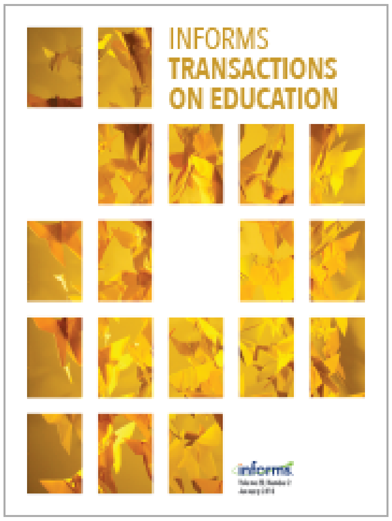

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Case

Dealing with the Bug in the Classrooms: Planning for a Pandemic

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In 2009, public and private organizations were forced to consider how the circulation of a new and potentially lethal infectious disease, the H1N1 flu virus, would affect their day-to-day activities. The virus started circulating in the spring of 2009 and in a matter of months it had already spread all over the world. Similarly, to what happened in the deadly 1918 Spanish influenza, it especially affected young adults, pregnant women, and people with weak immune systems. Universities, colleges, and school districts were among the organizations that had to design and implement response and mitigation plans that would not only protect their students, but that would avoid any disruption to the academic calendar while considering limited available resources. The following two-part case study describes some of the challenges faced by Rochester Institute of Technology (RIT), a private university in upstate New York, in dealing with H1N1, and gives students the opportunity to apply quantitative analysis to help the university develop a preparedness plan to deal with future pandemics.

Keywords: pandemic influenza; production control; management science; preparedness modeling; forecasting; work continuity
History: Received: October 2014; accepted: January 2016.

Note of Caution for the Readers

Although the author has used real data and figures to describe the evolution of the H1N1 in the United States and the challenges faced by RIT, many of the dialogs and thoughts attributed to the characters in this document are fictional, and are designed by the author to describe challenging situations that academic administrators may have to deal with during a pandemic. As a consequence, the data about RIT, the characters of this paper, and H1N1 contained in this case study should be used only for instruction.

H1N1: The First Global Pandemic of the 21st Century

In April of 2009 the H1N1 influenza outbreak was first detected in Mexico, when hospitals were overwhelmed by an unexpected number of patients with influenza-like illnesses (ILI), whose health quickly deteriorated into a fatal pneumonia. Moreover, in less than a month, Mexico reported more than 2000 confirmed cases of this new type of flu (World Health Organization 2009c). The unusual flu virus rapidly spread over the world and in a period of just 2 months, 74 countries reported over 28,000 confirmed cases, and 144 deaths (World Health Organization 2009d). In June 11, 2009 the World Health Organization (WHO) declared the state of a global pandemic.

The public reaction to this pandemic flu was intense. Although there had been discussions about the effects of a potentially deadly flu pandemic since 2005 (the avian flu, H5N1), many governments and organizations were not prepared for dealing with the pandemic and did not have mitigation plans in place. Additionally, even in countries having such plans, their implementation details and their effect on the day-to-day activities of public and private organizations were unclear or inexistent. It was only when the H1N1 pandemic attracted media attention that serious discussions about the consequences of the pandemic on everyone's daily routines began.

At the early stages of the pandemic, public health officials warned that available seasonal flu vaccines would not help to protect individuals from contracting the new H1N1 virus, given that the new virus strain had not been present among humans in the past, and because the available flu vaccine targeted three other types of flu strains. Therefore, a new vaccine had to be developed from scratch as soon as the new virus was identified and characterized. Experts suggested that such a development would take no less than 6 months (World Health Organization 2009a).

To control the effects of the influenza pandemic, public health officials also had in their arsenal two types of antiviral medication (Tamiflu© and Zanamivir©) (Centers for Disease Control and Prevention 2010a), which could be used to mitigate the mortality and morbidity (i.e., the lethality of the disease and its health consequences) of the H1N1 virus (Antivirals reduce the progression of the virus in infected individuals and help patients recover faster.) However, in the Spring of 2009, the global supply of antivirals was insufficient to treat all those who could be infected by the H1N1 in the months to come (Centers for Disease Control and Prevention 2010a). Antiviral production, although faster than vaccine production, could not be increased to satisfy the expected antiviral demand within the first 6 months. Furthermore, at the time, there was high uncertainty about H1N1, and hence the resulting demand for antivirals.

