SOCIAL CONTACT PATTERNS AMONG SCHOOL-GOING CHILDREN IN A RURAL LOCATION IN KENYA

BY

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DECLARATION

I declare this dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university and that to the best of my knowledge it does not contain any material previously published or written by another person except where due reference has been made in the text

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ABBREVIATIONS

RSV	Respiratory Syncytial Virus
LRTI	Lower Respiratory Tract Infection
URTI	Upper Respiratory Tract Infection
H1N1	An Influenza A virus subtype commonly referred to as 'swine flu'
SD	Standard Deviation
IQR	Inter- quartile Range

ABSTRACT

Contact patterns drive the dynamics of transmission of respiratory viruses. Schools, as places of very high contacts are presumably important for transmission. Contact data support modelling the spread of respiratory infections, in particular, emerging viruses such as pandemic influenza. There are no direct estimates on respiratory virus transmission or contact patterns in schools in developing countries. We demonstrate the use of paper diaries in defining contact patterns among school children in a developing country setting. 451 diaries (240 term, 211 vacation) obtained from 301 participants aged ≥10 years from 7 public schools (6 primary and 1 secondary) were analysed. Individuals were assigned contact diaries on two separate occasions, school term and vacation period. Recorded details of their contacts included age-group, sex, location and frequency of contact. A contact was defined as either conversation (type 1) or physical touch (type 2). Multi-level linear models were fit using STATA 11 to investigate source of variation in contacts at different levels (individual, age-group, school). The final model explored gender, age-groups and diary time..Students had significantly more contacts during the school term than the vacation period (mean term =29.8 versus vacation = 23.5, multi -level analysis: $p<0.001$). 59% of contacts during vacation occurred outside the home and 29% of these were in-school contacts due to vacation additional tuition. The trend for unadjusted mean number of unique contacts across age groups was significant ($p=0.001$) ranging from 30.5 in 11-13 year olds to 20 in those above 20 years. There was no significant difference in rates of type 1 (Mean (Standard Deviation) =12.7 (12.9) and type 2(Mean (SD) = 12.4(11.9) contacts; t (2) =-1.132, $p=0.375$. Students tended to mix with people of the same age groups . After adjustment for various variables, new contacts were significantly associated with being female Mean= 32.1 ($p>0.02$) and belonging to a lower age group (Mean = 26.8 $p>0.001$).This first study of school-child contact patterns revealed evidence for higher mixing among girls and younger individuals, coupled to significant assortative (within group) mixing. The demonstration of significantly greater contact rates in school term than vacation has potential implications for school closures during outbreaks of emergent viruses e.g. pandemic influenza. Diary studies in the developing country setting are feasible and have use in defining data for modelling disease spread.

1.INTRODUCTION

1.1. Background of the Study

Human Respiratory Syncytial Virus (RSV) is a major cause of childhood acute lower respiratory tract infection (LRTI) worldwide.. The virus normally causes annual epidemics, and approximately 60% of newborns are infected during their first year of life.

Concomitantly, the risk of severe RSV associated respiratory disease following infection is highest in early infancy, declining rapidly with increasing age beyond 6 months, probably as a result of physiological maturation of the airways Interventions for the prevention or control of infectious diseases are better formulated on the basis of a quantitative understanding of the determinants of the spread of infection within a population. In the case of directly transmitted respiratory viruses, such as influenza viruses and respiratory syncytial virus (RSV), transmission is effected through interaction or contact between individuals sufficiently close for virus to pass from one person to the next. It follows that the transmission dynamics of these viruses are determined by the structure and rates of such contacts between susceptible and infectious individuals in a population

Vaccine development, in particular live attenuated virus vaccines, has primarily targeted infants aged less than 3 months, but, as yet, no human RSV vaccine has been licensed. There are considerable obstacles confronting the development of vaccines targeting early infants, which include the immaturity of the immune system, presence of maternal RSV-specific antibodies, and balance between immunogenicity and the risk of upper respiratory tract congestion associated with live vaccines. Alternative strategies for RSV vaccination have therefore been proposed, including delaying delivery to an older age, for which there is empirical support. Vaccination of older age groups may lead to indirect protection of the

vulnerable infant through reduced circulation of virus in the population or prevention of chains of transmission to the infant. This potential benefit requires knowledge of the contact patterns among the older age-groups to determine the effect of vaccinating this target group.

The majority of contact diary-based studies have been conducted in developed countries, and only two have been in low income settings, one in an informal urban settlement in South Africa and the other in a semi-rural community in Vietnam. Given all of the above there IS a need to characterize contact patterns more widely, particularly in low income communities where least is known. Contact diary data reflect the social, behavioural and demographic characteristics of the study population, which may vary from location to location. Specifically, there will be variation between the different variables to be explored, all of which may have a bearing on the patterns and rates of contact and hence the spread of respiratory infection.

The source of direct estimates of contacts is usually the self-completed diary and follows the early work by Edmunds et al. A sample of the population under study is selected to complete a record of each of the contacts made by the participant with other individuals on a chosen day. These diaries usually aim to collect data on the age of the participant and the ages of all individuals contacted, stratified by the intensity of the contact encounter (usually conversation and touch), the frequency of contact with the same individual or the total duration of this pair-wise contact in the day, the location or context in which the interaction occurs , and the day of the week. There are inherent problems with diary collected data including failure to record all contacts and difficulty in comprehending the process of completion. Measures taken to minimize resultant error and bias include recap interviews on collection of diaries and provision of a 'shadow' to record the contact data for very young or illiterate participants .

Mathematical models of infectious disease transmission are recognized as important tools for exploring the potential impact of interventions. To capture greater reality these models generally incorporate age as the key structural feature governing transmission patterns. Increasingly the models designed for the study of respiratory infections utilize direct estimates of contact rates within and between age groups of a population by which to determine who acquires infection from whom.

1.2 Problem Statement

The major burden of severe respiratory syncytial virus (RSV) disease occurs during the first 6 months of life. Vaccine development for direct protection in this age group faces substantial obstacles. Targeting older individuals, such mothers and school going siblings, might indirectly prevent early infant infection. Assessing the potential of such a strategy requires knowledge of the source of infection to infants.

Previous studies have demonstrated that older children, particularly school going, are frequent introducers of Respiratory Syncytial Virus into households that lead to infant infection.

To date, little research has focused on characterizing this important portion of the social contact network for the spread of respiratory infections among and other close contact infections. A number of documented outbreaks (Measles, Rubella) have shown that information of on contacts of school children is of growing importance in development of vaccines.

To date, only one study provides a large-scale quantitative approach to contact patterns relevant for infections transmitted by close-contact route. Africa, only one prospective survey of social contact patterns relevant for spread of respiratory infections among a township population has recently been reported.

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1.3 Significance of the Study

Schools are very significant for the spread of infectious diseases, and in cases of those infections studied in most detail (including measles and rubella) Transmissions within schools determine the dynamics in the whole community. This has relevance to the transmission of endemic viruses such as RSV and of emerging viruses (such as (H1N1) influenza pandemic).

There are currently few data on school-based spread of RSV or on respiratory related contact patterns in developing countries. This study has aided our understanding of the transmission of respiratory viruses and diseases that are spread through close contact. In particular, we provide important information of the role of school-going children as a key source of infection to the household, and to the naïve infant, most vulnerable to severe RSV disease.

