumoniae* whose distribution vary geographically and with seasons [4]. PCV-10 is active against 10 serotypes of the more than 90 serotypes of *Streptococcus pneumoniae*. These ten include 1, 4, 5, 6B, 7F, 9V, 14, 18C, 19E and 23F [1]. Figure 2.3 shows the distribution of *Streptococcus pneumoniae* serotypes in Kenya [5].

In a cross sectional study carried out in Kilifi from 2006-2008 in which a single nasopharyngeal swab from the sample population was obtained and cultured for *Streptococcus pneumoniae*, 53 different serotypes were identified, 42% of which are contained in the 10 valent pneumococcal vaccine. This study also revealed that common serotypes were

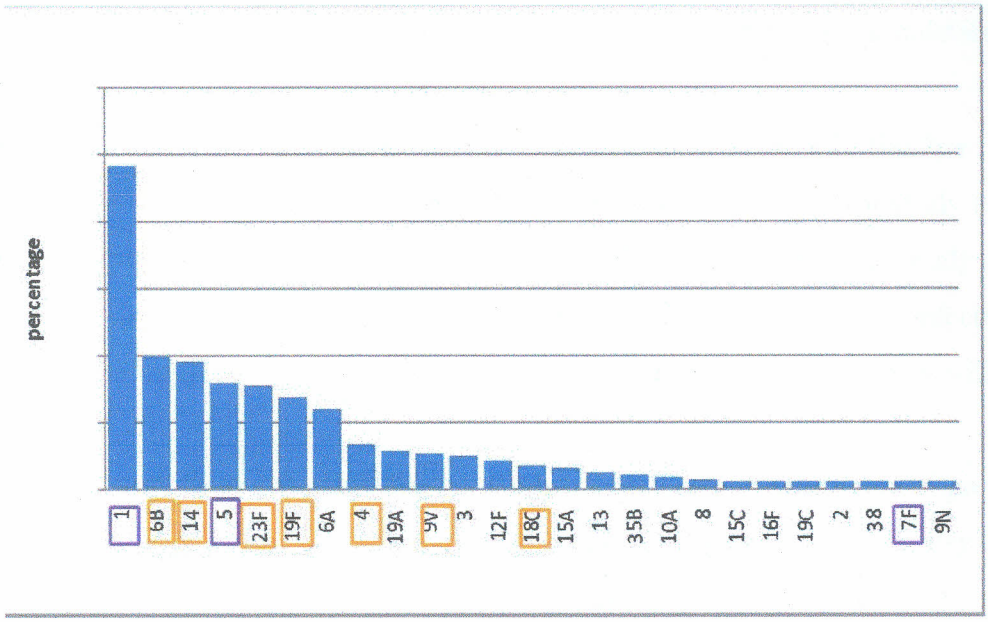

Figure 2.3: Pneumococcal Serotype Distribution in Kenya

Adapted from[5]

more in early childhood and carriage declined with age whereas the uncommon serotypes prevalence did not decline [9].These findings necessitates the conduct of the current study to ascertain the impact of the vaccine introduction.

Susceptibility to pneumococcal disease increases in the context of HIV [4] whose prevalence in Kenya among children aged between 18 months to 14 years in 2012 was 0.9%[16]. The same report also established that the rate of HIV testing among children of HIV infected parents was 45.4%. HIV infection therefore, in addition to increased resistance of *Streptococcus pneumoniae* to standard antibiotics makes vaccination against pneumococcus an important intervention [4]. This intervention is not without challenges as with previous PCVs like serotype replacement that should be monitored through surveillance studies [5], but this is beyond the scope of this study.

There are two recommended schedules for PCV-10; three primary doses without a booster 3p+0 or two primary doses with one booster dose 2p+1 from which each country chooses based on disease pattern and age of children affected [3]. Kenya opted for a 3p+0 schedule starting at 6 weeks which fitted well with the existing Division of Vaccine and Immunization schedule in Kenya. The 3 doses of PCV-10 are administered concurrently with the

3 doses of pentavalent vaccine since the vaccine can comfortably be administered at a different IM site with no interference with other vaccines [1].

Kenya being among 22 African countries with high HIV prevalence [14], the 2p+1 schedule would not have been appropriate considering finding of a case control study in south Africa on effectiveness of PCV-7 that had been introduced in 2009. This study showed that the 2p+1 schedule did not appear to offer adequate protection in HIV infected children hence the recommendation that this schedule is appropriate for countries with lower HIV prevalence [17].

Introduction of catch up vaccination improves impact through accelerated herd protection [3]. This catch up vaccination was done in Kenya since introduction in February 2011 to April the same year in 45 health facilities with two catch up doses for children aged 12-59 months. These children were not eligible for 3p+0 schedule and 60% received at least one dose and 20% at least two doses [17]. Herd protection is:

> *A condition in which the majority of a population community is vaccinated and the spread of certain diseases is stopped since the population that has been vaccinated protects those in the same population who are unvaccinated [1].*

Catch up vaccination eventually increases coverage rates which influences herd protection in addition to other factors such as host susceptibility, force of transmission and vaccine effectiveness [18] which, as already stated is likely to be affected by serotype replacement. The outcome of catch up vaccination was evident with PCV-7 introduction whereby catch up immunization was given at 12-24 months for previously unvaccinated children and high risk children between 2-5 years, this improved protection from pneumococcal disease at community level [4].