The H1N1 virus had several peculiar characteristics. Although the virus was highly infectious, it was fortunately less lethal than expected. By Spring of 2010, it had claimed fewer lives than the typical seasonal flu strains. Every year, in the United States an average of 30,000 individuals die as a consequence of seasonal flu, while between April 2009 and May 2010 the global number of deaths resulting from H1N1 as reported by the World Health Organization (WHO) was approximately 18,000 (World Health Organization 2010). In addition, when the flu outbreak started, public health officials expected that H1N1 would follow the life cycle of seasonal flu, ending during the summer time. However, in 2009 the number of people infected with the virus continued to increase during the summer months (Centers for Disease Control and Prevention 2010a).

The infectious cycle of influenza viruses, including H1N1, starts with the infection of a susceptible person, who will typically incubate the virus for 2–4 days without noticeable symptoms before showing flu-like symptoms. An infected individual is infectious between one day before the onset of symptoms until 5–7 days after the onset (Centers for Disease Control and Prevention 2010b).

About Rochester Institute of Technology (RIT)

RIT is a privately endowed, co-educational university in suburban Rochester NY. RIT is well-known for the quality of its STEM education, its co-op program, and for having more than 1,200 deaf and hard of hearing students supported by RIT's National Technical Institute for the Deaf. RIT's student body in 2013 was 18,292 students (15,410 undergraduates, and 2,882 graduates). Funded in 1829, the university adopted its current name in 1944. Until 2012, RIT's academic calendar was organized in four 10-week quarters: Fall (Aug.–Oct.), Winter (Nov.–Mar.), Spring (Mar.–May), and Summer (June–Aug.) quarters. RIT has one of the largest cooperative education programs in the world, placing more than 3,500 students in more than 5,500 co-op assignments every year. More information about RIT is available at http://www.rit.edu/overview/.

RIT and the Pandemic

In May 2009, RIT put together a special Influenza Committee (IC) appointed to deal with the possibility of an H1N1 crisis in campus. The committee comprised of the medical and administrative directors of the Student Health Center, a faculty with previous logistics expertise, a member of the county's public health department, members of the University's Registrar office, and a representative of campus food services. The committee reported weekly to the Provost with an overview of the national, state, and county pandemic status, information about any potential threats to campus life, and the details on the execution of any action plans. The committee's work began almost a month after the beginning of the pandemic. By Fall of 2009, the committee was required to report twice a week.

Table A.1 in the appendix describes the evolution of patients with Influenza-Like-Illness (ILI) reported in RIT during 2009.

In the Spring of 2009, health authorities expected that the pandemic receded and perhaps be contained during the summer season, but H1N1 proved to be unusual and continued to infect young adults at higher rates than those for seasonal flu. During the Summer of 2009, public health authorities and vaccine producers made public two positive news. First, they clarified that a single vaccine dose would provide full protection against H1N1 instead of the two doses originally planned (World Health Organization 2009b). Second, vaccine producers confirmed that Phase III tests were successful and that the H1N1 vaccine would be ready for distribution as early as October 2009 (Centers for Disease Control and Prevention 2010a).

Once the vaccine became available during the Fall of 2009, it became clear that local health officials were not ready to deal with the distribution of vaccines. For example, RIT placed an order of 13,000 vaccine doses, which were freely provided by the county health officials, but only received an initial batch of 6,000 doses. There was uncertainty regarding when the remaining doses would be provided. In contrast, smaller academic institutions in the area received more doses than needed. For example, a small private college in Rochester enrolling less than 3,000 students received more than 5,000 doses.

Additionally, a challenge for schools planning to provide immunization to their students and faculty was their inability to know if their students and faculty had already been vaccinated outside campus. Due to supply restrictions, public concern, and the fact that college students were considered a population at risk, many students and faculty took advantage of other opportunities in town to get vaccinated.

