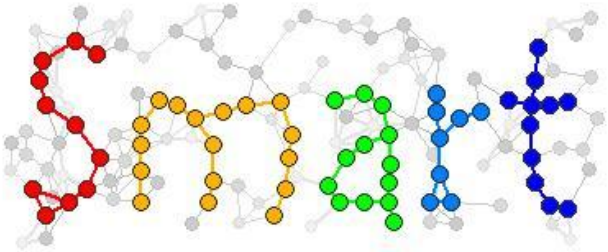
SOCIAL MIXING AND RESPIRATORY TRANSMISSIONT in SCHOOLS
(SMART Schools)
A Preliminary Report for the Propel and Canon-McMillan School Districts
June, 2012

INTRODUCTION

SMART Schools is a research study conducted by the University of Pittsburgh, and funded by the US Centers for Disease Control and Prevention (CDC). It is part of a national effort to understand how children spread respiratory diseases in K-12 schools. This will help improve response to pandemic influenza, and other respiratory diseases.



Substantial progress has been made during this project year. SMART collected a significant amount of mote and survey data. SMART staff is currently in the process of analyzing this data, and writing reports for the school community and for scholarly publication.

SCHOOLS

SMART has been conducted in 8 schools in two separate school districts in and around Pittsburgh. Figure 1 shows the location of schools in the two school districts under study.

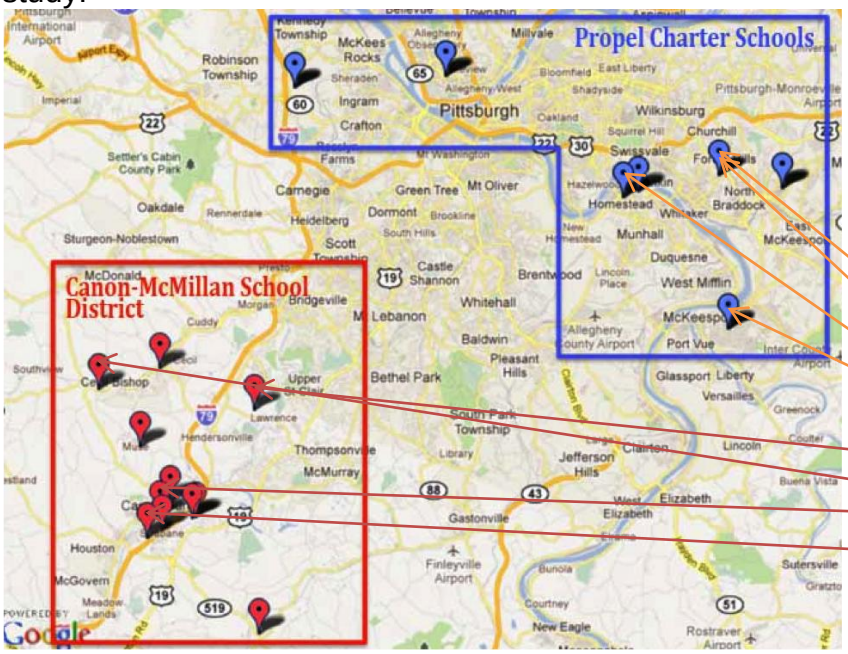


Figure 1:
SMART Schools:
Participating Schools and School Districts

Propel:
Braddock Hills Elem.
Braddock Hills HS
Homestead
McKeesport

Canon McMillan:
Hills-Hendersonville Elem
Cecil Intermediate
Canonsburg MS
Canon-McMillan HS

There were certain expectations of that the demographics of the study population would resemble Allegheny County (PA), with Pittsburgh at its heart. The county, which a population of over 1.2 million, is 83% White, 12.9% Black, 2.5% Asian, and 1.5% Hispanic. The resulting subject population was different, being less white (70.5%), more African American (25.8%), and less Asian (0.9%) than originally projected. Propel Schools are essentially urban. Canon McMillan has an urban core, but is largely suburban in nature, with some areas classified as rural.

