Teaching Epidemiology Online (Pandemic Edition)

Hailey R. Banack[1], Catherine R. Lesko[2], Brian C. Whitcomb[3], and Lindsay C. Kobayashi[4]

Correspondence to Dr. Hailey Banack, Department of Epidemiology and Environmental Health, University at Buffalo, Buffalo, NY, 14214 ph: 716-829-5358 email: hrbanack@buffalo.edu

Please note: All editorial queries should be addressed to Dr. Lindsay Kobayashi, Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, Michigan; ph: 734-763-0322 email: lkob@umich.edu

[1] Department of Epidemiology and Environmental Health, University at Buffalo, Buffalo, New York

[2] Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland

[3] Department of Biostatistics and Epidemiology, University of Massachusetts Amherst, Amherst, Massachusetts

[4] Center for Social Epidemiology and Population Health, Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, Michigan

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Abstract

In response to the threat posed by the COVID-19 pandemic, many universities are encouraging or requiring online instruction. Teaching an epidemiology course online is different in many respects than teaching in person. In this article, we review specific approaches and strategies related to teaching epidemiology online during the pandemic and beyond, including a discussion of options for course format, grading and assessment approaches, pandemic-related contingencies, and the use of technology. Throughout this manuscript we present practical, epidemiology-specific teaching examples. The pandemic has served to heighten our awareness of concerns related to student health and safety as well as issues of accessibility, equity, and inclusion. Moreover, we also examine: 1) how the lessons learned about the practice of epidemiology during the pandemic can be integrated into the didactic content of epidemiology training programs and 2) whether epidemiologic pedagogy and teaching strategies should change in the long term, beyond the COVID-19 pandemic. Our goal is to present a practical overview connecting pandemic-era online teaching with thoughts about the future of epidemiologic instruction.

Keywords: teaching epidemiology, online instruction, remote learning, COVID-19

In the Winter and Spring of 2020, many universities around the world transitioned to remote instruction in response to the COVID-19 pandemic. This mid-semester transition was difficult as courses designed

for in-person lectures, discussions, activities, and exams were rapidly transitioned to online formats. We recognize the tremendous efforts of instructors and University support personnel to provide access to education during a stressful time, while also juggling a myriad of personal and research-related responsibilities.

Although many instructors transitioned their courses online, it was a less-than-ideal situation. One faculty member in epidemiology likened the situation to "driving a car while building it". However, as the COVID-19 pandemic progresses, it has become clear that it will be a very long time before we return to teaching in person to classrooms full of epidemiology students. Many universities are currently encouraging or requiring fully remote instruction, or a hybrid approach to instruction combining in-person and online teaching. Despite the many downsides, there may be a silver lining to this situation: we now have the opportunity to consider best practices for online teaching in epidemiology.

Numerous adaptations have been required to ensure continuity of education in epidemiology training programs during the pandemic. This unexpected situation has been challenging but presents an opportunity for our field to evaluate whether traditional, classroom-based approaches for teaching epidemiology adequately meet the needs of our 21st century students. In this article, we discuss specific approaches and strategies related to teaching epidemiology online during the COVID-19 pandemic and beyond. Topics include course formats, didactic content, assessment strategies, use of technology, and contingencies to consider when teaching online. Our goal is to present an overview connecting pandemic-era online teaching with thoughts about the future of epidemiologic instruction.

Teaching epidemiology online during the COVID-19 pandemic

Course formats

The two primary approaches to online teaching are synchronous, where courses are conducted in real-time or asynchronous, prepared in advance with no "live" component. Some instructors may be given

the flexibility to choose a course format while other instructors may have the course format dictated by their university or department. Advantages and disadvantages of synchronous and asynchronous teaching methods in epidemiology are listed in Table 1. Regardless of course format, instructors should consider strategies to maximize student engagement (1, 2), such as weekly quizzes or "just in time" approaches to assess whether students understand the material being covered in class.(3, 4) Holding office hours via online video platform could be another strategy for students to interact with faculty or teaching assistants. In this section, we will introduce synchronous and asynchronous approaches and discuss strategies for using these approaches in epidemiology courses.