The challenge of matching vaccine demand with vaccine supply proved to be more complex than authorities and vaccine manufactures expected. The combined effect of coordination problems and the backlog of vaccine orders resulted in a large number of unused vaccines by the end of the summer 2010. In the United States alone, it is estimated that nearly 70 million purchased doses were left unused (Fox 2010). By August 2010, the H1N1 pandemic was officially contained, and RIT received the last number of doses that completed its original request, which were no longer needed.

Recommendations of the Influenza Committee During the 2009 Pandemic

The main challenge to the IC's work was the uncertainty related with the behavior of the flu and its impact on campus life. In the early stages of the pandemic, there was tremendous speculation about how severe the flu really was. It was not clear if it would develop into a Spanish flu-like pandemic, which reported between 50–100 million deaths worldwide (Taubenberger and Morens 2006), or if it would result in just a severe type of seasonal flu (with nearly 30,000 deaths per year in the USA). Since there was no vaccine for H1N1, the committee did not know if students would need to be vaccinated once or twice, and how spread out those immunizations had to be provided to ensure full protection. More importantly, it was not clear how lethal the flu strain was. Additionally, there was general concern about the efficacy and safety of the potential vaccines. For example, the media and blogs had speculated that the development of a new vaccine needed to be expedited, and because of that producers might not have enough time to do extensive safety tests. Sensationalist media (Glenn Beck, Oct 3, 2009) speculated that unlikely vaccine side-effects, such as those occurred during the 1970's pandemic linked to Guillain-Barré syndrome could re-occur with the H1N1 vaccine (Farley 2009).

Local health authorities had recommended that RIT's influenza preparedness plans deal with the consequences of infected individuals on campus until immunization was effectively available for most students and faculty. Under such circumstances, the committee faced the risk of planning activities that would have been unable to deal with the actual outbreak in campus, or that would have been excessively disruptive on the day-to-day activities. Once appointed, the IC wanted to know the most adequate actions to follow for dealing with an uncertain event within the following 8 months.

During their tenure, the committee established and coordinated plans that covered eight areas: (1) campus hygiene, (2) medicine and vaccine procurement, (3) confinement of infected students (4) public relations, (5) capacity planning of the medical center, (6) class disruption, (7) food and wastage logistics during the pandemic, and (8) class suspension. A complete description of these areas is provided below.

1. *Campus hygiene*: Influenza is an airborne transmitted disease that can live outside the human body between 2 to 12 hours depending on temperature conditions and the material of a contaminated surface. An individual could become infected with the virus by sharing fluids with an infected individual. Such exchange could occur through direct exchange of body fluids, by breathing air that contains infected saliva droplets, or by bringing the infected droplets deposited in a contaminated surface to one's mouth and nose. Accordingly, the Influenza Committee was convinced that hygienic practices would be crucial to contain the spread of the disease in RIT, and that such practices would constitute the most cost-effective intervention. Hygienic recommendations included installing hand disinfectant dispensers in highly transited areas of campus. Additionally, the IC started an aggressive campaign to increase awareness about the importance of sanitation to control the virus. Emails, group messages, posters, and classroom time were used to emphasize the need for adopting good preventive practices, such as washing hands, sneezing in your elbow, and avoiding spitting. The IC also recommended increasing the frequency at which doorknobs, computer keyboards, and bathrooms were sanitized.

2. *Medicine and vaccine procurement*: The IC recommended that the university's health center set up a stockpile of cold packages (i.e., analgesics, cough syrup, and decongestants) that could help diagnosed individuals alleviate their flu symptoms. Although antivirals (Tamiflu©and Zanamivir©) were recommended to treat symptomatic patients, universities were not allowed to build their own antiviral inventory. Antiviral producers had reported a backlog of orders and were given priority to state and national health care systems. Any needed antivirals would have to be externally supplied or be requested by the student's care provider. The main challenge in setting up the stockpile of cold packages was determining the number of packages to order, and where to store them. Additionally, the committee recommended that RIT established an inventory of ancillary supplies (e.g., masks and latex gloves) for at least 3,000 individuals.