Herd protection therefore protects not only infants who may not fully benefit from immunizations but also the elderly, immunocompromized population and reduces the burden in suboptimal coverage rates [18]. The PCV-10 immunization coverage in 2014 according to KDHS 2014 in Kenya is one dose 93.7%, two doses 90.8% and three doses (fully immunized)85.1% [28].

2.3 Summary of Literature Review

Pneumonia being a condition with diverse causation and a major cause of morbidity and mortality in paediatric population, its prevention and management is complicated. It is imperative to put into perspective all the causes as well as prevention strategies in order to effectively prevent pneumonia. Having stated this fact, vaccination is one of these strategies but vaccines are antigen specific: PCV-10 is pneumococcal pneumonia specific. However, it does not prevent against all the serotypes of pneumococcus, but only 10 of the over 90 species of *streptococcus pneumoniae*. In addition, there are various bacterial causes of pneumonia beside pneumococcus among them being; *Haemophilus influenzae*, whose vaccine has been in the immunization schedule for over 10 years but pneumonia has remained to be a prevalent condition in children. *Mycoplasma pneumoniae* and *Chlamydia trachomatis* among other bacteria are non-vaccine prevented in Kenya therefore a limitation in effective prevention of pneumonia.

Among other causes of pneumonia are viruses namely; RSV, influenzae viruses and parainfluenzae viruses. All viral causes in Kenya rely on non-vaccine prevention strategies such as hand hygiene and coughing and sneezing while covering the mouth. It is important to point out that the mode of transmission of these viral particles which includes droplet and airborne transmission reduces effectiveness of these strategies when especially the host immunity is compromised. In addition, immunosuppression complicates pneumonia prevention although this study will focus on children in early years when immune system is developing as well as after 2 years when the child's body develops natural active immunity.

There are also risks posed by the child's environment in pneumonia causation, to mention but a few exposure to smoke, poor ventilation and exposure to dust among other risks factors.

PCV-10; a 3p+0 schedule, was introduced in Kenya's immunization schedule in February 14^{th} 2011 with the support of GAVI Alliance in order to reduce the incidence of pneumonia whose burden has been high among children under the age of five years. The impact of this intervention has not yet been ascertained considering the elaborated challenges in prevention of pneumonia. Previous studies done on PCV-7 showed serotype replacement

and a recent cohort study done in Kilifi by KEMRI showed increased nasopharyngeal carriage in non-vaccine serotypes being likely causes of eventual negligible reduction of pneumococcal pneumonia with PCV-10.

PCV-10 therefore is likely to have an overall reduction in incidence of pneumonia or not at all hence this study examined this situation.In addition, there has been no study carried out to assess the impact of PCV- 10 in pneumonia prevention in Kenya and in Kijabe Hospital using the a retrospective unmatched case control design as the current study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Area of Study

The study was carried out at A.I.C Kijabe Hospital which is a level 5, Mission General hospital located in Kiambu County, Central region of Kenya. According to the 2009 national census results, Kiambu County covers an area of 2,449.21 km^2 with an estimated population of 1,623,282 [21]. The population density is 638 per km^2. Kiambu County is located in central Kenya and borders MurangâĂŹa County to the north and North East, Machakos County to the East, Nairobi and Kajiado counties to the south, Nakuru County to the west and Nyandarua County to the North West. The hospital serves a wide catchment area of Kiambu county and even beyond to include Nairobi, Naivasha, Nakuru, and also the wider Nyandarua county.

The hospital is located 65 kilometers northwest of Nairobi within the Rift Valley escarpment at an altitude of 2200m above sea level. The hospital is located along the Equator lying between $0^0$56' 0' South and 36°34' 0' North. The climatic conditions of the area is moderate with hot seasons temperatures ranging from 21.1°C to 26.7°C and nighttime temperatures of 21.1°C. Temperatures during the cool seasons ranges from 15.6°C to 21.1°C and nighttime temperatures of about 10°C. This is contrary to its location along the equator but this is attributed to its altitude [22, 23, 24].

The hospital is fully equipped to handle general medical and surgical cases. It has five wards (maternity, male and female medical, surgical and orthopedic, pediatric and an intensive care) with a total bed capacity of 265. The study was carried out in the paediatric ward Kijabe Hospital that according to the hospital's webpage, serves paediatric patients with pneumonia, malnutrition, birth defects, HIV, gastroenteritis among other conditions with a bed capacity of 60 for children aged 30 days to 15 years and 3 bed high dependency unit [24].

This hospital was selected because it serves a wide range of paediatric patients both pri-

mary patients and referrals from other facilities thus its catchment population provided the population of interest of this study.