This increased understanding will enhance our ability to predict the impact of interventions such as vaccination against respiratory viruses and school closure in the face of pandemic influenza. We are especially interested in the concept of vaccinating School-age children (who are thought to be less vulnerable to adverse reactions to RSV vaccines than younger children) as a means to protect infants from RSV infection during their first year of life. This approach has the potential to radically change the way in which vaccination programmes are designed and implemented.

1.4 Purpose of the study

To determine the patterns of contacts that may lead to transmission of a respiratory infection.

1.5 Research Objectives

1. To quantify the rates of contact within and between defined age groups, both within the school setting and between school-going children and the wider community.
2. To quantify the variation in contact rate during the school term and vacation period.
3. To demonstrate the use of contact diaries in defining transmission patterns within schools in a developing country setting

1.6 Research Questions

1. What are the contact rates of school children of different age groups and classes?
2. Can contact diaries define transmission patterns among school children?
3. Do variations in contact patterns exist between school term period and vacation period?

1.7 Limitations of the Study

The choice of the study site was based purely on convenience since it was easily accessible to the study team. The most obvious limitation of the study is its cross-sectional design. It is impossible to draw firm conclusions about the directions of causality implied in the model.

True causal inferences can only be drawn testing models using longitudinal data. Since only self-report measures were used, common-method variance and response consistency effects may have biased the observed relationships.

The data collection was confined to only a rural area and this data may not be representative of the urban set up. The study team also faced certain logistical constraints during data collection that may affect the outcome.

The study was limited to individual contacts. Consideration of group contacts particularly during the vacation period when they were not obvious might have produced different results.

1.8 Delimitations of the Study

In this study we only investigate the usage of paper diaries to record social contacts of students in 7 public schools in a rural highland location. The study population consisted of school-going children from 7 Government run schools within Soin location, Kericho District of which 6 are nursery/primary, and 1 secondary.

Pupils/Students attending public school within in Soin location who belonged to the upper primary classes were (standard 4 to 8) and those in the secondary school were eligible for inclusion in the study. A written consent by the participant's parents was obtained. Students ≥18 years were also required to sign an additional consent form and a verbal assent by the pupils <18 years old was required in order for them to participate in the to participate in the study.

1.9 Definition of Significant Terms

The following terms used in this study adopted the said definitions whenever they appeared in the study.

Contact

A contact was defined as either conversation where one was close enough to touch (at an arm's length) or an actual physical touch

Participant

A student who willingly accepts to be part of the study and their parents have given informed consent.

School term

The period during which students regularly attend school for 5 consecutive days and rest on weekends

Vacation period

A period during which students are on holiday do not attend school.

Day

A day was defined as the period from the time of waking up to time they sleep.

1.10 Organisation of the Study

The research study is organized in five chapters .The first chapter starts with the background to the problem followed by the statement of the problem. In the same chapter, the purpose of the study is outlined and the research objectives and questions highlighted . Limitations of the study and the scope of the study are also covered in the first chapter.

In chapter 2, a comprehensive literature review is done, Various themes that are relevant to the study aims are covered. Chapter 3 covers the methods including the design, target population, sampling and procedures. The instruments used in the data collection as well as the validity and reliability are also captured in this chapter. Chapter 4 contains the analysed results of the study while chapter 5 covers the discussion of the study findings as well as the conclusions drawn.

2. LITERATURE REVIEW

2.1. Social Contact Patterns

Contacts between individuals are instrumental for the direct transmission of many infectious diseases. Recently, increased effort has been put into measuring the numbers and characteristics of contacts that lead to the transmission of airborne infections like influenza (Beutels et al. 2006, Edmunds et al. 2006, Mossong J et al.2008). Although it is not known with certainty what type of contact between two individuals is sufficient for transmission of a pathogen, it has been shown that conversational contacts or social contacts in close proximity are a good proxy for contacts leading to transmission (Wallinga et al.2006). Quantitative information about these contacts is therefore needed to inform mathematical modelling that is used to analyse and evaluate intervention strategies and contingency planning (Glass LM et al. 2008, Glass RJ et al. 2008 Ferguson et al. 2006). Up to now the main focus of these measurements was on the numbers of contacts per day between different age groups. However, characteristics of contacts may also influence the way an infection spreads through a population, for example the place where contact occurs, or the proximity of contact. Additionally, it can be of interest, how individuals distribute their contacts across different locations, as opposed to overall distributions of contacts for the entire population across locations. A large study to collect this type of information in representative samples of the populations of eight European countries was conducted recently (POLYMOD project)(Mossong J et al.2008).

Several studies have reported data on mixing patterns from different populations and their impact on the spread of communicable diseases.(Mossong J et al.2008,Mikolajczyk R et al. 2008, Edmunds W et al. 1997, Wallinga J et al. 2006) only a limited number of studies have however reported data on mixing patterns that could lead to the transmission of respiratory

infections.(Mossong J et al.2008, Beutels P et al.2006,) To date, only one study(Mossong J et al.2008) provides a large-scale quantitative approach to contact patterns relevant for infections transmitted by close-contact route. In Africa, only one prospective survey of social contact patterns relevant for spread of respiratory infections among a township population has recently been reported.(Johnstone -Robertson S et al.2011)

In majority of the social contact studies ,(1 Mossong J et al.2008, Johnstone -Robertson S et al.2011) ,contact patterns of school age children have been estimated only as part of a general population. In this paper, we develop an approach to characterize social contacts of school children in a rural African setting. The results of this study will be useful in informing vaccination programs and in the design of social distancing policies. These results may also be useful in modelling of predictive capabilities for the potential transmission of respiratory infections in school age children through the use of social contact diaries.

Of particular interest, Edmunds et al.2006, differentiated contacts into 4 levels: level 1 for physical contact without conversation, level 2 for conversation, level 3 for conversation with physical contact, and level 4 for kissing and other intimate behaviour. These levels related to the potential that an infection like influenza will be passed during a contact.

2.2 Respiratory Syncytial Virus and Related Viruses.

RSV is a ubiquitous RNA virus of the *Pneumovirus* genus and Paramyxoviridae family responsible for frequent acute respiratory infections especially in young infants. Specific antibodies are detectable in 87% of infants younger than 18 months (Simoes E et al 2009) and virtually in all 3-year-old infants.

Human respiratory syncytial virus (RSV) is a major cause of childhood acute lower respiratory tract infections (LRTI) worldwide.(Glezen W et al.2000,Ohuma E et al. 2012) The virus normally causes annual epidemics , and approximately 60% of newborns are infected during their first year of life

It was estimated that over 33 million episodes of RSV-related lower respiratory tract infections (LRTI) occurred worldwide in 2005 in children younger than 5 years of age (Nair H et al.2011). During that same year, the estimated hospitalizations for severe acute LRTI in young children were 3.4 (2.8–4.3) million (16.9 per 1000 for infants aged 0 to 5 months and 5.1 per 1000 for infants aged 6 to 11 months). The mortality rate was 66,000–199,000/year for children younger than 5 years; 99% of deaths occurred in the developing countries (Hall C et al. 2009)

Concomitantly, the risk of severe RSV associated respiratory disease following infection is highest in early infancy, declining rapidly with increasing age beyond 6 months, probably as a result of physiological maturation of the airways.(Machata A et al.2010)

Vaccine development, in particular live attenuated virus vaccines, has primarily targeted infants aged less than 3 months, but, as yet, no human RSV vaccine has been licensed.(Karron R et al.2013) . There are considerable obstacles confronting the development of vaccines targeting early infants, which include the immaturity of the immune system, presence of maternal RSV-specific antibodies, and balance between immunogenicity and the risk of upper respiratory tract congestion associated with live vaccines.