3. *Confinement of infected students*: Almost 8,000 students lived in some of the available campus housing options. Most undergraduate students stayed in dorms,

where they shared a room with at least one additional student. One of the main problems faced by the Influenza Committee was to determine how to proceed when a student was diagnosed with influenza-like symptoms. For example, if a symptomatic student could not leave campus to recover at his family's home, he or she needed to be isolated for 4 days. If the student were to stay in his/her own room, the main concern was what to do with the patient's roommates. If roommates decided to stay in the room, they would have been unnecessarily exposed to the virus. If the roommates temporarily move out of the room, they could have been potentially infectious to others, as the roommates could have been already infected but not showing symptoms. Moreover, if the committee recommended to isolate infected individuals and their roommates, the committee had to establish who qualified for isolation, where to accommodate students, the maximum number of students to accommodate, as well as an estimated budget to cover for such plans.

During 2009, recommendations were constantly revisited based on the evolving available information. Initially, the official policy was to recommend infected individuals to recover at their parent's home, but if a patient was too sick to travel or if the family was too far from RIT, the student could have remained in campus. The patient's roommates were given the option to stay in the room if they wished and were asked to take extreme hygienic precautions for four days, and to wear a supplied mask and goggles at all times.

For the H1N1 in 2009 an exclusive isolation area was not necessary, but for more infectious and morbid strains, the university may have needed an area to assist infected students until they ceased to be contagious.

4. *Public relations*: The IC's focused on ensuring that the RIT community remained well informed and educated on practices that could have reduced the risk of spreading the disease. Moreover, the committee was careful not to overwhelm the public with general information, and maintained an easy-to-follow repository of RIT-relevant news. The committee set up a general web page which provided access to forums and discussion groups, and where medical personal and university authorities could clarify issues of general concern. Additionally, there was at least one information session per month in which questions could be posed directly to administrators and public health officials. When the influenza vaccine became available, the communications strategy focused on informing students about how the vaccination clinics would work, and what the public could do to facilitate the vaccination process.

5. *Capacity planning*: In 2009, one of the main concerns of the university authorities was whether the Student Health Center had enough capacity to assist students developing influenza-like symptoms. The center had 2 doctors and 7 nurses in staff and was open on average 9.5 hours per day Monday to Friday. Early in the Spring of 2009, neither the IC nor the Student Health Center had an accurate estimate of the number of infected individuals. All available estimates on the actual number of patients had significant margins of error.

The IC's actions focused on maximizing the available capacity at the healthcare center by changing the working schedule of doctors and nurses. Additionally, arrangements were made to have on-call access to additional medical support from one of the community hospitals in the area. However, such arrangements did not consider that hospitals themselves could have faced an increasing demand of services during the pandemic, and that such demand could have varied for pandemics with different mortality and morbidity.

Overall during the H1N1 pandemic the center was able to cope with the number of influenza cases during the season without the need of hiring new personnel.

6. *Class disruption*: One of the main concerns that the university community had with regards to the H1N1 pandemic was how it would disrupt classes and day-to-day campus activities. For students and parents it was important that the school year would not be delayed. Any postponement in the graduation day of a student was likely to result in additional costs for the student and the university. For the university, long class interruptions had a negative effect on the number of prospective students, who might have chosen to apply to other universities with undisrupted schedules.

The committee's work focused on setting up guidelines to help students and faculty deal with likely absences. Faculty was required to design their syllabi in such a way that they could provide a flexible grading scheme and remote access to course material. Although faculty were receptive to the idea of avoiding course interruptions, there were concerns about how students would perceive an online course, and whether evaluations for these courses would be considered differently for academic promotion.

7. *Food logistics during the pandemic*: The IC addressed the need to ensure meals to students affected with H1N1 if they were isolated in their rooms. Campus food services were asked to have a 2-week inventory of supplies to provide boxed meals to the students at their residences during the peak of the pandemic. Ill students needed to report to the healthcare center in order to receive meals delivered to their rooms.

8. *Class suspension*: The committee knew that public healthcare authorities could have provided recommendations on whether classes were to be suspended and if isolation needed to be enforced. However, the IC agreed that such decisions could be taken too late, and that if the disease severity was high, the university would have missed the window of opportunity

to effectively protect its students, faculty, and staff. Consequently, the IC unanimously recommended that the university pro-actively took action and did not wait for public health authorities to recommend a school closure. However, the IC was unable to suggest what factors and under which conditions such decision should have been adopted. Suspending classes had many consequences, including for example, the financial cost of paying faculty and staff during such a period, and the cost associated with overtime required to recover any missed teaching time. Additionally, since any suspension of classes would most likely occur during the Fall or early in the Winter, the school year would have had to be extended over the summer, which for students meant missing internships and full time job opportunities. Furthermore, many students would have needed to enroll in an extra term to take courses that were not offered in every academic period.

