CASE STUDY
Meningitis in College Students: Using a Case Study to Expose Introductory Neuroscience Students to Primary Scientific Literature and Applications of Neuroscience

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This case study was based on a popular press news article about Krystle Beauchamp Gridley's experience with meningitis while in college (Miller, 2019). Students in an introductory neuroscience course read the popular press news article as well as an empirical article that identified risk factors for contracting meningococcal disease in college (Bruce et al., 2001). Students used information from the empirical article to identify Krystle's risk factors for meningitis. Then, students evaluated their University's policy on students receiving the meningococcal vaccine based on what they had learned. This case supports two important goals of neuroscience education, 1) exposing students to primary scientific literature early in their undergraduate education and 2) developing an understanding of the broader implications of scientific research for society. Students enjoyed learning about meningitis using the case-study method, reading the primary scientific article, and considering how scientific research can be applied to policy decisions. Further, the case was instrumental in supporting the content and process learning objectives.

Key words: case study; meningitis; primary scientific literature; introductory neuroscience course; science applications

BACKGROUND AND CONTEXT

Case studies play an important role in the advancement of science. For example, Scoville and Milner (1957) initially identified the critical role of the hippocampus in their seminal report of patient H.M.'s memory deficits following the resection of the medial temporal lobe. Case studies are also impactful pedagogical tools in the classroom. Case studies personalize course content and foster elaborative encoding, which promotes long-term retention. As noted by Meil (2007), students may forget the functions of the hippocampus and frontal cortex but be able to remember the names and stories of H.M. and Phineas Gage. Classroom case studies can either be based on published case reports in peer-reviewed journals, such as the *Journal of Clinical Neuroscience*, or involve the application of course content to a story or scenario.

The current case study was based on a college student's experience with meningitis that was presented in a popular press news article (Miller, 2019). Students in an introductory neuroscience course learned about the individual's experience and then identified risk factors for meningitis present in the case after reading an empirical article on risk factors for contracting meningitis in college (Bruce et al., 2001). Exposure to reading and evaluating primary scientific literature during undergraduate education supports scientific literacy and success in graduate school (Kozeracki et al., 2006). However, many faculty do not incorporate primary scientific literature into introductory courses due to the focus on content versus process-based learning objectives (Coil et al., 2010). This lack of exposure subsequently results in students being intimidated by primary scientific literature once they reach upper-level courses (Smith, 2001). As such, there has been a call to begin developing scientific process skills, including reading and interpreting primary literature, early in students' undergraduate education (Coil et al., 2010).

The last part of the case required students to apply what they had learned about meningococcal disease. Students evaluated their University's policy on students receiving the meningococcal vaccine. The goal of this component of the case was to expose students to the broader impacts of scientific research for society and policy-based decisions. In addition to understanding the scientific process and quantitative reasoning, the *Vision and Change in Undergraduate Biology Education: A Call to Action* report by the American Association for the Advancement of Science includes understanding how science intersects society as a core competency of biological sciences, including neuroscience (Brewer & Smith, 2011).

The current case study on meningitis makes multiple contributions to neuroscience education. Whereas most neuroscience case studies have been implemented in upper-level undergraduate courses (e.g., Cook-Snyder, 2017; Sawyer & Frenzel, 2018; Mitrano, 2019; Ogilvie, 2019; Watson, 2019; cf. Roesch & Frenzel, 2016), the current case was implemented in an introductory neuroscience course. Further, students evaluated the case in relation to an empirical report on risk factors for contracting meningococcal disease in college, supporting their knowledge of how an individual case can fit within the context of broader scientific investigation. Lastly, students applied what they learned to evaluate their University's policy, demonstrating the practical implications of scientific research for society. Student materials and implementation notes are available from the corresponding author or from cases.at.june@gmail.com.

LEARNING OBJECTIVES

Content Objectives

At the end of the case, students will be able to:

- Identify the layers of the meninges on the brain and spinal cord.
- Provide symptoms of meningitis.
- Describe tests that can be performed in order to diagnose an individual with meningitis.
- Identify risk and protective factors for meningitis in college students.
- Understand the effectiveness of the meningococcal vaccines for different strains of the bacteria that cause meningitis.
- Apply their knowledge to evaluate their University's policy on students receiving the meningococcal vaccine.