3.2 Study design

A retrospective unmatched case control design was used in this study. The design is unmatched because controls were part of the sample of children unaffected with pneumonia in the current admission. Case control design was chosen since it is useful for generating hypotheses but does not prove causality. In addition, a case control design has the advantage of requiring less time to conduct because the disease has already occurred. It also allows for study of multiple exposures that comprises of PCV-10, hospital practices and environmental exposures in this study and a single outcome. This design was deemed appropriate due to its usefulness in establishing association of pneumonia prevention strategies and pneumonia[19, 20].

On the contrary, the retrospective nature of this design poses the challenge of recall bias [19, 20] whose effect the researcher minimized through allowing the respondent to confirm from immunization register available in MOH 216 book that care givers of paediatric patients are encouraged to carry with them whenever they visit the hospital. Also the questionnaire was designed in such a way that it limited the duration of recall to the most recent occurence.

The retrospective design also served to achieve the objective of ascertaining the total number of cases of pneumonia since 2009 before vaccination began to 2014 about three years after introduction of the vaccine.

3.3 Target population

The study targeted children under the age of five years who live in areas served by Kijabe Hospital.

3.3.1 Study population

The study population for this research comprised of children admitted in paediatric ward Kijabe Hospital.

3.3.2 Sampling technique

Stratified random sampling method was used whereby on the day of data collection, the inpatient numbers of children admitted in the paediatric ward aged below five years were taken and written in small pieces of paper for random sample generation and grouped into two strata as follows:

(a) The first stratum comprised of children aged 0 -$2\frac{1}{2}$ years who are expected to have received PCV-10 vaccine.

(b) The second stratum consisted of children aged above $2\frac{1}{2}$ years and under five years who possibly have not received the PCV-10 vaccine.

Using the inpatient numbers as codes, the required random sample from each stratum for that day were picked without replacement; then the sampled children were identified with their inpatient numbers and recruited into the study. After consenting, questionnaires were administered to the care givers by the enumerators. Sampling was done after every two days once data collection ensued so as to allow time for discharge for the already sampled population for the two month period in which data collection was done.

3.3.3 Sample size

Calculated sample

Accessible population: Total population in 0 - $2\frac{1}{2}$ years stratum in the past 6 months = 420; monthly average = 70. Total population in above $2\frac{1}{2}$ years stratum in the past 6 months = 240; monthly average = 40. Accessible population in two months when data collection was taking place:

Stratum 1, 0 - $2\frac{1}{2}$ years= 140

Stratum 2, Above $2\frac{1}{2}$ years= 80

Using, p of 0.05, a 95% confidence level and 5% precision, sample size was determined using the following formula: [30]

Infinite population sample:

$$n_0 = \frac{z^2pq}{e^2} = \frac{(1.96)^2 \times 0.5 \times 0.5}{(0.05)^2} = 384.16 \tag{3.1}$$

Where: n_0 is the sample size,

Z^2 is abscissa of the normal curve that cuts off an area α at the tails

($1 - \alpha$ equals the desired confidence level of 95%),

e is the desired level of precision,

p is the estimated proportion of an attribute that is present in the population, and

q 1-p.

The value for Z is found in statistical tables which contain the area under the normal curve.

Finite population correction for small population:

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}} \tag{3.2}$$

Therefore:

$$n = \frac{384}{1 + \frac{(384-1)}{220}} = 142 \tag{3.3}$$

Sample allocation to each stratum using proportional allocation [25]

$$n_h = (\frac{N_h}{N})n \tag{3.4}$$

Where n_h is the sample size for stratum h, N_h is the population size for stratum h, N is total population size, and n is total sample size.

$$n_{h1} = (\frac{N_h}{N})n = (\frac{140}{220}) \times 142 = 90.36 = 90 \tag{3.5}$$

$$n_{h2} = (\frac{N_h}{N})n = (\frac{80}{220}) \times 142 = 51.64 = 52 \tag{3.6}$$

The sample was increased per stratum by 10% to cater for none responses

Actual sample size

The calculated sample was inclusive of 10% more per stratum to cater for any none responses and possible failure to proceed with the study by any subjects.

Table 3.1: A Table Showing Calculated Sample Size

Stratum	Calculated Sample	10% additional	Total
Stratum 1, 0 - $2\frac{1}{2}$ years	90	9	99
Stratum 2, Above $2\frac{1}{2}$ years	52	5	57

Table 3.2: A Table Showing Actual Sample Size

	Calculated Sample	**Actual Sample**	**Difference**	**%**
Total	156	190	+34	21.7%
0 - $2\frac{1}{2}$	99	130	+31	31.3%
Above $2\frac{1}{2}$	57	60	+3	5.3%

Given that the design used was independent case control study design, all cases were recruited into this study in their respective strata during the time of data collection. Additionally, there was unforeseen majority admission of children with neurological problems who fall in the first stratum (0- $2\frac{1}{2}$ years) with pneumonia cases being quite low. Random samples of non-cases from both strata were then obtained as shown in Table 3.2. Discussions of this study are based on results obtained from the actual sample population.

3.3.4 Inclusion and exclusion criteria

Children under the age of five years admitted in paediatric ward Kijabe Hospital. Paediatric ward was selected because the ward cases were identified based on confirmed medical diagnosis of pneumonia as opposed to outpatient or maternal child health clinic where clinical diagnosis and treatment is done. All children admitted in paediatric ward Kijabe Hospital aged above five years were excluded from this study.