Synchronous instruction

Synchronous instruction most closely mimics a traditional classroom setting, where instructors and students 'meet' at a scheduled class time via an online platform, such as Zoom (Zoom, San Jose, California), WebEx (Cisco Systems, Santa Clara, California), Microsoft Teams (Microsoft Corporation, Redmond, Washington), or BlueJeans (Verizon Communications, San Jose, California). Synchronous teaching allows students and teachers to interact as the material is taught. Many synchronous teaching platforms also allow instructors to record lectures for students who are not able to attend class sessions. Instructors can pose questions to students during their lectures and pause for students to form answers(2), and students can ask questions or request clarification. Some software platforms include interactive features that facilitate synchronous teaching, such as virtual 'hand-raising', emoji reactions, polls, and chat boxes. Some platforms, such as Zoom, allow the students to be divided into breakout rooms for activities or discussions and instructors can 'drop-in' to different rooms to observe or answer questions. Small-group breakout sessions allow students to build rapport and establish social connections. Breakout rooms can also facilitate group work via screen sharing, which may be useful for collaborative epidemiology exercises such as generating 2x2 tables and estimating crude measures of association or drawing directed acyclic graphs (DAGs).

While synchronous teaching has advantages, it also raises important concerns about equity and inclusion. For students to successfully participate in real-time online class sessions, they must have access to a computer with high speed internet available at the scheduled class time, ideally in a distraction-free and quiet environment. Many students live in shared housing, which may interrupt synchronous learning. Students with children or caregiving responsibilities, those who live in multigenerational households, or those experiencing financial difficulties during the pandemic may be especially susceptible to experience challenges in synchronous environments. Synchronous approaches also have the potential to exacerbate differences in educational attainment; students most likely to encounter difficulties with synchronous learning will disproportionately be those from racial/ethnic minority groups, those who identify as female, or of lower socioeconomic status. Further, epidemiology students may be involved in public health response efforts themselves, such as contact tracing, testing, or field research, or have clinical responsibilities. Instructors must carefully balance the educational advantages of synchronous learning with the practical realities faced by many students during the COVID-19 pandemic.

During the pandemic, many students and faculty are connecting to synchronous class sessions from home. Instructors teaching synchronously must consider unique issues related to rules or expectations for online class sessions, such as: muting microphones, bathroom breaks, unexpected interruptions, 'arriving' on time, appropriate attire, and the use of web (video) cameras during class sessions. There are valid arguments both for and against requiring students to use video cameras. Having cameras on facilitates interaction between instructors and students and can help develop student rapport. On the other hand, some students may not have the required technology or may not be comfortable broadcasting their home environment to the entire class. Clear communication about how you wish to handle these issues is key to ensure everyone is on the same page.

Asynchronous instruction

Asynchronous instruction typically involves pre-recorded lectures that are posted online. This approach allows students to access course material according to their schedule or preferences. Asynchronous approaches raise a different set of challenges than synchronous approaches (Table 1). It may be difficult for students to maintain motivation and attention while watching pre-recorded lectures. Asynchronous content can be split into shorter discrete "modules" (e.g., 10-30 minutes long), with multiple modules replacing what would otherwise be a longer in-person session.(2) Module topics and learning objectives should be indexed along with the recording. Faculty may consider encouraging students to stay up-to-date with course material by linking videos to exercises that allow students to consolidate and reinforce their knowledge of the topic in the video. For example, for a lecture on misclassification, students could be asked to pause the recorded video to calculate sensitivity, specificity, positive predictive value and negative predictive value. Students could also be asked to pause videos for 'thought experiments'. In a causal inference course, when learning about the concept of emulating a target trial, you may consider posing a question with a description of research question from a fictitious observational study and asking students to pause the video to think through how they would design the analogous target trial (e.g. eligibility criteria, causal contrast, follow-up).(5)

