Teaching Epidemiology and Principles of Infectious Disease using Popular Media and the case of Typhoid Mary

Amy Siegesmund
Department of Biology, Pacific Lutheran University, Tacoma, WA, 98447

Abstract
Allied health students often struggle to understand how particular content, such as epidemiology, connects to their future careers. This activity uses the case of Typhoid Mary as a foundation for exploring epidemiology and infectious disease principles. Students utilize popular media (book, podcast, video) to look at both the scientific and social aspects of infection and public health. This approach provides students the opportunity to learn and engage with content while also discovering its importance in their future as health care professionals.

Learning Goal(s)
Students will:
• Understand the general principles of infectious disease
• Explore basic epidemiological principles using the case of Typhoid Mary
• Reflect on social, economic, and cultural factors impacting health care in the early 1900s to synthesize an opinion about how these factors impact health care today.
• Connect epidemiology and infectious disease principles to their future careers.

Learning Objective(s)
Students will be able to:
• Describe the reservoirs of infection in humans.
• Distinguish portals of entry and exit.
• Describe how each of the following contributes to bacterial virulence: adhesins, extracellular enzymes, toxins, and antiphagocytic factors.
• Define and distinguish etiology and epidemiology.
• Describe the five typical stages of infectious disease and depict the stages in graphical form.
• Contrast contact, vehicle and vector transmission, biological and mechanical vectors and identify the mode of transmission in a given scenario.
• Differentiate endemic, sporadic, epidemic, and pandemic disease.
• Distinguish descriptive, analytical, and experimental epidemiology.
• Compare and contrast social, economic, and cultural factors impacting health care in the early 1900s and today.

INTRODUCTION
While the majority of students in allied health microbiology courses are interested in careers in the health care profession, often times they initially fail to recognize the relevance of particular topics to their chosen profession. Although several textbooks have tried to make epidemiology more appealing to students by including it in chapters focused on infection and infectious disease characteristics, students still view the content as “laundry lists” to memorize without appreciation for the larger context and application to their future careers. This activity uses a case-based approach to make the topic more relevant to students’ lives and careers as well as to actively...
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engage students in learning.

A student-centered, active approach to learning has been at the forefront of biology education reform in recent years (1). The benefit of active learning approaches has been clearly demonstrated (2), and there are a wide variety of techniques for engaging students. Case studies are an effective way to engage students, and deliver and apply content (see http://sciencecasenet.org/). This lesson is based on the story of Mary Mallon, aka Typhoid Mary. The use of a historical figure provides a reference point from which students can build. In addition, popular media engages students with outside resources and presents the story from a human-interest perspective rather than from a strictly scientific perspective. Using case studies with a more personal presentation improves content retention and helps students appreciate economic, social, and cultural issues surrounding patient care (3), providing an opportunity to explore the relationship between science and society (1).

The case begins with a short background story about Typhoid Mary and a brief description of the pathogenesis of Salmonella Typhi. In conjunction with a video, book excerpt, and podcast, students investigate the case of Mary Mallon and, in the process, achieve learning objectives related to epidemiology, infection, and infectious disease.

INTENDED AUDIENCE
This activity was designed for sophomore-level students in a non-majors microbiology course with a primary population of allied health students.

REQUIRED LEARNING TIME
The entire activity was completed in a 65-minute class period.

PRE-REQUISITED STUDENT LEARNING
There are no pre-requisite knowledge requirements for this activity.

SCIENTIFIC TEACHING THEMES

Active learning
Outside of class, students are required to read (textbook & article), view a video, and listen to a Radiolab story (www.radiolab.org). Students use the information from all of these sources to independently answer the questions associated with the case. In class, students work with their group to come to consensus for the answer to each question, requiring debate and discussion. As part of this work, the groups are also responsible for generating a flow chart outlining an epidemiological study from historical records. Groups also generate a graph of disease progression and relative number of S. Typhi from a case narrative. During the class-wide discussion, students are responsible for providing the answers to each question and for assessing the accuracy of the answers provided by their peers.

Assessment
The discussions that occur among students in the small and large group discussion provide students with opportunities for formative self-assessment. Formative assessment by the instructor occurs during the interaction of the instructor with each small group and during the large class discussion. Summative assessment consisted of short answer exam questions.