Alternative strategies for RSV vaccination have therefore been proposed, including delaying delivery to an older age, for which there is empirical support.(Hall et al.2013) Live

attenuated vaccines have been found safe and immunogenic in seronegative children 6 months of age and over; sub-unit RSV vaccines boost protective antibodies in previously infected individuals and 40%-60% of RSV associated community severe and hospitalised disease occurs in children 6 months and above(Anderson LJ 2013 ,Anderson et al. 2013).

Respiratory Syncyntial Virus primarily spreads when an infected person coughs or sneezes fluid droplets containing a virus that another person may come into contact with through the air and sometimes on surfaces (Darville et al.1998, Handforth et al. 2000). The social contact network, and the way people interact is critical to the spread of RSV and other related viruses e.g. Influenza.

Studies have demonstrated that social distancing measures can be designed to target the portion of the social contact network most responsible for influenza's spread and thus guide the design of effective community measures. (Glass R et al. 2008)

2. 3 Transmission of Respiratory Infections And Schools

For many respiratory infections, spread is thought to occur predominantly through close person-to-person contact [Nair H et al 2011] There has been considerable interest in quantifying these interactions, particularly in understanding how different age groups mix and the extent to which mixing is assortative by age [Mossong J et al.2008]. This interest has been driven by the role human contact patterns play in determining the effectiveness of vaccination and social distancing measures, and in the ability of mathematical models to predict the course of epidemics and the effectiveness of interventions [Edmund et al.2008]. However, empirical studies of social mixing specifically targeted at understanding the spread of respiratory infections have been restricted to European countries , particularly the USA (Mossong Jet al.2008). These studies have measured the distribution of number of

daily contacts, the proportion of contacts made within various social and environmental settings, as well as other properties of contacts thought to be important for direct transmission of infectious disease, such as duration and frequency of encounter, and whether the contact included touch or not. There is evidence that these self-reported contacts are relevant to the transmission patterns of acute respiratory infections, such as mumps, influenza, chickenpox and parvovirus.

It is thought that the older school going siblings are the most common route of introduction of Respiratory infections ,particularly RSV into a family, as they are predominant among index cases (Hall CB et al.1976) . School age children are critically important for the spread of respiratory infections spread by close contact. Understanding the social contact networks of school children is important in order to contain a pandemic locally.

During the flu pandemic in 2009, temporary school closure was a common intervention (Cauchemez S et al. 2009).To date, little research has focused on characterizing this important portion of the social contact network for the spread of respiratory infections among and other close contact infections.(Mikolajczyk Ret al.2008) A number of documented outbreaks (measles rubella)have shown that information of on contacts of school children is of growing importance in development of vaccines. (Calvert N et al 1994)

2.4 Use of Diaries In Data Collection

Recent studies of infectious diseases have attempted to construct more realistic parameters of interpersonal contact patterns from diary-approach surveys. Diary-based large surveys help distinguish contact patterns not only among various social groups within a population, but also across different countries.

The use of diaries as a tool for collecting data is prone to several limitations, the most common being recall bias and compliance (Wallinga et al.2006) People tend to recall the events that happened more recently, or those that had more impact during their daily chores. This can be easily circumvented by using prompts that trigger the diary-keeper to record events at regular intervals (Wiseman et al. 2005). Non-school-going children areoften excluded in the self-reporting contact studies (Glass L et al. 2008) due to the complexity involved in filling in the diaries, and options for this include having parents or guardians shadowing the children.

Elder siblings, especially those in the school-going age groups, have been found to have the highest potential of transmitting infections to their younger siblings due to the high contacts experienced at schools within their peers(Hall CB et al.1976). This enforces the need to know further the age-specific contact rates in order to develop targeted approaches to control measures.

3. METHODOLOGY

3.1 Introduction

This chapter describes the methods that were used to carry out the research project. It further explains the study design, the sampling technique ,the study population, and tools used in collection and analysis of data.

3.2 Study Area

The study was conducted in Soin location, Soin Division, Kericho district, Rift Valley, Kenya. All the public (government run) schools in i location were enrolled in the study. A total of 7 schools were enrolled. The selection of the study location was based on convenience, as it was easily accessible to the research team.

3.3 Study Design

The study adopted a descriptive survey design based on the nature of the data being collected. The intention of the study was to obtain a snap shot of the contacts incurred by the students only on the occasions in which the diary was given.

3.4 Study Population

The study population consisted of school-going children from 7 government run schools within Soin location, of which 6 were primary, and 1 secondary

(i) Criteria for inclusion of subjects

- Pupils/Students attending public school within Soin location and are in upper primary class and above (above standard 3) or secondary school
- Written consent by the participant's parents, and by students ≥18 years.

- Verbal assent by the pupils<18 years old to participate in the study

(ii) Criteria for exclusion of subjects

Any student who did not belong to a class in upper primary or secondary.

Any student planning to move out of the study area.

3.5 Sampling and Recruitment

The location of the study was selected based on the convenience of the researcher. Participants were randomly selected from the school registers. Random numbers were generated in a computer using the Microsoft Excel package. Eligibility for the contact study was based on the classes the students belonged to. Only the students belonging to upper primary (classes 4 to 8) and secondary school (Forms 1 to 4) were eligible for the contact study. From the 7 schools, a total of 451 students were eligible for the study.

Diaries were administered to 384 students during the school term and 324 during the vacation period. (Figure1).Permission to conduct the study was obtained from the National Ethical Review Board as well as the local the provincial administration and the school authorities. Participation in the study was voluntary. Consent was obtained from the parents/guardians of the participants. All participants were required to give verbal assent.

3.6 Data Collection Methods and Tools

3.6.1. Diaries.

Diaries were kept on two different occasions; during the school term period and during the vacation period. Individuals were assigned a single day of the week, selected at random, to record their contacts and the related details which included: age-group, sex, location and frequency

Figure 1: Sample Diary Format

CODE	HOUSE HOLD	AGE GROUPS /CATEGORIES							SEX	LOCATION						FREQUENCY
Initials/ Code	Yes (Y) or No (N)	Infant <1yr	Preschool 1-5yr	Lower primary 6-11yrs	Upper primary 12-15yrs	Secondary 16-18yrs	Adult >18yrs	Elderly	Male (M) or Female(F)	Home		School		Other		No. of contacts
										1	2	1	2	1	2	////
R.M	N			X					F		X				X	//
Dad	Y						X		M		X					///

3.7 Data Collection Procedure

Training sessions on how to keep the paper diaries were conducted in a class room set up by the study team. Before the diaries were distributed, the importance of contacts for the transmission of infectious diseases and what types of contacts are relevant for droplet infections was explained extensively to the participants. Each participant then randomly selected a day of the week in which they would keep the diary. They were then given a copy of the diary and instructed to keep it on the selected day from the time they woke up to the time they went to bed. Diaries were collected on the day after the supposed day of filling by the study team or allocated teachers.