Process Objectives

- Read and interpret primary scientific literature.
- Begin learning how statistics can be used to evaluate scientific hypotheses.
- Identify real-world implications of neuroscience research.

COURSE OVERVIEW

This case on meningitis was implemented in an introductory neuroscience course that included 30 students. Prerequisites for the course included either introductory psychology or introductory biology. Students completing the course ranged from first-semester freshman to seniors. Students primarily intended to major in Neuroscience (53%), Psychology (23%), and Biology (17%). The case was presented the third week of the semester as we began covering the structure of the nervous system, including cerebrospinal fluid, the meninges, neural development, and gross anatomy. The case was the students' first exposure to primary scientific literature in the course.

The case was designed to reinforce knowledge of the meninges, expose students to primary scientific literature, and require students to apply knowledge learned in class to a real-world situation. As such, the case included a news article describing the experiences of a college student that contracted meningitis, an empirical article evaluating risk factors for contracting meningitis, and an evaluation of the University's policy on students receiving the meningococcal vaccine. This case would be appropriate for neuroscience, psychology, or biology courses that include a unit on neuroanatomy. Alternatively, this case could also be used to educate students about the immunological mechanisms of vaccinations or to facilitate a discussion about ethics associated with vaccination.

CLASSROOM IMPLEMENTATION

This case implementation in the classroom involved a modified think-pair-share approach. Students independently completed guided readings prior to class. Then, students discussed responses in small groups during the class meeting prior to the larger class discussion. Before the class period during which the discussion of the case took place, students:

- Read a short textbook passage about the meninges (i.e., dura mater, arachnoid mater, pia mater). The passage identified characteristics of each layer of the meninges as well as their location in relation to the brain and spinal cord.
- Read and answered four questions about a popular press news article about Krystle Beauchamp Gridley's experience with meningitis (Miller, 2019). Specifically, students were asked to list signs and symptoms of meningitis experienced by Krystle, identify how doctors diagnosed Krystle with meningitis, whether there was anything Krystle could have done to avoid contracting meningitis, and the long-term effects of meningitis experienced by Krystle.
- Read and answered questions about an empirical article from the *Journal of the American Medical Association* titled, "Risk factors for meningococcal disease in college students" (Bruce et al., 2001). Students were asked to consider how details of Krystle's case aligned with risk factors identified in the article and assess whether her meningitis could have been avoided if she had received the meningococcal vaccine.

During the 50-minute class meeting, students learned

Survey Statement (1 = Strongly Disagree; 5 = Strongly Agree)	Average Rating ($M \pm SD$; n = 30)
1) I enjoyed learning about meningitis in the case study format.	4.23 ± .73
2*) I would have preferred a lecture about meningitis rather than reading and working through the case study.	2.37 ± 1.06
3) I gained more knowledge about meningitis from the news story presented in the case than what I previously learned about it, either from a textbook or lecture.	4.2 ± .66
4) The class discussion increased my knowledge about meningitis.	4.03 ± .93
5) This activity caused me to think about meningitis in a different way than if I had just read the text or listened to a lecture.	4.48 ± .62
6) I enjoyed evaluating the University's policies on meningitis based on the case study and article.	3.93 ± .91
7*) Completing the assigned reading and analysis worksheet was too much to ask of us.	1.53 ± 1.01
8) This case should be used again to teach meningitis.	4.17± .70

Table 1. Presents the mean (± SD) for items on the evaluation questionnaire. *Items 2 and 7 were reverse-worded statements.