Inclusive teaching
This activity features components that access several learning modalities. The textbook chapter and article, along with the associated questions, require students to read/write (see http://vark-learn.com/). The video tutor, text, and lecture figures (Supporting File S1) provide visual learning tools, while the Radiolab story and class discussions incorporate auditory delivery of material. Since students must come to class with answers to all of the case questions, they are individually accountable for moving learning forward. Within the small groups, all students can actively participate by vocalizing their ideas and by listening to others. The discussion in both the small and whole-class format provides students with the chance to see the value of different perspectives.

LESSON PLAN
Please see Table 1 (on page 3) for a recommended timeline of the activity.

CLASSROOM ENVIRONMENT
This lesson was taught to a class of approximately 60 students where students worked in groups of four. Groups were formed on the first day of class and remained stable throughout the semester. Group work was a part of every class throughout the semester; by the time this lesson was taught, the expectation that students would complete tasks outside of class in preparation for group work was well established. I taught the lesson in a lecture hall, but it is adaptable to almost any physical space.

PRE-CLASS TEACHER PREPARATION
The primary pre-class tasks for instructors is to disseminate the case to the students and prepare the visuals to accompany the class-wide discussion. While Powerpoint (Supporting File S1) was used by this instructor, the format allows for teachers to utilize the method they are most comfortable with for visual presentation.

PRE-CLASS STUDENT PREPARATION
In preparation for class, students were assigned the corresponding chapter (“Infection, Infectious Diseases, and Epidemiology”) from their text (4), a “video tutor” on virulence factors (from textbook online materials), an excerpt from Anthony Bourdain’s book Typhoid Mary: An Urban Historical (5), and the Radiolab podcast The Most Horrible Seaside Vacation (6). Students were expected to have all assignments and case questions completed before coming to class.

IN-CLASS PART 1: SMALL GROUP DISCUSSION
(about 25 minutes)
To start the discussion, groups discussed their answers to each of the case questions. Students were allowed to use their completed case study as well as any notes they had from their reading and other preparatory work. The goal was for the group to develop a consensus answer for each question. Since students worked in groups during every class period, they typically did a good job of moving through the questions. While students were working, the instructor walked through the classroom, answering questions and clarifying any misconceptions. These interactions also provided a chance for the instructor to ask questions about content that might not be a direct answer to a case question. For example, Question 2 (Supporting File S2) asked students to identify the reservoir...
### Activity

| Activity                     | Description                                                                 | Time        |
|------------------------------|-----------------------------------------------------------------------------|-------------|
| **Teacher Preparation**      | 1. Read textbook chapter and book excerpt.                                   | Variable    |
|                              | 2. Watch video tutor                                                          | -5 minutes  |
|                              | 3. Listen to Radiolab story.                                                 | 15 minutes  |
|                              | 4. Prepare powerpoint presentation and plan class discussion                  | Variable    |
| **Student Preparation**      | 1. Read textbook chapter and book excerpt.                                   | Variable    |
| (out of class)               | 2. Watch video tutor                                                          | -5 minutes  |
|                              | 3. Listen to Radiolab story.                                                 | 15 minutes  |
|                              | 4. Complete questions on case study.                                         | Variable    |
| **Student Group Discussion** | 1. Students work within their established groups to develop a consensus answer for each question in case. | 25 minutes  |
| of Case                     | 2. Instructor circulates among groups to answer questions, clarify misconceptions, and ask leading questions in preparation for class-wide discussion. |            |
| **Class Discussion of Case** | 1. Student groups are called on to present their answer to each question.    | 40 minutes  |
|                              | 2. Instructor provides illustrating and synthesizing visuals for each question and leads extended discussion around content. |            |

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of disease in the typhoid outbreaks. During discussion with students, the instructor let students explain their answer and then asked them to name some other reservoirs. This questioning set the stage for the class-wide discussion that covered not only the content in the case, but the content in the chapter and other learning materials. It also helps reveal any misconceptions or misunderstandings that students had, allowing the instructor to address these during the class-wide discussion.