Participants were instructed to record each individual they met individuals only once in the diary (one contact per row).The number of times an individual was contacted was recorded in a “frequency” column where participants were required to place tallies of how often they contacted the same individual.

Two types of contacts were recorded in the diaries. A ‘conversation’, contact was where the participant and the contacted individual exchanged three or more words and were in a proximity close enough to touch. This was also known as a type 1 contact.

The second type of contact was a 'physical contact' which was defined as direct skin to skin contact such as a handshake, an embrace, kissing or sharing of a bed and was referred to as a type 2contact. All the contact recorded as both types I and type II were classified as type II contacts.

The ages of the persons contacted were grouped into six different age group categories - infants, preschool, lower primary, upper primary, secondary, adults and elderly. These categories corresponded to ages < 1year, 1-5years, 6-11 years, 12-15 years 16-19 years,>18 years and >50 years respectively. The age groups of the contacts were mapped to the Kenyan educational levels to make it easier for the students to estimate the age-groups of their contacts. If the age group of a contacted person was not known precisely, participants were asked to indicate the educational level (if known) or estimate the age group.

The diaries had two sections in different languages – English and Swahili. Participants were to liberty to fill in the sections they preferred.

3.8 Pilot Study

The diary was pilot tested prior to the study within a small group of 30 students of various ages (9 to 18 years) from one of the schools. The pilot was aimed at assessing and acceptability of the diary and to test the students comprehension of the diary. Children under the age of 11 years were unable to complete the diary unassisted. Primary schools have eight classes (classes 1 - 8) including two classes of day care. A decision was made to administer the diaries to only those aged above 11 years or above or were in the final 5 classes of primary school (classes 4-8) commonly referred to as upper primary.

3.9 Generalizability of The Study

This study was conducted in a rural location and spanned two climatic seasons. In Kericho district, Soin division has high poverty rates , and the main economic activity is farming.

Even though much of sub-Saharan Africa remains predominantly rural, such results are contextual and can only be generalized with high confidence to similar regions in the Kenya where these activities are prevalent. Future studies should aim at characterizing social contact patterns across different spatial regions in Kenya and elsewhere, particularly in the urban setting which is rapidly growing.

3.10 Data Analysis

The data were double entered in Filemaker 11 software, and transferred to STATA 11, where comparisons of the two databases were made and the data was cleaned and thereafter analysed. The data were naturally hierarchical; contacts were recorded within diaries belonging to participants who belonged to different age groups and classes within different schools.

A unique contact was defined as a separate individual contacted during the day, while total contacts referred to the all repeated contacts with separate individuals during the day. This paper will from here henceforth refer to unique contacts and total contacts

Multi-level linear models were fit using STATA 11 to investigate source of variation in contacts at different levels (individual, age-groups, school).The two types of contacts (talk ,touch) were further analysed as separate outcomes. The variables explored were gender, age-group, day of week, type of school; size of school. Statistical variables used at each level included size of school (school level) age /age group and sex (participant level) diary time (diary level) age of contacted person (contact level). A univariate analysis was conducted for each of the explanatory variables to establish whether they were independently significantly.

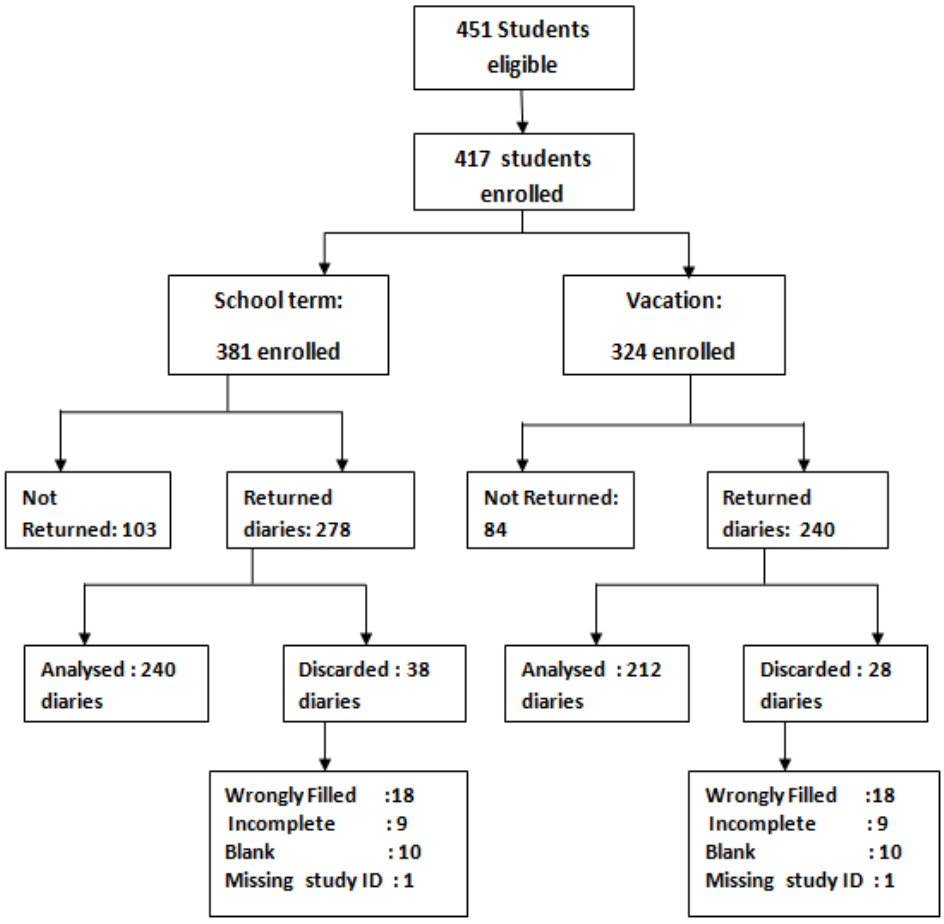
Various ways of building the multilevel model were explored to establish any significant differences in the outcomes. Final models were be elaborated at both levels, and similar outcomes were observed. Certain variables (diary time, age group and gender) were considered of great importance to mixing patterns and were therefore included in the final model.

4. RESULTS

4.1 Diary Response

A total of 451 students from the main study were eligible for the contact study. Only 417 students from the all the 7 schools participated in the study. A total of 705 diaries were administered to students, 381 during the school term and 324 during the vacation period. Of the 705 diaries, 73.5 % (518) of the diaries were returned. 12.5% (66) of the returned diaries had to be excluded from the final analysis because of various reasons. (Figure 1). Majority of the discarded diaries were from the lowest classes [grades 4&5] of upper primary. This paper discusses 451 diaries kept by a total of 301 participants.

Figure2: Flow chart indicating the diary administration and outcome.



4.2 Participants Characteristics

The analysed diaries were obtained from 301 participants aged between 10 -26 years with the highest proportion being in the 14-16 years group and from classes 5 and 6 of primary school [Table 1].

A total of 150 participants kept diaries on both occasions and 151 participants had diaries from only one time period Primary school students constituted 76.5%of the participants. Female students constituted 58% of the participants.

The secondary school enrolled a higher number of participants than the other schools [24.1%] because all its students were eligible for the contact study and it also had the fewest number of discarded diaries [1.8%].