about anatomical directions and the layers of the meninges for the first 25-30 minutes of class. The remainder of the class period was spent on the case study in which there were three pair-and-share opportunities. Students discussed their responses in groups of 3-4 students and then we had a group discussion. During the first pair-and-share, students discussed Krystle's experience with meningitis. Second, they considered Krystle's case in relation to risk factors identified in the empirical article after a brief discussion of statistics. I explained that scientists typically use a threshold of .05 for determining whether an effect is statistically significant. Then, together as a class, we identified which risk factors in Tables 2 and 3 from the *JAMA* article were significant predictors of meningococcal disease and which were not. Based on that discussion, students identified Krystle's risk factors and spent the most time discussing the fact that Krystle did not receive the meningococcal vaccine. We discussed that the meningococcal vaccine most college students receive protects against some, but not all, of the serogroups that commonly cause meningococcal disease. Additionally, the specific serogroup that caused Krystle's meningitis was not identified in the news article, so we were unable to definitively state whether the meningococcal vaccine would have protected Krystle from contracting meningitis. Lastly, the students were provided with and asked to evaluate the University's policy on students receiving the meningococcal vaccine (which can be found on most Universities' websites).

CASE ASSESSMENT

The questions students answered when completing the case study were not evaluated because I intended for students to perceive the activity as a learning opportunity versus an assessment. The University's Institutional Review Board approved the case assessment, and students consented to having their data from the exam and evaluation of the case study contribute to the present report. Learning objectives for the case study were included on the list of exam objectives, which students received a week before the exam. Four questions on the first exam (8 points) related to the meninges or meningococcal disease. Two questions were multiple-choice with four response options, and two questions were short answer. The multiple-choice questions required students to 1) provide the order of the layers of the meninges in relation to the brain and 2) identify which medical procedure was most likely used to test for meningitis. Twenty-six of 29 students (89.66%) correctly identified the order of the layers of meninges relative to the brain as well as the procedure used to diagnose meningitis (one student's performance on the multiple-choice questions is missing because the scantron was not evaluated with the rest of the class). The first short-answer question required students to identify two symptoms of meningitis. Twenty-nine of 30 students (96.6%) received full credit on this question. One student correctly identified only one symptom of meningitis. The second question required students to identify one precaution that can be taken to reduce the probability of contracting meningitis; 100% of students correctly identified that vaccination can protect individuals from contracting meningitis.

After the conclusion of the case study, students completed an anonymous evaluation of the meningitis case. Students responded to eight statements regarding the case using a 5-point Likert-scale (1 = Strongly Disagree, 5 = Strongly Agree; See *Table 1*). Students overall responded favorably to the case study. Another goal of the case study was for students to consider how scientific knowledge can be applied to real-world situations. Students agreed that it is important to consider the broader impacts of scientific knowledge (M = 4.48 $\pm$ .63), and ratings were lower for students indicating that they had previously thought about the way scientific knowledge can affect policies (M = 3.53 $\pm$ 1.14). Most students did not respond to the open-ended question at the end of the questionnaire that asked for other feedback about the case study. However, one student commented, *"case studies are a great way for undergraduate student to learn, in a memorable way, about different ailments."*

DISCUSSION

The meningitis case was the first case presented in the semester and the student's first exposure to primary scientific literature. Self-reported data indicated that the majority of the students enjoyed learning about meningitis using the case-study method, reading the primary scientific article, and considering how scientific research can be applied to policy decisions. Students performed well on the examination questions, and the case provided students with low-stakes exposure to primary scientific literature before they completed four graded empirical article evaluations. As such, the case was effective in promoting the identified content and process objectives.

There are many ways this case can be adapted in the future. Students could independently investigate the meninges or which meningococcal serogroups are targeted by the quadrivalent meningococcal vaccination. The case study could also be adapted for courses in immunology or epidemiology. For example, the case study could be focused on the meningococcal serogroups or involve students comparing data from the *JAMA* article to recent reports by the CDC (2019; (https://www.cdc.gov/meningococcal/surveillance/index.html). Further, how the case study is applied could be modified. Rather than evaluate their University's policy on students receiving the meningococcal vaccine, students could create their own policy, which would challenge them to think at a higher level of Bloom's taxonomy. Students could also consider the costs versus benefits of the vaccinations given the rarity of meningococcal disease. For example, a relatively recent article in *The New York Times* discussed concerns related to the cost of the vaccinations in relation to the rarity of meningococcal disease (Luthra, 2017).

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