METHODS

SMART deployed motes to 2,079 students in all eight participating schools. In addition, 128 teachers wore motes. A mote is a small (1"x3"x3/4") electronic device powered by 2 "AA" batteries. They send out a weak signal - similar to a cordless phone - every 20 seconds. Motes record the signal of other motes. SMART had 500 motes. These were sufficient to cover the entire school in most cases. One of three teams was done in Canonsburg Middle School (9 home rooms). Teams are independent units within the school. Seventeen first period social studies classes, comprising 25% of the school population, was done in CM High School. A small number of motes were used as stationary "master" motes to synchronize the student motes and to provide a geographic frame of reference within the building. See Table 1.

TABLE 1: Summary of Schools and Activities

School	Grades	Motes (Student)	Motes (Students Plus Teachers)	Survey 1	Survey 2
PROPEL Braddock Hills Elementary	K-5	223	248	74	75
PROPEL McKeesport	K-8	367	384	140	151
PROPEL Homestead	K-8	264	277	155	155
PROPEL Braddock Hills High School	9-11	174	193	177	177
C-M Hills-Hendersonville Elem.	K-4	153	167	118	118
C-M Cecil Intermediate	5-6	290	304	74	74
C-M Canonsburg Middle School	7-8	209	218	102	232
C-M High School	9-12	399	416	387	387
TOTAL		2079	2207	1227	1369

SMART was able to conduct one overnight mote test using 2 schools during the same period of time. Students from Hills-Hendersonville and Cecil Intermediate wore the motes during one school day, at home and then through the second school day. The purpose of this was to measure contacts of students outside school, and potentially with students at the other school.

SMART used online and paper-based contact dairies to measure self-reported contacts of school-age children. Students completed 2,596 diaries. They were asked to recall who they had come in contact with on the prior day, and to describe these contacts (male/female, adult/child, attend school, length of contact, type of contact, sharing of items, etc.). The contact dairies were done, where possible, on the day after mote day, and one other random day.

One 15 minute video was obtained for a random classroom at each grade level (K-12) during a mote day. These videos will be compared to mote results from the same time period.

RESULTS

Figure 2 below shows some preliminary results from a mote deployment in Cecil Intermediate School (grades 5 and 6). Using ~400 motes, there were 2.1 million recorded contacts during the school day. In an initial network analysis, SMART built a network using all the day's data for the entire school. Grade structure is immediately apparent. Each circle represents a student and the lines represent interactions between students as measured by the motes. The color of the circles indicates the grade of the student.

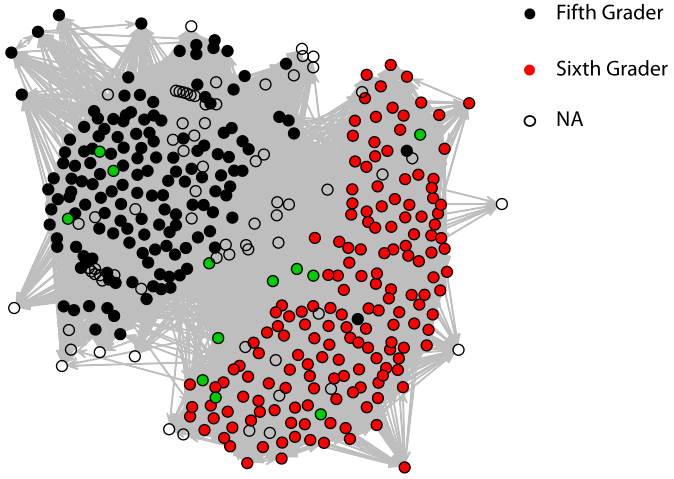


Figure 2: Network of Cecil Intermediate data with links indicating any contact. (black, 5th, red, 6th, green stationary, white, missing).

The data clearly shows that 5th graders are much more likely to contact other 5th graders than 6th graders even though there are lots of contacts between each group. On average, each child interacted with 92 other children during the school day.

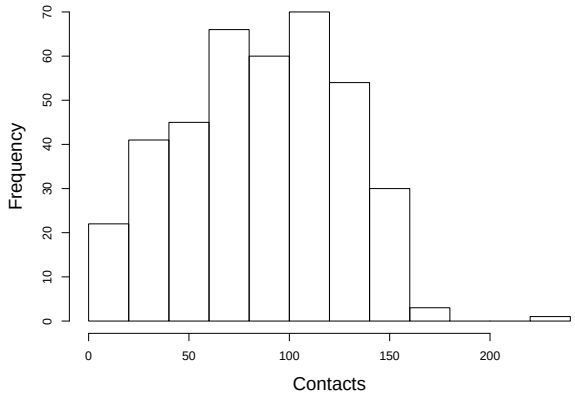


Figure 3: Degree distribution of frequency with which different numbers of unique motes are recorded throughout the day. On average, children were in proximity with 92 other children.