IN-CLASS PART 2: LARGE GROUP DISCUSSION

(about 40 minutes)

After students had worked through the case in their learning groups (about 25 minutes), the class was brought back together. For each question, the instructor asked for a group to volunteer an answer. After the answer was given, the instructor asked the class if any group had anything to add or change. Then the instructor presented figures from the text (or other sources) that aid in synthesizing important concepts and extended the discussion around the content (Supporting File S1 and S3). For instance, Question 1 (Supporting File S2) asked students to define and distinguish epidemic disease from other types of disease. Nearly every microbiology textbook contains an image comparing endemic, epidemic, sporadic, and pandemic disease. After a group presented its answer, the image was presented to visually reinforce the verbal answer. The discussion was extended, asking students to define sporadic disease and give an example of each type of disease occurrence. Identifying examples helps the students put the technical definitions into a more relatable framework and also helps illuminate any misunderstanding students might have about the definitions. The final question in the case focused on the social aspects of health care and public health as a springboard for discussion about issues that are relevant for today's health care professionals (Question 11, Supporting File S3). For example, since Mary Mallon never got sick with typhoid, she failed to believe that she could be a carrier. This observation led to a discussion about how patient beliefs (whether or not they are scientifically accurate) impact their response to care. The class extended the discussion to talk about what they as nurses (or other health care professionals) could do in similar situations. The teaching notes include a description of visuals and provide extension ideas for each question (Supporting File S3). Suggestions for PowerPoint visuals can be found in Supporting File S1.

TEACHING DISCUSSION

STUDENT ACHIEVEMENT OF LEARNING OBJECTIVES

The case of Mary Mallon provides a framework for students to explore and apply content related to infectious disease, infection, and epidemiology. It also helps instructors to identify and clarify misconceptions that students might have. For example, students often believe that the presence of a pathogen is always associated with disease (Mary's status as a carrier is very intriguing to them) or that pathogens need to produce a lot of virulence factors to cause disease. As students retrace the steps in the Mary Mallon case, they begin to understand the essential role of epidemiology in public health. They also make the connection between microbial pathogenesis and clinical presentation (Supporting File S2, Question 7). Exploring content in this manner is not only engaging for students, but it helps clarify subtle, but important differences. For instance, students often confuse pathogenicity/virulence and etiology/epidemiology. Distinguishing these concepts within a case context led to better understanding in subsequent assignments and exam questions; no student used these terms incorrectly after the case. On an exam, students were presented with a mini-case that tested their ability to apply their knowledge in a new scenario—a patient presenting with Rocky Mountain Spotted Fever (RMSF). The majority of students were able to correctly respond to short answer questions corresponding to four of the case learning objectives—accurately identifying the reservoir, mode of transmission, and portal of entry and creating a graphical representation of disease stage and number of bacteria.

ADAPTING THE CASE TO OTHER COURSES AND CONTEXTS

Target audience: Although this case was used in a non-majors biology course with a majority population of allied health students, it could easily be adapted for use in a majors or non-majors introductory course or an upper level majors microbiology course.

Simulations: Further investigation of the content in the case could be explored either in lab or lecture by having students participate in a "simulated epidemic" exercise (Epidemic Simulation Classroom Kit; Carolina Biological #154665; www.carolina.com).

Other interactive activities: Although the content of this lesson can be found in any microbiology text, the video tutor was specific to the text that we used. Alternatives to this proprietary video tutor can be found online (e.g. https://www.youtube.com/watch?v=E15p4DEI9uA) or with other textbook ancillary materials.

Different time frames: The discussion extension ideas provided in the case teaching notes are easily adaptable for either shorter or longer class periods. This activity was completed in a 65-minute class period; instructors teaching in a 50-minute class period could easily eliminate some of the discussion extension questions without compromising student learning. The discussion portion could be altered so that groups were assigned a question to report back to the class. This adaptation may be advantageous in classrooms where student-driven discussion is not as regular. By assigning responses, all groups are responsible for reporting and the discussion will move forward effectively.

STUDENT REACTION TO THE ACTIVITY

The student response to case studies was overwhelmingly positive. On end of the semester evaluations, one student commented, “The case studies were very helpful. Not only did I process information on my own and in a group, but the addition of the lectures made concepts clear.” Another student highlighted the value of the class discussions associated with the case “I learned a lot from the discussions in class because the open dialogue helped me to understand others perspectives and fresh ways to think about concepts.”

Presenting this content through the story of Mary Mallon makes the material more personal and relatable to students. While they must consider the science behind the case, they also explore social and cultural issues relevant to health care
and public health. As one student wrote, “it teaches me to think in a much more ‘nurse’ way.”

**SUPPORTING MATERIALS**
- S1: Typhoid Mary-Presentation File
- S2: Typhoid Mary-Case
- S3: Typhoid Mary-Case teaching notes

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