Key Lessons from H1N1 2009–2010

Several lessons are likely to influence future planning efforts:

- If a new influenza virus appears, for at least 6 months there will not be an available vaccine.
- Vaccine distribution could begin as early as 6 months or as late as 9 months after the flu virus is first characterized.
- The lethality and infectiousness of the virus will directly affect any plan for containing the disease.
- Any RIT response plan to a new pandemic will have to consider the implementation of actions before and after vaccines become available to students, faculty, and staff.
- It is important to establish social distancing strategies to minimize the rate of infection among students and faculty.
- Independent of the influenza characteristics, the most problematic time for having a pandemic will be the Fall, because the university will have to deal with the consequences of the disease during the entire academic year.

Revisiting RIT's Pandemic Response Plan

It is the first day after Labor Day and RIT's Provost, has just finished his morning exercise routine. He is now getting ready to join the President at the inauguration ceremony of the new academic year. This time of the year usually brings the opportunity to revise institutional plans and set up new strategies. For this year, one of the key plans that the Provost aims to revisit is the Pandemic Response Plan that was adopted after the 2009 H1N1 pandemic. Although great things happened during the 2009–2010 academic year (e.g., the men's hockey team made it to the NCAA finals) he cannot forget the uncertainty and concern he felt at 2009's academic year inauguration. At the time three questions preoccupied RIT administrators: *How many of our students will be infected with H1N1? Would there be any fatalities? What should RIT do to deal with the pandemic?*

Although, during the Summer of 2009, public health officials had warned that the H1N1 epidemics was not as lethal as expected, as Labor day approached, parents started calling the Provost's office to inquire about the university plans for mitigating the spread of the H1N1 virus in campus, and about how their children were going to be protected. Parents asked whether the university would vaccinate students and if the school year would be delayed. They also asked for details on RIT actions if their children became infected in campus. Due to the number of calls, the Provost frequently repeated his speech: *We are doing everything we can according to the recommendations of the national and state public health officials. We have made all necessary arrangements to avoid any teaching disruption and we will make sure that student's health and safety is RIT's number one priority*. However, no matter how many times he repeated those words, he was always concerned, and often wondered if there was anything else that could be done.

Although 2009 pandemic is now part of history, RIT's Provost is aware that a more lethal type of influenza can occur at any time and for that reason he wants RIT to revisit its response plans. Although, the RIT community reacted well to the H1N1 pandemic, if H1N1 had been a bit more lethal, the strategy adopted by the university may not have been effective. The Provost would like to review the preparedness plan for future pandemics, and would like the assessments to be *analytically based* and to provide clear guidance on how to manage the school resources during different and potentially more severe outbreaks. He wants RIT to have the capacity to react to any flu pandemic.

Part 1: Can We Make Sense of a Disease As It Spreads?

Consider the information provided in Table 1, which contains the daily number of students diagnosed with influenza-like illness (ILI) at RIT during the H1N1 pandemic in 2009–2010.

1. Plot the number of students with ILI over time. Can you explain why the number of patients with ILI shows the distribution depicted in your graph?
2. Can you identify a model to explain the number of newly infected individuals at RIT over the course of the H1N1 pandemic? Describe the *strengths and the limitations* of your model. You may want to consider the following in your analysis:
   - What role can forecasting the number of new patients with ILI have on RIT's decision-making if a new pandemic occurs?

• How often would you forecast the number of students with ILI and why?

• What would you use as the causal variables for your model? Explain why.

• What challenges do you foresee in collecting the necessary data?

• Do different infectious rates have an effect on the forecast accuracy?

3. How accurate is your forecast?
4. Could your model have been useful during the 2009 H1N1 pandemic? Can it be useful for responding for future pandemics? Explain why? Or why not?
5. Correlate the information provided on the number of patients with ILI at RIT (Table 1) with the percentage of visits for ILI Reported by the U.S. Outpatient Illness Surveillance Network (ILINET) (See: http://www.cdc.gov/flu/weekly). Comment on the results of your analysis.