3.4 Data collection

Existing hospital records were used to collect data for determining incidences of pneumonia and number of episodes of pneumonia for the past six months. The advantages of this secondary data source are that it is economical in terms of cost and time, participation problems for instance cooperation and respondent bias are eliminated.

Interviewer-administered questionnaires were used to collect data for a period of 3 months beginning 16th February, 2014 to May 2014 in paediatric ward. All cases in the 0-$2\frac{1}{2}$years stratum were recruited into the study and a random sample of controls was selected. This was done after every two days upon commencement of data collection, which allowed time for patient turn over hence avoid repetitive sampling. Upon willingness of the sampled caregivers to participate, questionnaires requiring a maximum of 10 minutes for filling each were administered to caretakers of the children preferably mothers in a private room one at a time.

The same criteria was applied to the stratum of children aged above $2\frac{1}{2}$ years

3.4.1 External validity

These research sampling strategies explained were aimed at ensuring external validity which is the extent to which inferences from the sample can be generalized to the target population [26].

3.4.2 Internal validity

The enumerator training was done a week prior to commencement of data collection in which three enumerators were taken through the study objectives and the entire methodology of the study. As outlined in sampling, an appropriate sample selection was done and this enabled obtaining a representative sample. The questionnaire was pretested to determine if the measurements obtained are what the study intended to measure; the pretest informed adjustments that were done on the questionnaire prior to data collection. All these were deliberate means of controlling effects that would reduce precision of this study. This is what constitutes internal validity; ' the extent to which effects detected in the study is a true reflection of reality, rather than being the effects of extraneous variables ' [26].

3.4.3 Tool development

A questionnaire was developed based on objectives of the research. It was pretested through a pilot study before actual data collection to check its reliability.

3.4.4 Data entry and validation

Data entry and validation was done using CSPro whose preparation was done as soon as tool development was completed. Data entry ensued as soon as data collection was done.

3.5 Data analysis

As soon as data entry and validation was complete, data was exported to and analysed using SPSS version 22. Odds ratios were calculated with logistic regression and p-values were computed using SPSS to determine association between study variables.

3.5.1 Minimization of bias

Bias was minimized through use of appropriately designed questions requiring recall to a minimum suitable duration and available confirmatory records, that is, the MOH 216 register: the Mother and Child Health Booklet, using adequate sample and appropriate training of the enumerators.

3.6 Ethical Considerations

A copy of the research proposal was submitted to the Institutional Review Board in Kijabe Hospital for approval to conduct the study in paediatric ward of Kijabe Hospital. As soon as the approval to conduct the study was given by the institutional review board, letters requesting for permission to carry out the study in paediatric ward were sent to the Head of Bethany Kids Kijabe Hospital and the paediatric ward nursing officer in charge. This was done after the approval of the proposal by the School of Graduate Studies of Maseno University.

Informed consent was sought from the eligible participants before questionnaires were administered and respondents had free will to withdraw from the study. Confidentiality was assured and maintained by ensuring no names were written in the questionnaires but rather numbers were used. However, data obtained may be used in publications or presentations at a later date. No gifts were given for eligible participants to participate nor to those who participate in the study but the findings of the research have the primary

goal of benefiting children below the age of five years receiving care in Kijabe Hospital through adequate prevention of pneumonia.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter explores the processing and presentation of results obtained from the process of data entry, cleaning and validation. The data was processed using version 22 of SPSS after being exported from CSPro that was prepared and utilized for data entry. Odds ratios were computed for case control categorical data that was gathered as well as p-values that were interpreted as per the study objectives. The formula used for odds ratio calculation that was computed by SPSS which is the cross-product ratio of the entries in the 2-by-2 table is as follows:

Exposure variable	Response Variable		
	+	-	Total
+	A_1	B_1	n_1
-	A_2	B_2	n_2
Total	m_1	m_2	N

$$\hat{OR} = \frac{A_1 B_2}{A_2 B_1} \tag{4.1}$$

Binary logistic regression was run using SPSS to generate the computed findings presented and discussed in this study. Logistic regression was used because it is a predictive analysis and it is used to describe data and to explain the relationship between one dependent binary variable and one or more metric (interval/ ratio scale) independent variable. Binary logistic regression was appropriate for this study because the dependent variable pneumonia is binary in nature; present or absent. [31]

The logistic regression model: [31]

The "logit" model solves these problems:

$$ln\frac{p}{(1-p)} = \mathbf{a} + \mathbf{B}X + e \tag{4.2}$$

or

$$\frac{p}{(1-p)} = exp(\mathbf{a} + \mathbf{B}X + e) \tag{4.3}$$

Where:

ln is the natural logarithm, log_{exp}, where $exp = 2.71828$âĂę

p is the probability that the event Y occurs, $p(Y = 1)$

$p/(1-p)$ is the "odds ratio"

$ln[p/(1-p)]$ is the log odds ratio, or "logit"

All other components of the model are the same.