Preliminary analysis of data from all schools estimated that children over all grades had a mean of 108.8 contacts per school day. The mean number of contacts varied by age. High school students (14-18 year olds) reported more contacts per day (112.0) than middle school students (102.1). The average number of contacts increased with the amount of time students were observed. Students encountered more students during the middle of the school day. Being in the same grade and/or classroom was highly predictive of whether two students had a recorded contact. The overnight mote test suggests that students have contact with one another outside school.

SMART was able to obtain the individual student class schedules for 3 schools - Propel Braddock Hills High School, Canon McMillan High School and Canonsburg Middle School. These schedules were used to construct computer models representing the movement of individual student within schools. These show each student moving realistically from class to class. A model like this allows simulation of such things as student behavior change, disease spread through a school (such as influenza), and even the “mote” experiments that are performed in this study. It is a powerful virtual laboratory which can look at real world interventions on the canvas of a realistic student school day.

These models, which look like animations are provided via the links, below.

Braddock Hills High School: http://www.smart.pitt.edu/simudemo/bhhs.swf.html

Canon McMillan High School: http://www.smart.pitt.edu/simudemo/cmhs.swf.html

Canonsburg Middle School: http://www.smart.pitt.edu/simudemo/cms.swf.html

As an example, the animation of Braddock Hills High School simulation displays 176 students' activities in the school throughout a day. This starts with their entering the school in the morning and runs until their leaving at the end of the day. (The animation loops when it ends). Each student has his/her own class schedule, which guides his/her movements among classrooms. The background is based on the floor plan of Braddock Hills High School (one floor building), with grey cells representing walls and brown cells representing objects like desks or chairs. Students are represented by the moving colored dots.

The animations represent the spread of influenza disease. It is initiated by 15 students entering the school at the beginning of the day infected, and able to transmit the disease to other students. Students who can get influenza, called being 'susceptible', are colored blue. They can possibly contract the virus by coming in close contact with an 'infectious' student (colored red). Once infected, the student has the virus, but is not yet showing signs of being infected. This is called 'exposed'. It is colored yellow. Eventually these students can move to being 'infectious', and will turn red. After a period of time, the student recovers from the influenza infection, and becomes green. They are no longer able to contract the virus or infect other students. For illustrative purposes, these animations speed this process to show the spread of the virus throughout the school in a single day. In reality, this spread would occur over multiple days.

The other animations are similar. The model for CM HS was based on 480 students and 25 entering the building infected. This is smaller than the number of students in the school, but the model would run very slowly with a larger number. The model for Canonsburg MS is based on the schedules of one 7^{th} and one 8^{th} grade team. These were the schedules provided by the school. There are 248 students and 40 entering infected with flu.

A sample data run was done using Braddock Hills High School, one single day from 8:00 AM to 3:15 PM and more normal parameters. Starting with 176 students and 15 infected students, 32 students would be exposed to disease, but no more infected. The model shows that without intervention, an influenza outbreak can spread quickly over several days through the population of school. This highlights the need to understand the dynamics of disease spread and how it can most effectively be staved off by school based interventions.

This model gives us a framework to use the schedule data for a school to understand disease spread and ways to stop it. It will provide a virtual laboratory for school officials and other policy makers to explore how to best protect their student population from the harm that can be caused by a rampant outbreak of disease in their school.

SMART will use data which was collected when the students wore motes in school to make similar models. Comparison of these models will improve understanding of disease spread among students in schools. Using the data on student contact patterns

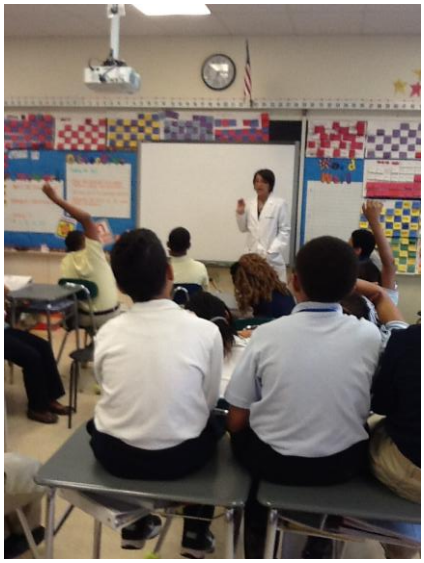
that was obtained from motes to calibrate the models will ensure that these models show realistic, normal student behavior.

