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Students in Differential Equations and Epidemiology model a campus outbreak of pH1N1

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Title

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Running Head and Foot

Math and biology students model pH1N1

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0

Conflict of Interest Notification Page

No conflicts of interest exist.

Key Words

pH1N1, differential equations, epidemiology, mathematical biology education

Introduction

We describe a semester-long collaboration between a mathematics class and a biology class. Students worked together to understand and model the trajectory of a campus-wide pH1N1 outbreak the previous semester. Each course had about thirty students and was an upper-level elective for majors. Some mathematics students had taken no college-level biology, and some biology students had taken no college-level mathematics. All students had taken at least three quantitative courses, so they had some experience working with data. Our goals were to allow students to work with and model a real data set (2, 3, 4), to explore how the outbreak spread within our small campus, and for students to share their areas of expertise. This project created opportunities for synthesis and evaluation (1).

Procedures

The fall 2009 outbreak of pH1N1 on campus provided real data relevant to our students. Shortly after the outbreak, Professors Greer and Palin asked our campus Director of Health Services for these data and filed an IRB application for this project. Collected data included incidence, isolation, vaccinations, and demographics, and identifiers were removed.

Our courses were scheduled for the same time period in winter 2010 and we planned four joint meetings. Before the first meeting, each instructor asked her students to consider ways to explore the outbreak from the perspective of their discipline. Students contemplated what knowledge they would bring to the data analysis and what their colleagues in the other course could contribute.

At our first joint meeting, early in the semester, we administered a survey assessing knowledge about pH1N1. Professor Palin reviewed influenza virus biology and discussed current knowledge about pH1N1 spread. Professor Greer introduced SIR (Susceptible-Infected-Removed) models and showed their use with past influenza outbreaks.

Students then formed small mixed groups to discuss both topics. They brainstormed use of SIR-style models and what data they would need. Epidemiology students had completed the NIH web-based training course "Protecting Human Research Participants" and shared information about ethical research protocol.

Our second joint meeting was one month later. As homework, using Health Center data, Epidemiology students had generated incidence and prevalence graphs and mapped the outbreak by residence halls. They had also estimated incidence rates to use in SIR modeling, making assumptions from knowledge of student behavior during the outbreak. During class, professors and students discussed students' assumptions about incidence and prevalence. Students considered together how factors such as student risk behaviors affected transmission. Students further discussed how the following could affect their modeling: illness duration, when vaccine became effective, and any overlap between students immunized at vaccine clinics and those already immune due to illness.

The third meeting was two weeks later, just past the semester's halfway point. Students in small groups used *Mathematica* to simulate their models. They varied parameters to best fit the data with their models. The mathematics students led this part of the project, but several groups had students with strengths in both subject areas, and these groups found the most interesting models to describe the outbreak.

On the last day of classes, we held our final joint meeting. The Dean of Students, the Director of Health Services, and other Health Center staff joined us. We administered the same survey as we had on the first day and two Epidemiology students presented data they had collected comparing outbreaks at other colleges with the outbreak at Bates. Students, professors, and visiting administrators discussed our analyses and what could be done differently in a future outbreak.

Conclusion

Students worked with real data, rather than text or literature examples. They quickly realized that data are often incomplete, not all data collected are useful, and potentially useful data are not always collected. Historical models for influenza spread did not fully explain what happened on our campus; this led students to question assumptions and try new models.

Groups comprised of students from both classes worked together during the first three joint meetings. They produced ideas, predictions, and modeling results. They considered effects of thinking of the campus community as open or closed. They wondered whether pH1N1 spread more easily over the weekend, due to parties and other social events. They questioned when a student had recovered and was no longer infectious, noting that symptom relief or resolution could cause students to break self-imposed isolation and return to classes.

During *Mathematica* simulations, groups first used a combination of epidemiological knowledge and trial-and-error to estimate best parameters for fitting a standard SIR model to the Bates data. The groups incorporated changes to the model, according to which hypotheses they wished to test. Some used a periodic incidence function that peaked on Saturday and was lowest mid-week, postulating that weekends corresponded to higher exposure.

We compared student results on the pH1N1 quiz (written by the biologist) given in our first and last joint meetings. Among Epidemiology students, student responses held steady or improved for all questions. For Differential Equations students, class response improved on three questions, but fewer students answered correctly on three other questions. Three unscored quiz questions asked students to make predictions, which they then examined through data analysis and modeling. These included estimating the basic reproduction number R_0 and considering vaccination levels necessary for herd immunity in both open and closed communities.

We polled our students at the end of the semester, then requested further feedback two years later. Some students felt the combined days were the best of the semester. These tended to be students with interest and experience in both fields. Other students saw both positives and negatives: they found the idea very interesting, but had different preferences for how we used class time, or felt their particular small group did not gel as well as they would have liked. Some of the mathematics students enjoyed the chance to see real data brought into a course that is otherwise more theoretical. One epidemiology student noted that working together in mixed groups forced students to bring their different perspectives together and that by the end of the semester, both sets of students had a “pretty good” working knowledge of both perspectives.

We saw, and students seconded, ideas for improvement. These include making it clearer, each time we meet, what we hope to accomplish. The professors felt we had done this at the start and end of the semester, but with multiple weeks between meetings, some students no longer recalled our exact goals. Further, on a given class day about half the students seemed less able to contribute: early in the semester the math students mainly learned from the biology students, and on *Mathematica* day the biology students relied on help from their mathematics teammates. Common preparatory readings, homework assignments, and class discussions may increase the abilities of all students to participate more equally.

We believe this was a solid first attempt to integrate the concepts explored in both Differential Equations and Epidemiology and to provide our students with exposure to real world situations. Students worked in teams to expand their perspectives and knowledge; for future combined courses, we would increase student preparation before joint meetings and implement more thorough assessment. After the winter 2010 semester, the professors continued the modeling and data analysis, resulting in a publication and a new research direction. We look forward to other ways of integrating our courses and our scholarship, in keeping with the liberal arts tradition.

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