The logistic regression model is simply a non-linear transformation of the linear regression. The "logistic" distribution is an S-shaped distribution function which is similar to the standard-normal distribution (which results in a probit regression model) but easier to work with in most applications (the probabilities are easier to calculate). The logit distribution constrains the estimated probabilities to lie between 0 and 1. [32]

Data is presented in this chapter in tables and graphs.

4.1 Characteristics of the study participants

The present study enrolled a total of 49 case patients and 141 control patients. Among the cases, 37 patients (75.5%) were aged less than $2\frac{1}{2}$ years while in the controls 93 patients (66.0%) were of a similar age. Of the 49 cases, 27 patients (55.1%) were male. On the other hand, 92 of the 141 patients were males (65%) as shown in Table 4.1

.

4.2 Children vaccinated for pneumococcal pneumonia

Out of the 190 children enrolled in the study, 155 (81.6%) had received the vaccine against pneumococcal pneumonia (PCV-10). Those who had received one and two doses within fourteen weeks after birth were eleven (7.1%) and nineteen children (12.3%) respectively Table 4.2. Majority of the children had received three doses within 14 weeks of birth 121 (78.1%). Additionally, 176 (92.6%) children had received pentavalent vaccine with 16 (9.1%), 17 (9.7%) and 143 (81.3%) children having been vaccinated once, twice or thrice

Table 4.1: A Table Showing Characteristics of the Study Participants

Descriptive Variable	**Cases**		**Controls**	
	Number(n=49)	**%**	**Number(n=141)**	**%)**
Age (years)				
0- $2\frac{1}{2}$	37	75.5%	93	66.0%
Above $2\frac{1}{2}$	12	24.5%	48	34.0%
Gender				
Male	27	55.1%	92	65.2%
Female	22	44.9%	49	34.8%

respectively.

Table 4.2: A Table Showing Children Vaccinated for Pneumococcal Pneumonia

Characteristics	**Frequency**	**Percentage(%)**
Received PCV-10 (n=190)		
Yes	155	81.6
No	35	18.4
No. of PCV-10 doses (n=155)		
1 dose within 14 weeks of birth	11	7.1
2 doses within 14 weeks of birth	19	12.3
3 doses within 14 weeks of birth	121	78.1
1 dose after 14 weeks of birth	4	2.6
Received pentavalent vaccine (n= 190)		
Yes	176	92.6
No	14	7.4
No of times child has received pentavalent vaccine (n= 176)		
Once	16	9.1
Twice	17	9.7
Thrice	143	81.3

4.3 Trends in pneumonia cases

Figure 4.1 shows the temporal variation of cases of pneumonia per annum during the period ranging from 2011 to 2014. The highest number of cases are reported in the months of June and July a drop is witnessed beginning from the month of August. Lowest number of cases are reported in September, October, November, December and January.

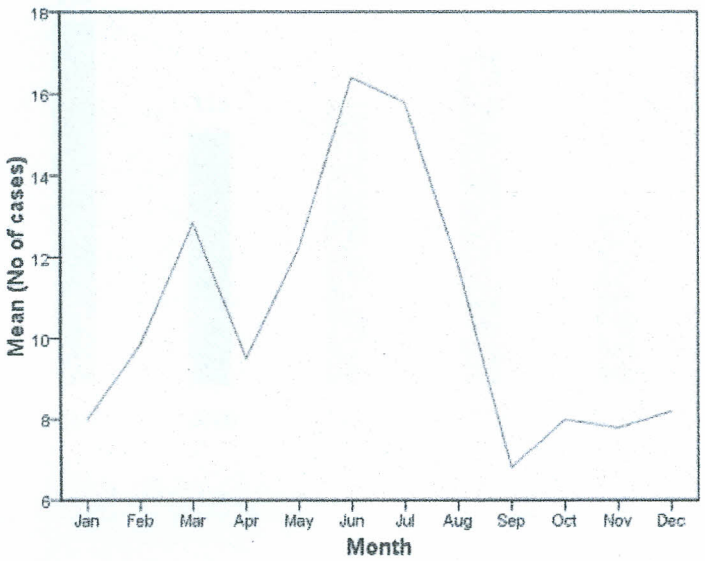

Figure 4.1: Trends in Pneumonia Cases

Figure 4.2 shows the pneumonia cases for the period (2009-2014). A decline in the incidence of pneumonia was observed from 2009; 168 cases to 2010; 118 cases. A steady increase followed in 2011 when there were 133 cases and 2012 had 154 cases. Incidence of pneumonia then declined since then to the year 2014 when data collection was concluded. The cases of pneumonia reported in 2013 and 2014 were eighty and fifteen respectively.