Synchronous and asynchronous teaching for epidemiology

Both synchronous and asynchronous strategies can be successfully used in epidemiology courses; the choice of whether one is more appropriate than the other depends on the instructor's preference, institutional requirements, and the specific course being taught. Epidemiology courses that are heavy with didactic content, such as introductory or intermediate methods courses, may lend themselves well to asynchronous instruction, provided instructors build in opportunities for students to ask questions (e.g., office hours, discussion boards). Asynchronous lectures allow students to learn at their own pace, slow down the lecture speed, and pause the lecture to review readings or take notes. For example, consider a lecture introducing the concept of 2x2 tables and odds ratios. During an asynchronous

lecture, instructors could encourage students to pause the video and use a calculator to practice using the formula to obtain an odds ratio from the a, b, c, and d cells of a 2x2 table. This could also be accomplished by recording a synchronous class lecture but may require the student to watch the lecture twice if they want to slow down or stop (i.e., once in real time and then again as a recorded lecture). Asynchronous instruction may also be advantageous when class sizes are large, as is sometimes the case in undergraduate epidemiology courses or Master of Public Health (MPH) programs, or programs with a high proportion of clinicians (e.g., MD, RN, RD) who are also working full time. This format provides maximal flexibility in terms of scheduling and avoids the technical requirements of a remote teaching platform that can accommodate hundreds of participants at once (and the almost inevitable technical difficulties that will cut into class time or preclude some students from participating in real-time).

Alternatively, synchronous teaching approaches may be better suited for advanced-level epidemiology courses that are primarily discussion-based or require high levels of student engagement. This is more common among doctoral courses and seminars. One core skill that is frequently taught as part of doctoral training programs in epidemiology is critical appraisal of epidemiologic literature. Asynchronous instruction may not be feasible for a critical appraisal class, given the importance of peer-to-peer discussion and the value of each student bringing a different perspective to the class. In this type of setting, the instructor acts as a facilitator and coordinator. A pre-recorded lecture covering the main points of the article being discussed may not be an effective strategy for teaching students the skills involved in critical appraisal. Given the logistics of and lead-time required for pre-recording lectures, synchronous instruction may be preferred to asynchronous instructions for classes focused on current topics in epidemiology and public health. For instance, the evidence base related to the current pandemic is developing rapidly; each week new research is published furthering our understanding of COVID-19.(6) What we knew in the early days of the pandemic about SARS-CoV-2 transmission and

high-risk populations is different than what we know now.(7, 8) Even adding a week of lead-time to class preparation may make lectures feel outdated.

Didactic content in the pandemic era

Core concepts covered in most epidemiology programs include measures of disease occurrence, including calculating effect estimates, types of study design, and analytic strategies.(9, 10) However, the COVID-19 pandemic has raised questions about potential gaps in epidemiology training programs. Certain topics have come to the forefront over the past several months and it is worth considering whether these should be included in the basic training of all epidemiology students. A sample of these topics include 1) infectious disease epidemiology and surveillance, 2) the role of social determinants of health and health disparities, and 3) public health ethics. Here, we present additional discussion on two specific topics that have been highlighted by the COVID-19 pandemic.

The importance of descriptive epidemiology

Early in the pandemic, United States surveillance often did not incorporate routine collection of race and ethnicity data alongside infection data. This neglect delayed the identification of important racial and ethnic inequities in COVID-19 incidence, hospitalization, and mortality and in the United States.(11-15) The pandemic has highlighted the importance of rigorous descriptive epidemiology, especially in times of public health crisis. High-quality data on measures of morbidity and mortality by person, place, and time are essential precursors for analytic epidemiology and causal inference. Descriptive epidemiology is often overlooked in favor of causal effect estimation, yet the COVID-19 pandemic has highlighted the importance of including a rigorous treatment of descriptive epidemiology and surveillance, and their role in an effective and equitable public health response, in training programs.