Table 1: Number of diaries completed during term and vacation times by 301 children stratified by different characteristics from kilifi district in April -June 2010

Characteristic	Category	Term	Vacation	Both	No. of students who kept one or more diaries. No(%) N=301
		No(%) N=240	No(%) N=211	No(%) N=451	
Age group(years)	10_13	57(23.8)	29(13.7)	86(19.1)	63(20.9)
	14-16	88(36.7)	78(37)	166(36.8)	109(36.2)
	17-19	56(23.3)	57(27.0)	113(25.1)	71(23.6)
	>20	39(16.3)	47(22.3)	86(19.1)	58(19.3)
Gender	Female	142(59.2)	126(59.7)	268(59.4)	174(57.8)
	Male	98(40.83)	85(40.3)	183(40.6)	127(42.2)
School	1	44 (18.3)	36(17.1)	80(17.7)	52(17.3)
	2	32(13.3)	17(8.1)	49(10.9)	37(12.3)
	3	31(12.9)	30(14.2)	61(13.5)	39(13.0)
	4	27(11.3)	29(13.7)	56(12.4)	35(11.6)
	5	19(8.3)	15(7.1)	34(7.5)	27(9.0)
	6	39(16.3)	23(10.9)	62(13.8)	40(13.3)
	7*	48(20.0)	61(28.9)	109(24.2)	71(23.6)
Class_general	4	43(17.9)	26(12.3)	69(15.3)	49(16.3)
	5	46(19.2)	29(13.7)	75(16.6)	52(17.3)
	6	39(16.3)	36(17.1)	75(16.6)	53(17.6)
	7	40(16.7)	38(18.0)	78(17.3)	45(15.0)
	8	24(10.0)	21(10.0)	45(10.0)	31(10.3)
	F2**	12(5.0)	19(9.0)	31(6.9)	21(7.0)
	F3**	14(5.8)	20(9.5)	34(7.5)	23(7.6)
	F4**	22(9.2)	22(10.4)	44(9.8)	27(9.0)
School type	Upper primary	192(80.0)	150(71.1)	342(75.83)	230(76.4)
	Secondary	48(20.0)	61(28.9)	109(24.17)	71(23.6)

***Classes within the secondary school *Secondary school*

4.3 Contact Rates

The students reported contacting 12139 people, 7180 were contacted recorded during the term and 4959 during the vacation .Of all the recorded unique contacts, 5,746 were type I contacts and 5,609 were type II contacts.

The median number of type I contacts was 9 (inter quartile range (IQR)4-17 while the median number of type II contacts was 9(inter quartile range (IQR)4-17) On average, each child made a contact with 27 (S.D = 16.8, variance=282) people and had a total of 78 repeated contacts (S.D. =63.6, variance=4045.9)per day.

A total of 35,411 repeat contacts were reported. Most of the contacts occurred less than five times with the same individual.

Figure 3: Frequency of contacts with the same individual for all the diaries kept during school term and vacation period

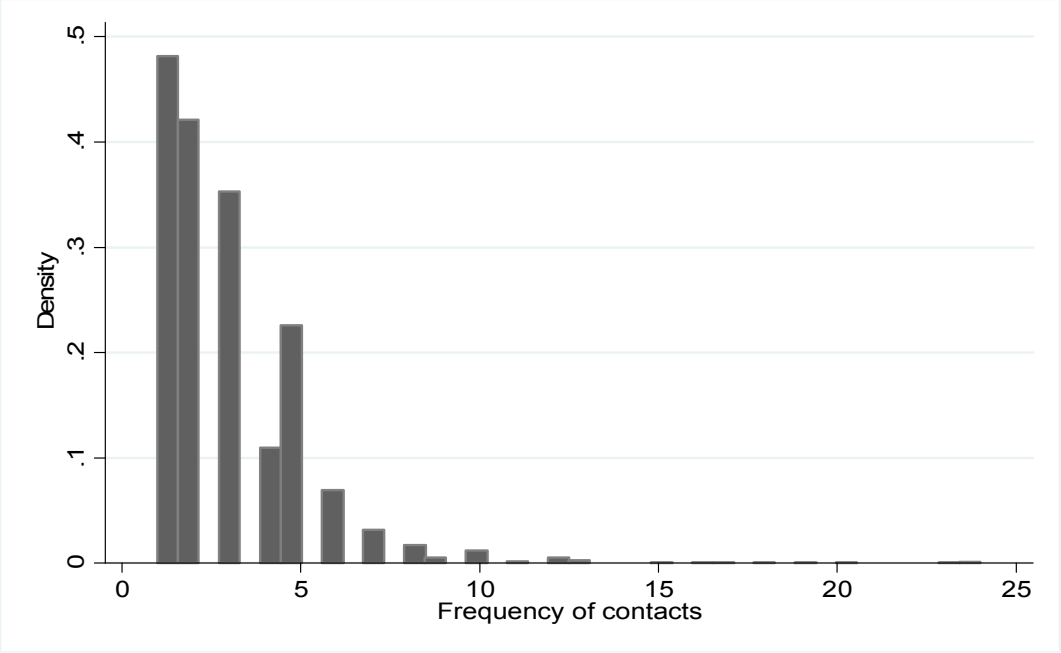


Table 2: Number of different individuals contacted per day recorded by age group, gender, contact type and day of week from a total of 451 diaries kept by 301 students in Kericho District 2012 stratified by type of contact

Characteristic of diary keeper	Category	Total number of diaries in sample	Total number of individuals contacted	Type I contacts Median (IQR	Type II contacts Median(IQ	Type I contacts Mean (SD)	Type II contacts Mean(SD)
Age group	10-13 years	86(19.1)	2621	10.5(17)	10.5(17)	14.1(14.3)	14.7(15.1)
	14-16	166(36.8)	4577(37.7)	8(18)	10(12)	12.7(13.4)	13(11.8)
	17-19	113(25.1)	3208(26.4)	11(12)	9(14)	13.9(13.1)	12.6(11.7)
	>20	86(19.1)	1733(14.3)	7.5(9)	7(10)	12.7(12.9)	8.8(7.5)
Gender	Female	268(59.4)	7751(63.9)	10.5(17)	10(14)	9.8(9.3)	13(11.8)
	Male	183(40.6)	4388(36.2)	8(11)	8(12)	10.7(11.2)	11.6(12.1)
Day of Week	Monday	81(18)	2241(18.5)	8(14)	11(15)	12.4(13.4)	13.7(12.5)
	Tuesday	63(14)	1577(13)	8(14)	10(11)	10.7(10.8)	12.4(11.1)
	Wednesday	72(16)	1938(16)	11(14)	8(10)	13.8(12.7)	11.6(12.7)
	Thursday	65(14.4)	1871(15.4)	10(12)	8(16)	13.7(13.1)	13.1(14.1)
	Friday	65(14.4)	1731(14.3)	9(12)	7(13)	13.8(15.1)	11.3(11.4)
	Saturday	57(12.6)	1499(12.4)	8(10)	9(12)	11.9(12.5)	12.5(11.5)
	Sunday	48(10.6)	1282(10.6)	10(14)	10(14.5)	12.8(12.2)	12.1(9.1)
Day type	Week day	346(76.7)	9358(77.1)	9(14)	9(13)	12.9(13.1)	12.5(12.4)
	Weekend day	105 (23.3)	2781(22.9)	9(12)	10(14)	12.3(12.3)	12.3(10.4)