CONCLUSION

Students have a large number of contacts each day in schools. The number of contacts depended on age, and the probability of recording a contact was strongly affected by class and grade structure. These results indicate that the structure of schools is highly predictive of social contacts between students and may be used to develop transmission models of respiratory diseases in schools.

OTHER ACTIVITIES

SMART staff is an educational resource to the schools. SMART staff provided a presentation "The Germ Show" to six 5th grade classes in PROPEL elementary schools, a follow up, and an advanced version for the high school. This covered public health and infectious disease topics such as influenza, hand hygiene and vaccination. They also judged the Science Challenge at PROPEL Braddock Hills High School. At right, Dr. Shanta Zimmer, MD, Principal Investigator, discusses infectious diseases with students.



SMART is available to provide additional educational activities.

IMPORTANCE OF THIS RESEARCH

This purpose of the research is to study ways that influenza transmission in schools can be controlled. This work will build better models to improve understanding of how influenza spreads through schools. The models will be used to evaluate control programs. School-age children are thought to be drivers of respiratory epidemics due to their high numbers of close contacts. Very few details about these contact patterns are known. Student contacts lie at the heart of many important epidemics. The research will help to more fully understand community-wide transmission of influenza and school children's role in transmitting and acquiring influenza. This will be important not only in understanding control and prevention strategies but also predicting epidemics and viral spread in communities outside of school.

The knowledge obtained will be shared with CDC. SMART study personnel will work with CDC to interpret this data, and create recommendations/policies for response to pandemic influenza, seasonal influenza and other respiratory diseases.

This research will help the CDC craft their policy on school closure and other measures for influenza outbreaks. Results from this study can be used to inform decisions about the impact of control measures such as vaccination, school closures and sick leave policies for children and teachers. It will be used to shape national, state and local policies on disease control.

Contact networks within schools can be useful in understanding the spread of other important public health problems such as obesity, violence or other infectious diseases. Finally, studies of this kind enhance the relationships and partnerships between schools and public health researchers and agencies. They serve to improve the dissemination and implementation of public health policies and practices.

THE FUTURE

Due to the tremendous progress of the study, the CDC has indicated that funding will be available for year 2 of the SMART project (2012-2013 school year). It is intended that this research continue with PROPEL and Canon-McMillan School Districts if district administration and parents are interested in continuing. SMART would like to propose the following:

1. During influenza season (usually sometime in the period Dec-May), SMART would monitor absenteeism in all schools, and test students for influenza.

Parents of absent students would be called to determine if the student was ill, and to determine if this was a flu-like illness. Children who were absent due to a flu-like illness would be tested upon return to school. Children who came to the school nurse with flu-like illness would also be tested. A small sample of students in the classroom of an ill child would also be tested. The test involves a simple nasal swab, essentially a “q-tip” placed into the nose to get some mucus.

SMART would propose to have a staff person in each school for a three-four month period. Preference would be to hire a parent or other school volunteer. This person would be trained by SMART study personnel.

2. SMART would do more overnight mote tests where children are given motes in the morning and asked to return motes the next afternoon. This information will yield novel and extremely useful information for understanding the amount of contact that occurs among students in non-school settings. This is critical to assessing the usefulness and impact of school closures in controlling disease outbreaks and epidemics.

3. SMART would obtain contact diaries about contacts that take place on holidays, snow days or school closures. This would help identify the impact of school closures.

RECOGNITION

SMART is very pleased to recognize Kristen Golomb of PROPEL Schools and Grace Lani of Canon McMillan, who were the direct points of contact for the SMART Project. We also acknowledge the individual school principals who went out of their way to cooperate and make us feel welcome.

We thank the parents and students. SMART has a 93.5% participation rate, which is very good. This study is not possible without the cooperation of the parents and their students.

SMART is a large and complex project, which required substantial teamwork. It reflects an unprecedented level of cooperation between a university research team and the two school districts. Please accept the heartfelt thanks of the University Of Pittsburgh Graduate School Of Public Health.