Knowledge translation and health communication

As the COVID-19 pandemic progresses, epidemiologic research is rapidly and iteratively informing healthcare and public health policy, including clinical guidelines for hydroxychloroquine (HCQ), antibody treatments, and convalescent plasma as potential COVID-19 treatments, vaccine development trials, and local and statewide policies for mask-wearing and social distancing.(16-18) The importance of accurate dissemination of information (and uncertainty) from epidemiologists to policy makers and the news media cannot be understated. Knowledge translation is a skill that should be taught as part of epidemiologic curricula. For example, it is important for epidemiologists to be able to explain how bias can influence the results of studies purporting to identify key risk factors for disease.(19) A case-study in poor public health communication could be made of the messaging on masks, where initial lack of evidence for masks as protective against COVID-19 was interpreted as evidence of absence of a protective effect, and subsequent recommendations for masking were interpreted as a lack of scientific consensus on the topic. Further, the pursuit of public health research topics that have become entangled with a political agenda, such as HCQ for the treatment of COVID-19 or mask-wearing policies, could be discussed in coursework in relation to research ethics(20, 21) and best practices for scientific communication with the media and policymakers. (22)

Exams, grading, and assessments

Exams are a major part of student assessment in many epidemiology courses, especially in large introductory-level courses. There are several logistical challenges to consider for instructors administering exams remotely. It is difficult to ensure that students complete exams independently in remote settings. There are software programs that can be used to proctor exams remotely, using strategies such as locking an individual's computer for a set amount of time or recording the student's movements through a webcam. Apart from ethical concerns about surveillance, students have reported that these forms of remote exam proctoring are extremely stressful and make it more difficult to focus. Fortunately, epidemiology lends itself well to open book, take-home exams focusing on applied

calculations, interpretation, and critique. Indeed, after students graduate, rarely will they be asked to practice epidemiology without access to reference materials. One possible exam question might provide students with an abstract from a recently published article and ask them to identify the study design and summarize the key results. In advanced epidemiology courses, an exam could require a student to design a study to answer a specific research question or reproduce specific calculations from the results of a published article. These approaches could work well in both core and substantive epidemiology courses. Regardless of the format, it is imperative that expectations be clearly articulated. Instructors must specify what students may or may not use as aids during the exam. Can they use their class textbook or notes or search the internet? Are they allowed to discuss answers with classmates? Can they post on Twitter seeking answers from #epitwitter?

Epidemiology instructors may also consider a variety of other student assessment methods: quizzes, weekly exercises involving calculations, contributions to online discussion forums or wikis, study design or analysis projects, writing a mock grant proposal, or group presentations. Group presentations in remote learning may involve structuring the presentation assignment so each student is responsible for a specific section and then having students pre-record their presentations and post online. For example, if students are to do a group presentation on critical appraisal, each student could prepare and present slides on one section of the assigned article (introduction, methods, results, and discussion). If the presentations are being done synchronously, each student could take a turn speaking on the video call. Of course, instructors must weigh several factors when choosing an assessment approach that works best for their course. There is a need to balance the benefits of authentic assessment(23) approaches with the particularities of the course they are teaching, such as the number of students enrolled and the availability of teaching assistant support for grading. The assessment approach for a cancer epidemiology course of 200 students will likely differ from a doctoral seminar on social epidemiology with 5 students.

Given the uncertainties surrounding COVID-19, instructors should be prepared to be especially flexible regarding grading policies. Details of flexible policies should be outlined in the course syllabus for students to see at the outset of the course. Some specific policies that could be implemented include: dropping the lowest quiz mark from the final grade, or incorporating peer-review of students' assignments and the opportunity for students to revise their assignments in response to such review prior to grading. The latter suggestion has the added benefit of emulating the peer-review process and collaboration that is the mark of epidemiologic practice in the real world. Courses that award participation points should allow for non-traditional forms of class participation such as: contributing to the conversation on a class Slack channel, posting to an online discussion board, engagement in collaborative note-taking (where students rotate and contribute to a shared class resource summarizing the topic covered in class that week). These approaches have an additional advantage of allowing instructors to gauge student understanding in near real-time.