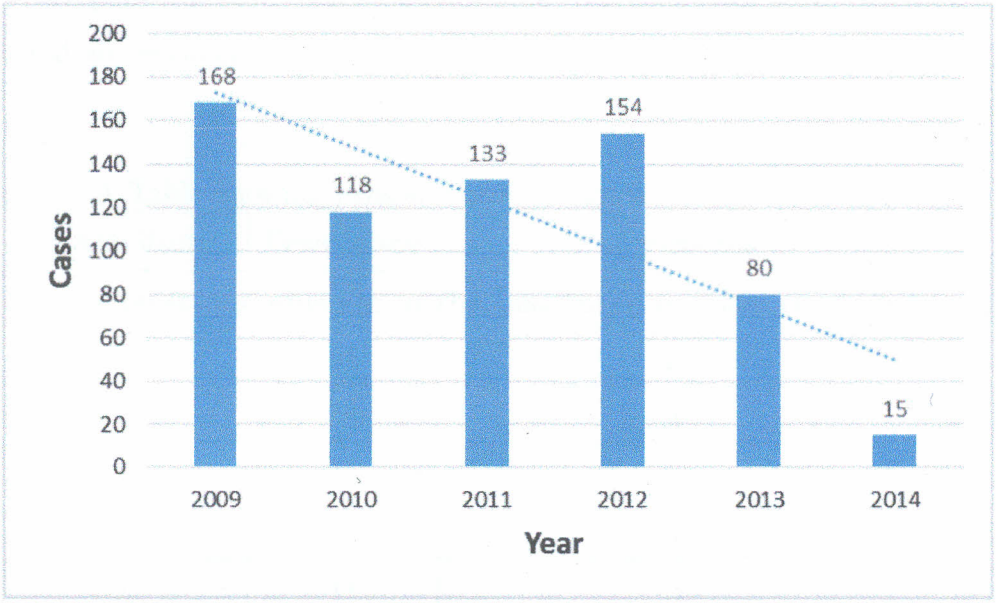

Figure 4.2: Pneumonia Cases Time Series Plot for the Period (2009-2014)

4.4 Episodes of pneumonia within a six months period

The study collected data on the episodes of pneumonia in a child in the six months prior to the survey. Overall, 94 children (49.5%) had suffered at least one pneumonia episode in the six months preceding the survey. The frequency of episodes of pneumonia within the six month period were as follows; once (57, 60.6%), twice (11, 11.7%), thrice (7, 7.4%) and four and above times (19, 20.2%) as shown in Table 4.3 below.

Table 4.3: A Table Showing Episodes of Pneumonia Within a Six Months Period

Attribute	**Frequency**	**Percentage(%)**
At least one episode in the last three months (n= 190)		
Yes	94	49.5
No	96	50.5
No. of episodes (n= 94)		
One	57	60.6
Two	11	11.7
Three	7	7.4
Above three	19	20.2

4.5 Factors contributing to cases of pneumonia

The proportion of younger children ($<2\frac{1}{2}$ years) was higher in the cases as compared to the controls, 75.5% and 66.0% respectively. However, age was not a significant factor for pneumonia (p=0.215). Similarly, gender was not a significant predictor of pneumonia (p=0.206). The odds in favour of having pneumonia if a child has been vaccinated with PCV- 10 was 0.683 the odds in favor of unvaccinated child acquiring pneumonia as shown in Table 4.4below. This association is statistically significant given the p- value was 0.032 rejecting the null hypothesis that PCV-10 does not protect against pneumonia.

Table 4.4: A Table Showing Factors Contributing to Cases of Pneumonia

Variable	Cases(n, %)	Controls (n, %)	OR (95% CI)	P-Value
Age (Years)				
0- $2\frac{1}{2}$	37(75.5%)	93(66.0%)	1.423(0.801-2.528)	0.215
Above $2\frac{1}{2}$	12(24.5%)	48(34%)	Reference	
Gender				
Male	27(55.1%)	92(65.2%)	0.732(0.453-1.183)	0.206
Female	22(44.9%)	49(34.8%)	Reference	
PCV- 10				
Yes	39(79.6%)	120(85.1%)	0.683(0.202-0.929)	0.032
No	10(20.4%)	21(14.9%)	Reference	

4.6 Evaluation of the association between environmental factors and pneumonia

Table 4.5 presents the findings on the evaluation of the association between environmental factors and pneumonia. Exposure of children to crowded areas was significantly associated with pneumonia (p=0.019). More children among the cases were found to have been sleeping in rooms whose window(s) were always open although this failed to reach statistical significance (93.9% versus 90.1%, p=0.567). Living in a house with a kitchen, using firewood and/or charcoal as a source of fuel or living with a smoker are known risk factors for pneumonia however, in this study the extent of association was not statistically significant. Having been infected by a cold from a family member was associated with a two-fold increment in the odds of having pneumonia (OR=2.002 (95% confidence interval (CI): 1.040-3.852), p=0.026). Having been breastfed exclusively for the first six months showed no significant variation between the cases of pneumonia infections and the controls (p=0.891).