Characteristic of diary keeper	Category	Total number of diaries in sample	Total number of individuals contacted	Type I contacts Median (IQR	Type II contacts Median(IQR)	Type I contacts Mean (SD)	Type II contacts Mean(SD)
School		80(17.7)	2529(20.8)	12(20)	12(15)	15.7(14.1)	14.1(10.8)
		49(10.9)	1440(11.9)	10(13)	13(18)	11.9(11.2)	15.2(12.2)
		61(13.5)	1184(9.8)	6(9)	7(7)	9.5(10.8)	8.7(6.7)
		56(12.4)	1478(12.2)	8(11)	12(12.5)	9.4(8.5)	15.1(12.6)
		34(7.5)	810(6.7)	12(11)	7(11)	13(8.7)	10(12)
		62(13.8)	2297(18.9)	11(22)	11.5(21)	17.9(18.7)	17.2(17.7)
		109(24.2)	2401(19.8)	9(9)	6(8)	11.4(11.6)	8.8(8.4)
Classes general		69(15.3)	2133(17.6)	9(17)	11(16)	13.5(14.1)	15.7(16.6)
		75(16.6)	1904(15.7)	6(14)	8(9)	12.1(14.7)	11.2(12.3)
		77(17.1)	2223(18.3)	10(17)	10(14)	13.6(12.8)	13.6(11.8)
		76(16.8)	2160(17.8)	10.5(13)	12(13.5)	13.2(13)	13.8(9.9)
		45(10)	1318(10.9)	12(14)	12(14)	13.4(11)	14(11.6)
	F2	31(6.9)	728(6)	7(9)	8(7)	11.2(13.9)	10(9.5)
	F3	33(7.3)	825(6.8)	9(13)	5(10)	14.2(14.5)	8.8(7.7)
	F4	45(10)	848(7)	9(9)	5(8)	9.6(6.2)	7.9(8.1)
School_type	primary	342(75.8)	9738(80.2)	13.2(13.3)	13.6(12.7)	10(15)	10(15)
	Secondary	109(24.2)	2401(19.8)	11.4(11.6)	8.8(8.4)	9(9)	6(8)

Students had significantly more contacts during the school term than the vacation period (mean term 29.8(SD =18.46, variance = 340.8) versus mean vacation 23.5(SD =13.96, variance = 195.1), multi -level analysis: $p<0.001$).

The mean number of reported contacts per student did not vary strongly by the day of week as was expected (Table 2). The trend for unadjusted mean number of unique contacts across age groups was significant ($p=0.002$) ranging from 30.5 in 11-13 year olds to 20 in those above 20 years. There was no significant difference in rates of type 1 contacts (Mean (Standard Deviation) =12.7 (12.9) and type 2 contacts (Mean (SD) = 12.4(11.9) contacts; t (2) =-1.132, $p=0.375$.

4.4 Contact Patterns

Of all the contacts recorded, 27.6% occurred with people belonging to the same household as the participants, 53.7% of these were type II contacts. During the school term, 24.2% of all the contacts were with people belonging to the same households as the participants as opposed to 32.3% during the vacation period. Of all type II contacts 29.1%were with people from the same household during the school term period as opposed to 35.5% during the vacation period.

Students tended to mix with people of the same age groups .Contacts recorded by secondary school students were with other secondary students were 43% while primary school participants contacts with other upper primary students were 43.8% ($p=0.001$) . Only 2.5% of the contacts recorded were with infants, 66% of which were type II contacts

There were apparent differences in the mixing patterns of the students during the school term and the vacation period.

Table 3: Number of different individuals contacted per day recorded by age group, gender, contact type and day of week from a total of 451 diaries kept by 301 students in Kericho District, stratified by term and vacation.

Characteristic of diary keeper	Category	Unique contacts Mean (SD) per diary (Term)	Unique contacts Mean(SD) per diary (Vacation)	Unique contacts Mean (SD) per diary (Both)
		n=240	n=211	N=451
Age group (years)	10-13	33.3(20.7)	24.8(16.13)	30.5(19.6)
	14-16	30.5(18.0)	24.3(15.7)	27.6(17.1)
	17-19	32.0(18.3)	24.9(12.8)	28.4(16.1)
	>20	20.7(18.5)	19.7(10.1)	20.2(11.5)
Gender	Female	32.8(17.8)	24.5(13.4)	28.9(16.4)
	Male	25.7(18.7)	22.0(14.7)	24.0(16.9)
Day of Week	Monday	31.5(18.3)	23.8(12.1)	27.7(16.0)
	Tuesday	27.9(16.8)	20.6(13.9)	25.0(16.5)
	Wednesday	27.7(18.5)	26.2(14.6)	26.9(16.5)
	Thursday	30.9(18.9)	26.6(17.6)	28.8(18.3)
	Friday	32.1(19.0)	21.4(13.8)	26.6(17.3)
	Saturday	31.2(20.4)	19.0(9.2)	26.3(17.8)
	Sunday	27.8(18.4)	25.2(14.0)	26.7(16.5)
Day type	Week day	30.0(18.2)	23.9(14.4)	27.1(16.7)
	Weekend	29.7(19.5)	22(12.0)	26.5(17.1)
School	1	35.9(19.1	26.4(15.8)	31.6(18.2)
	2	30.3(18.9)	27.7(13.3)	29.4(17.0)
	3	20.9(11.3)	17.9(14.4)	19.4(12.9)
	4	30.7(15.3)	22.3(9.9)	26.4(13.4)
	5	27.3(17.6)	19.5(9.9)	23.8(19.5)
	6	41.4(21.4)	29.7(13.1)	37.0(19.5)
	7*	21.3(13.8)	22.6(14.6)	22.0(14.2)
Classes_general	4	36.9(21.3)	21(14.7)	30.9(20.5)

	5	27.7(19.0)	21.8(16.4)	25.4(18.2)
	6	33.0(18.8)	23.1(12.8)	28.3(16.8)
	7	31.2(16.6)	26.7(11.0)	29.0(14.2)
	8	31.6(16.8)	26.6(14.5)	29.3(15.8)
	F2**	19.0(12.0)	26.2(20.4)	23.5(17.8)
	F3**	26.1(18.1)	23.7(10.8)	24.7(14.1)
	F4**	19.5(11.2)	18.4(10.5)	19.0(10.8)
School_type	Primary	32.1(18.9)	23.9(13.7)	28.5(17.3)
	Secondary	21.3(13.8)	22.6(14.6)	22.0(14.2)

**Classes within the secondary school *Secondary school

4.5 Location Of Contacts

39.4% of all the contacts recorded occurred within the homes(regardless of whether the contacted people were from the same households as the participants),52.2% of these occurring at home were also type II contacts.

During vacation period 59% of the contacts occurred outside the home, 29% of these were in-school contacts due to vacation additional tuition that took place in all the schools. Our main analysis of the data includes these contacts. In order to mimic a school closure situation, we analysed the data without the school contacts and there, was no significant difference in patterns observed.

4.6 Multi -Level Analysis

Using the '*xtmixed*' command in STATA, a univariate analysis was conducted to establish the significance of each of the variables on their own. The results of the univariate analysis are represented in table 4.The most significant variables were some age groups, diary time and gender. We thereafter constructed a multivariate model using all variables explored in the univariate analysis

Table 4: Univariate analysis of unique contacts per diary of various variables.