Flexible grading policies, including those described above, are critical to promote equity. It is almost inevitable that some students will fall ill with COVID-19, have family members or friends who fall seriously ill, have child-care related crises, or experience mental health challenges related to or exacerbated by the pandemic. These burdens will not fall equally among our students.(14, 24-27) Students who belong to racial/ethnic minority groups, from low socioeconomic backgrounds, international students, and those with childcare or caregiving responsibilities are likely to be disproportionately affected by the pandemic. We must be sensitive to these concerns. When possible, look out for signs that your students are struggling, such as missed class sessions, lack of communication, late or missed assignments, or declining class performance. We recognize that an instructor's ability to monitor their students' well-being may be limited in remote settings. However, fostering an environment of open communication and clearly addressing this topic with students at the outset may help them feel more comfortable reaching out, when needed.

Technology

Success in online teaching is dependent on access to technology and internet. Most institutions have created and disseminated general guidelines related to the use of online learning management software such as Canvas (Instructure, Salt Lake City, Utah), Blackboard (Blackboard Inc., Washington, DC) and Brightspace (D2L Inc, Kitchener, Canada). Most platforms have features that facilitate online instruction, such as blogs, wikis, collaborative notetaking, student peer-review, and grade management systems. Additionally, several popular video recording applications - Zoom, Panopto (Panopto Inc, Seattle, Washington), Kaltura (Kaltura Inc, New York, New York), and Echo360 (Echo36 Inc) - have built-in voice recognition software and enable instructors to add closed captions to the lectures. This highlights an important advantage of using technology to enhance accessibility. Beyond closed captioning, instructors should consider color choices, text size, and students who may use screen reader technology.

Access to statistical software may be a particular concern for epidemiology courses focused on data analysis as students may have lost access to on campus computer labs or software. Some universities offer remote access through virtual computing sites as an option, although these sites are often slow and require a continuous Internet connection for use. One option for instructors would be to consider using open source software packages, such as R. Despite these challenges, online teaching has the potential to be beneficial for instructors using statistical software in their courses, such as the ability to share screens and write code collaboratively. Consider a class focused on data analysis. During a synchronous class, the instructor may prompt students to calculate the median of a simple data set using PROC Means in SAS (SAS Institute, Cary, NC). If students are having trouble getting their code to run properly, they can share their screen with the class to troubleshoot the problem, or the instructor can share their screen to show a walkthrough of the process. Real-time feedback using screen sharing from instructors or peers could help to alleviate some of the stress and frustration students feel when learning data analysis or a new coding language.

COVID-19 contingencies

Substantial uncertainty remains about how the pandemic will unfold over the upcoming weeks, months, and potentially, years. It is important for instructors to acknowledge that many students face increased threats to emotional well-being and mental health challenges owing to the pandemic. Some students are also experiencing instability and stress due to social, economic, environmental, and political disruption concurrent with the pandemic. Now, more than ever, it is essential that instructors become familiar with the physical and mental health services and resources that are available to students at their institutions. An additional pandemic-related consideration is how to manage students who become ill and cannot participate in class (even online) or complete an assignment or exam. Under normal circumstances, it is standard for instructors to require a doctor's note, but should the same rules still apply? COVID-19 testing is a complicated process, access is not equal, and results can take many days to come back.

A Look Toward the Future: Teaching epidemiology online after the COVID-19 Pandemic

Once the pandemic ends, we will hopefully have the opportunity to return to a more traditional style of teaching in on-campus lecture halls. However, this leads to an important question: is classroom-based learning the best approach for teaching epidemiology? In this final section we discuss how epidemiologic pedagogy may change in the long term as we all become more comfortable with online teaching technology. Integrating technology into higher education has the potential to transform training in epidemiology so it reaches a broader and more diverse group of students.(28)

Flipped Classroom Approaches

In recent years, flipped classrooms have received considerable attention as a teaching strategy. The flipped classroom is a student-centered instructional method that moves didactic content outside of the classroom in an asynchronous format and uses in-class time for active, problem-based learning.