Table 4.5: A Table Showing Association Between Environmental Factors and Pneumonia

Characteristic	Cases(n,%)	Controls(n,%)	OR(95% CI)	P-Value
Exposure of child to crowded areas				
Yes	29(59.2%)	108(76.6%)	0.561(0.349-1.090)	0.019
No	20(40.8%)	33(23.4%)	Reference	
Sleeping room window always open				
Yes	46(93.9%)	127(90.1%)	1.507(0.524-4.333)	0.567
No	3(6.1%)	14(9.9%)	Reference	
Main house with kitchen				
Yes	26(53.1%)	96(68.1%)	0.630(0.391-1.014)	0.059
No	23(46.9%)	45(31.9%)	Reference	
Source of fuel firewood/ charcoal				
Yes	41(83.7%)	117(83.0%)	1.051(0.438-2.524)	0.911
No	8(16.3%)	24(17.0%)	Reference	
Lives with a smoker				
Yes	14(28.6%)	33(23.4%)	1.217(0.720-2.057)	0.470
No	35(71.4%)	108(76.6%)	Reference	
Got cold from family members				
Yes	40(81.6%)	91(64.5%)	2.002(1.040-3.852)	0.026
No	9(18.4%)	50(35.5%)	Reference	
Exclusively breastfed				
Yes	38(77.6%)	108(76.6%)	1.041(0.583-1.860)	0.891
No	11(22.4%)	33(23.4%)	Reference	

4.7 Assessment of the influence of selected practices on pneumonia

Being aware of the need of avoiding exposing children to cold and coughing while covering the mouth failed to associate in a statistically significant way with pneumonia as shown in Table 4.6. Awareness on washing hands after blowing nose or sneezing was associated with pneumonia (p=0.028).

Table 4.6: A Table Showing Influences of Selected Practices on pneumonia

Variable	Cases(n,%)	Controls(n,%)	OR(95% CI)	P-Value
Coughing while covering the mouth				
Aware	48(98.0%)	130(92.2%)	3.236(0.488-21.464)	0.192
unaware	1(2.0%)	11(7.8%)	Reference	
Washing hands after blowing nose or sneezing				
Aware	48(98.0%)	122(86.5%)	5.647(0.824-38.723)	0.028
unaware	1(2.0%)	19(13.5%)	Reference	
Avoid exposing children to cold				
Aware	48(98.0%)	129(91.5%)	3.525(0.528-23.535)	0.189
Unaware	1(2.0%)	12(8.5%)	Reference	

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study sought to estimate the proportion of children under five admitted to Kijabe Hospital vaccinated for pneumococcal pneumonia. Also, to identify the trends in pneumonia cases at Kijabe Hospital in children under the age of 5 years and find out the number of episodes of pneumonia among these children during six months prior to data collection. Additionally, the study was conducted in order to identify for further study the association between PCV-10 and other factors, and pneumonia among children under five years.

The study found out that 81.6% of children managed in Kijabe hospital have been vaccinated with PCV-10. There was a progressive increase in the trends of pneumonia till the year 2012 when the annual incidence began to decline. The peak incidences were observed during the months of June, July and August Table4.1. The lowest being from September to January. Overally, 94 children (49.5%) had suffered at least one pneumonia episode in the six months preceding the survey. PCV-10 was significantly associated with pneumonia, odds ratio 0.683(0.202-0.929) and p- value = 0.032 Table 4.4. This shows that PCV-10 is effective against pneumococcal pneumonia which resulted in reductio of predictions of pneumonia cases for vaccinated children.Environmental factors were shown to be associated significantly with pneumonia and of these factors, exposing a child to crowds was significantly associated with pneumonia (p=0.019) and having been infected by a cold from a family member was associated with a two-fold increment in the odds of having pneumonia (OR=2.002 (95% confidence interval (CI): 1.040-3.852), p=0.026). General awareness on pneumonia prevention practices was evident among the cases with hand washing after blowing nose or sneezing reaching statistical significance (P = 0.028) Table 4.6.

5.2 Discussion

The current study showed that the proportion of children vaccinated against pneumococcal pneumonia was high 81.6% (155). This finding is reflected by the findings of the Kenya Demographic and Health Survey of 2014 which found out that the countryâĂŹs PCV-10 immunization coverage (Fully immunized) was 85.1% in the year 2014 [28]. Those who had not received were either younger than 6 weeks and the majority in the above 2 $\frac{1}{2}$ years stratum being none beneficiaries since inception of national PCV-10 vaccination. The 4 who received a dose after 14 weeks of age were the few beneficiaries of catch up vaccination that was done in few health facilities in Kenya, Kijabe Hospital not being one of them. This shows that herd protection may not have been achieved since catch up vaccination increases coverage and eventually the immune population protects the unvaccinated population [17, 18]. However, the calculated odds ratio from this study 0.683(0.202-0.929), showed significant association in favor of children unvaccinated with PCV-10 suffering from pneumonia at 95% CI and a p-value of 0.032 hence the null hypothesis is rejected. A 15.8% increase in pneumonia cases was observed between the year 2011 when PCV-10 was introduced and the year 2012, a case of serotype replacement that was witnessed with use of other PCVs [5]. On the contrary, the incidences of pneumonia have been shown to decrease over the years as shown in Figure ?? from 2012 after PCV-10 introduction indicating a high likelihood of PCV-10 protecting against pneumococcal pneumonia. On the other hand, this does not dispute the fact that the decline could possibly be attributed to other factors given that the causes of pneumonia are diverse [1]; bacterial, viral, chlamydial pneumonia among others, which the current study was not able to control.