Univariate Analysis				Lrtest vs null	
Parameter	Intercept	coefficient	P value	Chi^2 value (◦of freedom)	P value
Null model					
Age* continous variable	37.04	-0.65	0.039	4.21(3)	0.2394
Age group					
11-13 years(intercept)	30.68		0	11.37(5)	0.0445
14-16 years		-4.37	0.038		
17-19 years		-2.3	0.332		
>20 years		-9	0.003		
classes					
classid1	31.96		0	10.97(9)	0.2777
class_id2		-6.96	0.009		
3		-4.78	0.072		
4		-3.41	0.193		
5		-4.3	0.159		
6		-8.5	0.184		
7		-7.28	0.252		
8		-12.98	0.037		
Female	25.3	3.03	0.057	3.57(3)	0.3117
Term	24.17	5.41	0	12.91(3)	0.0048
Week day	27.34	-0.3	0.866	0.03(3)	0.9987
Primary school	22.03	6.02	0.271	1.10(3)	0.7762
School size	28.14	-0.26	0.809	0.06(3)	0.9963
Day of week					

Parameter	Intercept	coefficient	P value	Chi^2 value (◦of freedom)	P value
Monday(intercept)	26.01		0	1.31(8)	0.9954
Tuesday		0.34	0.902		
Wednesday		1.53	0.559		
Thursday		2.72	0.309		
Friday		0.78	0.769		
Saturday		1.5	0.591		
Sunday		1.16	0.693		

Table 5: Multivariate analysis:Association between the numbers of unique contacts within the different clusters of school children separated by type of contact.

Model	**Type I contacts**				**Type II contacts**			
Coefficient	**Crude mean(SI**	**Estimate[SE]**	**P value**		**Crude mean(SD)**	**Estimate [SE**	**Pvalue**	
11-13 [reference]	14.06 [14.3]	9.90[2.91]	0.001		14.73[15.12]	11.95[3.42]	0	
14-16	12.78 [13.46]	-0.97[1.63	0.55		13.01[11.81]	-2.13[1.55]	0.169	
17-19	13.92 [13.09]	0.4[1.86]	0.83		12.60[11.68]	-1.59[1.76]	0.368	
>20	9.79 [9.30]	-2.78[2.42]	0.251		8.81[7.48]	-3.2[2.3]	0.163	
Female	14.11 [13.76]	2.86[1.22]	0.019		13.04 [11.81]	0.02[1.17]	0.984	
Term period	15.75 [14.25]	6.24[1.16]	0.0001		12.74[13.18]	-0.15[1.11]	0.89	
Week day	12.88[13.08]	0.61[1.37]	0.657		12.47 [12.38]	-0.02[1.29]	0.988	
Primary school	13.27 [13.16]	1.96[3.44]	0.213			5.29[3.75]	0.158	
School size	**	-1.21[0.47]	0.01		**	-0.47[0.65]	0.468	
	Random parameters _variance(SE)				_			
Level 2 (school)		0.769(2.05)				4.54[4.01]		
Level 1 (student)		147.97(9.967)				132.6[8.92]		
* [agegroup_11-13;male;weekend; secondary; smallest school size] **Different means for each school.								

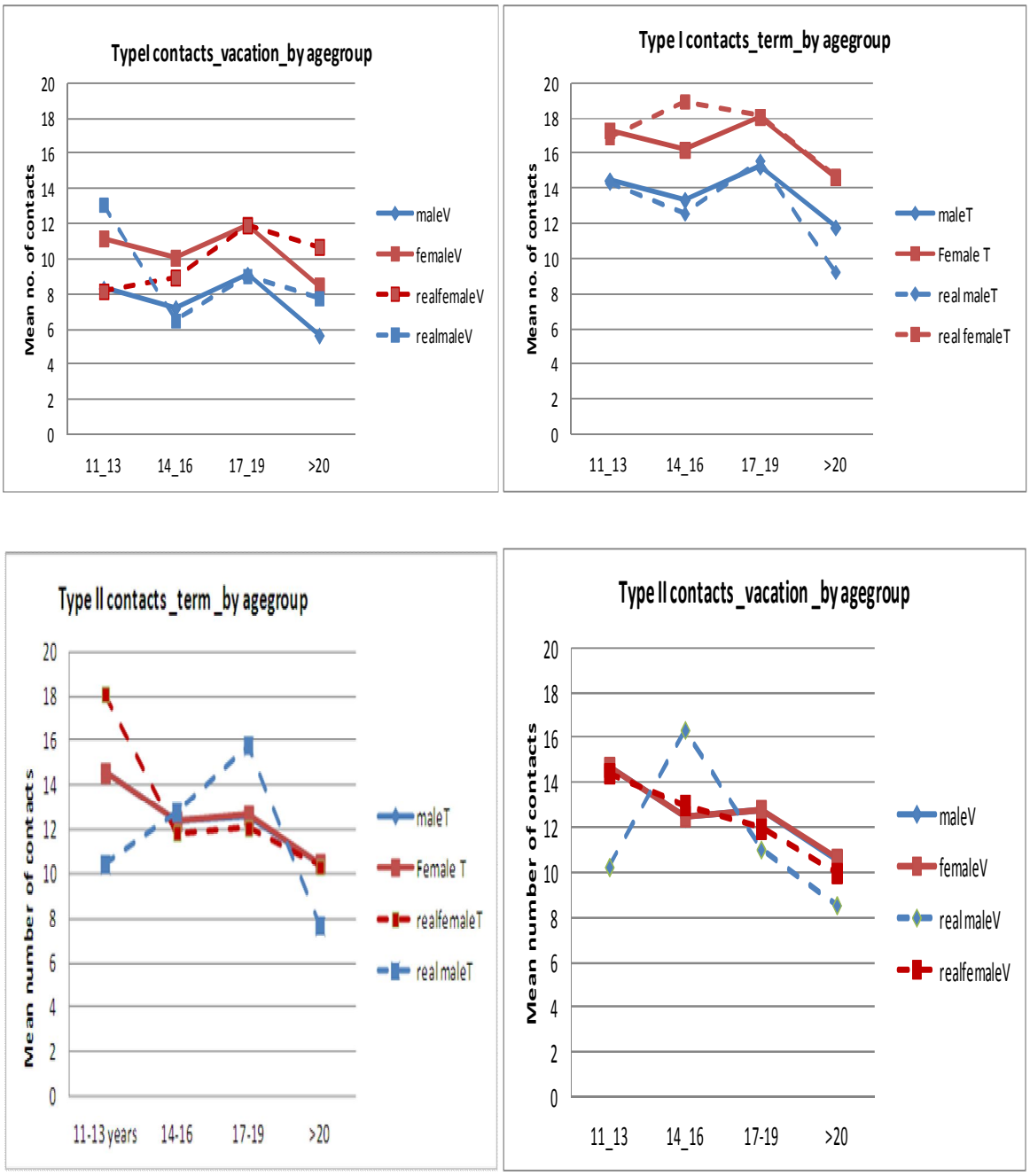
Both methods of model building were employed. When using forward stepping method, individual variables were added to the model and checked for significance, and if the coefficient for an individual variable was not significant, the variable was deleted. The backward stepping method involves adding all variables of interest are added simultaneously at the beginning, and a variable is eliminated if the accompanying coefficient is not significant.