Education researchers have demonstrated that this approach can improve the quality and efficacy of teaching, and can result in improved academic performance, student engagement, critical thinking, and less confusion among students.(29) Baytiyeh (2016) demonstrated that using a flipped classroom model enhances students' feelings of autonomy, problem solving skills, teamwork, communication, enjoyment, and creativity.(29)

Flipped classrooms seem particularly well suited for epidemiology courses. There are many core topics in epidemiology that are conceptually difficult but become much clearer when students have the chance to work through the steps of the calculations. For example, consider direct and indirect age standardization. In traditional classroom-based approaches, the instructor would introduce these topics and demonstrate the steps involved with the calculations. Students would observe and take notes to reinforce or augment the instructor's lessons. In a flipped classroom model, the instructor would create an asynchronous online lecture on the topic, with similar content to a traditional lecture. Students would watch this lecture and then attend an in-person class session (or, in the case of remote-learning, a synchronous online session) that has them use simple tabular data from the population of interest and a reference population to calculate the age-standardized mortality rate. In this approach, students get hands-on experience and have the opportunity to see that simple algebraic equations underlie many key concepts in epidemiology. In advanced courses, the same model could be used, but with students using in-person or synchronous online time for programming using statistical software. Instructors interested in implementing this model should consider that it requires students to devote substantially more out-of-class time. All time spent watching lectures asynchronously and then doing course-related exercises in person or synchronously should count toward required credit-hours to avoid overburdening students.

Beyond pedagogic advantages, the flipped classroom model introduces and reinforces the notion of teamwork and collaborative science as important skills for epidemiologists. Time spent working through exercises and calculations allows students to learn from each other, build rapport, and establish social

connections. From an instructor's perspective, lectures or modules recorded for asynchronous instruction during the pandemic could be repurposed and utilized in a flipped classroom model after the pandemic.

Conclusion

Teaching and learning during the COVID-19 pandemic have been tremendously challenging on many levels. However, we look forward to the innovations in epidemiologic teaching that may unexpectedly emerge from this difficult time. Epidemiologic pedagogy has taken several steps forward over the past few months, and we have learned many lessons as a field from the practice of epidemiology and the attention it has received during COVID-19.(30) We encourage instructors to evaluate which aspects of online teaching have worked particularly well, or even better than, traditional approaches. There are still likely to be many challenges ahead, including the possibility that some instructors will be required to adapt their teaching strategies mid-semester (e.g., in person to hybrid or fully online) as the pandemic evolves. The strategies discussed herein are intended to benefit all epidemiology instructors interested integrating online pedagogy into their courses, regardless of whether they are planning for fully remote or hybrid teaching or required to switch from in person to online mid-semester. To help facilitate discussion across instructors at different institutions, we have established a Slack workspace focused on teaching epidemiology online and for sharing resources related to instruction during the COVID-19 pandemic. If you are an epidemiology course instructor interested in joining, please reach out to the corresponding author by email or contact @haileybanack or @epikobayashi on Twitter.

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Table 1. Advantages and disadvantages of synchronous and asynchronous online teaching in epidemiology

Advantages & Disadvantages	Synchronous teaching	Asynchronous teaching
Advantages	Student engagement Interaction between students and instructors Allows real-time demonstration and collaboration, such as drawing causal diagrams, solving equations, creating 2x2 tables Opportunities for questions Real-time feedback Fostering collaborative learning Reduces feelings of social isolation	Flexible and convenient, in particular for students living in different time zones Potentially reduces scheduling demands on instructors because lectures can be pre-recorded Self-guided learning ("learner-centered") Students can slow down or pause videos, such as pausing to estimate an odds ratio from a 2x2 table presented by the instructor
Disadvantages	Less flexibility in scheduling Time-zone challenges, which may disadvantage international students Unequal access to quiet learning space Technical requirements (hardware, software, internet access) Greater burden on students with caregiving, employment, or other related responsibilities, such as involvement in public health pandemic response or clinical responsibilities	Social disengagement, feelings of disconnectedness, lack of peer support Limits of attention span for online video learning Requires self-discipline Technical requirements (hardware, software, internet access) Loss of networking opportunities (instructor-student, peer-to-peer)