Age showed a weak association with pneumonia with odds of 1.423 (0.801-2.528) favouring younger children suffering pneumonia than their older counterparts (above $2\frac{1}{2}$) and the p= 0.215. This is because, during the childâĂŹs growth and development, exposure to various antigens occur hence the child develops natural active immunity against those very antigens or microbes [18]. In addition, immune system of a child matures with age, therefore, natural active immunity is developed against several causes of pneumonia [1]. This was evident in the population of cases that was higher (75.5%) in the first stratum than the population of cases in the second stratum of children aged above $2\frac{1}{2}$ years. Also,the

weak association could be attributed to, although younger children have a high carriage of more common serotypes unlike older children, the carriage of uncommon serotypes did not decline revealed in the KEMRI study at Kilifi [9]. The other causes of pneumonia possibly accounts for the weak association as well [1].

In order to identify the trends of pneumonia, the study obtained data from admission register since 2009 till 2014. The highest number of cases were reported in the months of June, July and August. The climatic conditions of the catchment area of Kijabe Hospital is moderate with temperatures during the cool seasons falling within these months ranges from 15.6°C to 21.1°C and night time temperatures of about 10°C [22, 23, 24]. This season favors mycoplasma and other types of pneumonia [1]. Lowest number of cases are reported in September, October, November, December and January. These are months with hot seasons whose temperatures range from 21.1°C âĂŞ 26.7° C and night time temperatures of 21.1°C [22, 23, 24]. This seasonal variation as well contributes to the association between PCV-10 and pneumonia in that data was collected during low seasons.

It is possible that the current non cases could have suffered an episode of pneumonia or two episodes prior to the time of data collection. This study sought to ascertain this fact as well as to identify whether there are cases who had had recurrent pneumonia. The patientâĂŹs files provided the secondary sources of data which showed that 49.5% of children enrolled into the study had suffered at least an episode of pneumonia. It is worth noting that of the 49.5%, 27.6% had suffered recurrent pneumonia (those having three or more episodes of pneumonia within a period of six months) [1].

This study also found out the significance of other factors in pneumonia causation and of great contribution was environmental factors. Of these environmental factors, exposing a child to crowds was significantly associated with pneumonia (p=0.019) and having been infected with cold by family members was associated with a two-fold increment in the odds of having pneumonia (OR=2.002 (95% confidence interval (CI): 1.040-3.852), p=0.026). This is backed up by the fact that transmission of colds and flu is airborne through coughing and sneezing and droplets with high carriage of *Streptococcus pneumoniae* in children with coryza and cough [9]. Contact on hands and surfaces [1] result

in transmission of usually viral particles the most common being Respiratory Syncytial Virus. Therefore with effective hand hygiene transmission of pneumonia causing microbes is prevented [10]. On the contrary, knowledge on these strategies did not significantly associate with pneumonia except awareness on hand washing after blowing nose or sneezing (p=0.028). This means that awareness does not necessarily translate to practice thus the care givers of cases were aware yet these children suffered pneumonia. This association reveal that, it is possible that health care workers do too much too late: giving health education on prevention of pneumonia when the children already have the disease. These health messages would only help prevent recurrences if practiced.

Although exclusive breastfeeding rates were high 38 (77.6%) for cases and 108 (76.6%) among the controls, this failed to associate with pneumonia odds ratio 1.041 (0.583-1.860) and p-value = 0.891. The cases of malnutrition are equally high in Kenya according to the KDHS 2008-09 and KDHS 2014 reports [13][28]thus regardless of breastfeeding, inadequate complementary feeding tend to mask the effect of breastfeeding in pneumonia prevention. This is because with poor nutrition, immunity will also be poor.

5.3 Conclusion

In conclusion, PCV-10 protects against serotype specific pneumococcal pneumonia as has been proven [9]; these was evident in the current study through reduction of the incidence of pneumonia over time from the year 2012 (154), 2013 (80) and projected 2014 (45); a reduction of 48.05% from 2012 - 2013, and 43.75% from 2013 to 2014. Also, PCV-10 was significantly associated with pneumonia, odds ratio 0.683(0.202-0.929) and p- value = 0.032. This means that the vaccinated children are less likely to suffer pneumonia compared to unvaccinated children. In addition, of other causes of pneumonia, viral transmission was notably high measured by the current study for example despite awareness on selected strategies with a statistically significant association in knowledge on hand washing after sneezing, coughing or blowing the nose having a p-value of 0.028, children still suffered pneumonia.

5.4 Recommendations

Based on the research findings the following recommendations have been made:

(1) Another study using a larger sample in various regions of the country could be conducted to increase generalisation of the findings of the current study.

(2) The highest proportion of both cases and controls have awareness of risk factors for pneumonia. However, this does not translate to action towards reducing the risks to children. Therefore ways to address reduction of pneumonia risk factors besides awareness need to be explored.

(3) A prospective cohort study enrolling children with pneumococcal positive nasopharyngeal swab cultures and viral pneumonia be done to ascertain the actual association between PCV-10 and pneumococcal pneumonia and compare disease burden. This is because the methodology employed in the current study could not determine the actual cause of pneumonia.

(4) Given that the trends of pneumonia have been reducing over time, other factors that may directly or indirectly influence occurrence of pneumonia need to be investigated and addressed for instance viral causes of pneumonia.

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