The explanatory variables that we sought to explore were gender, class, age (as a continuous variable) age groups, diary time, school size and day of the week.

On both occasions the only significant variables were certain age groups, gender and diary time. After adjusting for all other variables in a multivariate analysis, diary time was the displayed the most significant difference .When the results were further stratified by type of contact, only diary time was significant for type I contacts and none of the variables was significant for type II contacts. The results of the 3 complete models stratified by types of contact are represented in Table 5.

The final model includes age groups, and gender and diary time having considered these as important variables (Figure 4)Across all locations and for both type of contacts, female students tended to have more contacts than their male counterparts for all the age groups Further tests were conducted for interaction effects of these variables, none was significant.

Figure 4: Multi level model of age groups, gender and diary time by type of contact.



Key

Male T: Model for male -term period;

Male V:Model for male _vacation period

RealmaleT: Actual results for male _term period

Realmale V:Actual results for male_vacation period

5. DISCUSSION AND CONCLUSION

This paper describes social mixing patterns of school population in a rural African set up. The analyses focused on social contacts (both conversations and physical contacts) relevant to the spread of respiratory infections(Hall CB et al.1976) stratified by school term period and vacation period. Clustering of contacts in the different groups within the school population was addressed in the analysis through the use of multi level modelling.

Data on school based contact patterns will inform the planning of intervention measures in case of an outbreak of pandemic influenza. This data provides quantitative information on mixing patterns on mixing patterns of school going children during different time points and will act as a guide to school closure policies and vaccine target studies.

Social contact patterns of school going age group have previously been discussed as part of larger population surveys.(Mossong J et al.2008 ,Wallinga J et al.2006) A previous similar study has collected data on school children, all aged between 6-12 years (Mikolajczyk R et al.2008) in Germany. A retrospective questionnaire was administered, and children were assisted to fill in the diaries by their parents. Our study made a similar observation as the Germany study in which little variation existed in the characteristics of their contacts apart from day of the week and the weather .This study was however conducted in only one school in Germany. Contacts with their teachers and classmates were not recorded in the questionnaires.

A recent prospective survey of social mixing patterns was conducted in a township set-up in South Africa(Johnstone -Robertson S et al. 2011). In this study, contacts were classified into physical contacts, close contacts and indoor contacts. This study recorded a higher number of close contacts than the POLYMOD study(Mossong J et al.2008).Physical contacts recorded were more frequent among the youth. The numbers of contacts recorded in this study cannot easily be

compared to our study because of the differences in the definition of contacts. Different studies have classified the contacts into different levels. A study by Edmunds et al. (Edmunds W et al.2006) further differentiated contacts into 4 levels: level 1 for physical contact without conversation, level 2 for conversation, level 3 for conversation with physical contact, and level 4 for kissing and other intimate behaviour. The level of contacts differentiated in this study are however comparable to those assessed in other studies (Mossong J et al.2008, Edmunds W et al.2006, Mikolajczyk R et al 2008)

A major finding in this study was that school children reported to have more contacts during the school term period than the vacation period. There was also a trend in the number of contacts related to the age group. The older age groups tended to have fewer contacts than the younger age groups for all types of contacts. The age and intensity patterns of contacts are similar to the patterns observed in the European studies (POLYMOD) (Mossong J et al.2008) although participants in our study reported having more contacts per day than that recorded in the POLYMOD study for the same age group.

Another important finding was that female students tended to have more contacts than their male counterparts on all occasions - school term and vacation period .When the data was stratified by type of contact, this effect was only observed in type I contacts. Differences in contacts by gender have not been reported in previous studies. We are unable to establish the reasons for this difference.

The POLYMOD study reported that contacts of children and adolescents were more assortative than for other age groups. We observed similar pattern during both the term and vacation periods, however the upper primary school students appear to have more contacts with their secondary school counterparts than vice versa. It is debatable whether there were actually more

contacts made by the primary school students or there was a reporting bias among the secondary school students.

Diary studies have been previously employed to quantify mixing patterns especially on respiratory infections (Mossong J et al.2008, Wallinga J et al.2006, Edmunds W et al.2006, Mikolajczyk R et al 2008) and sexually transmitted infections (Aral S et al. 1999,Ghani A et al.1998,Youm Y et al.2002, and Laumann E et al.1999). The use of diaries among rural communities in Africa has previously been explored. A paper published in 2005 by Wiseman et al (Wiseman V et al.2005)provided practical insights into the design and application of diaries particularly in the African set-up. Our study also aimed to assess the feasibility of diary use among school going children in a rural setup. Our results established that diary studies can be successful with school going age groups in the African rural set-up. The use of picture diaries with younger age groups and the uneducated community members has been explored in a similar study within our set up. Diary response rates (defined as number of diaries returned by the students over the number administered) was higher in the older classes. Also noted was that the number of diaries discarded were mostly from the lower classes of the upper primary group. This could be attributed to a difficulty in understanding of the diary keeping procedures. Future diary studies should employ one on one training on diary keeping to ensuring that participants fully understand the procedures. There however appears to be no relationship between the compliance and the quality of the diaries.

Despite the difference in the number of contacts recorded during the vacation period and the school term, a notably high number of contacts during the vacation period occurred outside the participants' home. We are unable to tell the actual locations of theses contacts since they were all classified as "other". It would be beneficial to establish whether exact set-up where these contacts occurred.

School closure, a common intervention during a pandemic is aimed at reducing the number of students infected at the closed school, and reducing transmission.

The specific goal of a closure is a policy decision; various ways of possible that school closure could reduce student-student contacts while enhancing student-community contacts, possibly reducing student infections but accelerating community implementing the closure to achieve that goal should be looked into. Health messages requiring that these school children limit their interactions with the general population during closures may be one such strategy. School closures have not always been successful; a disease induced closure in Hong Kong found that the closure was ineffective(Cowling B et al.2008) . Respiratory viruses such e.g. SARs that may be spread through additional routes such as sewage contamination may not be prevented through school closures

Our study had a number of limitations; just as in other diary studies ,self-reported information may suffer from recall, social-desirability, or other biases. A section of the diary required that participants to indicate whether they had difficulties filling in the diary or make recommendations to have the diary improved .

Despite only 9% reporting having forgotten left out some contacts, we do not rule out the possibility of some contacts not being captured. There is need for future diaries to be validated through the use of exit interviews or shadowing of participants. Majority of the participants recommended that the diaries be more colourful and smaller in size. Our methodology may have also left out other risk events such as group contacts.

It was common for the schools to have large crowded classes that could contribute greatly to the spread of RSV. Another limitation of our study is that all the schools involved were in a rural setting. It is possible that mixing patterns of students in the urban set up could be different.

Schools drive the epidemic and social distancing, aimed at school going children could successfully reduce transmission and locally prevent a pandemic. This study is the first research to investigate the contact numbers and contact characteristics for school-age children during the school term and a holiday period in Kenya. With regard to public health, this study could provide the basic contact information and database for modelling influenza epidemics for minimizing the spread of influenza and respiratory diseases that depend on personal contacts for transmission. Our results will be useful for the future design of social distancing policies and to improve the accuracy of their impact.

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