Part 2: Suspend or Not Suspend? That is the Question!

You have been asked to be part of the team of experts who will help RIT review its preparedness plans for future pandemics. The challenge that RIT faces in preparing these plans are primarily the uncertainty regarding the lethality and severity of the influenza strains, as well as the time needed for having an available vaccine. As requested by the Provost, RIT preparedness plans need to be analytically based, and provide clear recommendations on what RIT should do if a new pandemic occurs.

The key concerns that you have been asked to consider in the preparedness plans are:

1. Under which conditions should RIT suspend classes?
2. How many beds and how much space should RIT set aside, if patient isolation is recommended for those with ILI (influenza like symptoms)?
3. What is the number of doctors and nurses on staff needed at the university's health care center during a pandemic?
4. What level of antivirals should RIT stockpile (if allowed)?
5. What level of masks and gloves should RIT stockpile?

Consider using an epidemiological compartmental model to simulate the progression of different pandemics at RIT. Compartmental models have been commonly used to understand the spread of infectious diseases in a population. For an example of a compartmentalized model consider SEIR (Susceptible-Exposed-Infectious-Recovered model), which assumes that a patient can transition through the following health states (compartments) as a consequence of influenza: *susceptible*, *exposed*, *infectious*, *recovered*, and *dead*. For more details on these models refer to May and Anderson (1991), Mahaffy (2009), World Health Organization (2009). SEIR assumes that a *susceptible* individual can be *exposed* to an influenza virus and remain in a state of latency (non-symptomatic stage) for several days before the patient becomes *infectious* and symptomatic. Additionally, after several days an infectious individual can *recover* from the disease and become immune to it, or due to further complications the patient can die. It is assumed that the population growth during the duration of a flu epidemic is negligible, as well as the death rate from other diseases. You may want to modify the SEIR model for your analysis.

For your compartmentalized model consider that the following information is known (these are parameters):

• the probability that a contact between an infectious and a susceptible individual results in the susceptible individual becoming exposed, β;

• the probability that an exposed individual becomes infectious, a;

• the probability that an infectious individual recovers (i.e., the reciprocal of the infectious period), ν;

• the probability that an infectious individual dies due to the infection, d;

• the probability that a vaccinated individual acquires life-long immunity to the disease, P;

• the probability that a susceptible individual is vaccinated, r;

• the number of days after the first infectious individual appears in campus for vaccines to be available, k.

Implement your compartmentalized model in Excel and then propose an experimental procedure that will allow you to observe the evolution of different flu pandemics scenarios at RIT. In this experimental design, you will define testing scenarios by setting different parameter values for the data required by your model to run. You should consider different *severity levels* (% of infected individuals who die), different *infectiousness* (i.e., the number of individuals that get infected by one infectious patient), and different *availability of antivirals and vaccines*.

Remember that the model is not the final delivery of your work, it is a tool that will help you develop a preparedness plan for future pandemics that addresses the 5 concerns listed in the previous page. Your plan must be quantitatively based and easy to use for non-technical administrators.

A challenge you will face is the lack of information on the triage procedures and the way the medical center will interact with infected students. Such procedures will depend on the severity of the pandemic virus. However, consider the interaction you have experienced when visiting a provider in order to estimate the amount of time a nurse and a doctor spend on each patient.

Complementary Readings

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Appendix.

Table A.1 Evolution of Patients with Influenza-Like Symptoms at RIT During the Fall of 2009 and Spring of 2010

Quarter and Week F: Fall, W: Winter S: Spring	Number of patients with ILI
F 0	1
F 1	7
F 2	6
F 3	4
F 4	3
F 6	6
F 7	11
F 8	59
F 9	114
F 10	130
F 11	34
W 1	9
W 2	6
W 3	2
W 4	5
W 5	4
W 7	2
W 10	2
W 11	1
S 4	1

Notes. F11 and W11 corresponded to the exam weeks of the Fall and Winter quarters, respectively. RIT was closed during W8 and W9 due to Christmas break.

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