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# Development, implementation, and evaluation of a novel multidisciplinary one health course for university undergraduates

Deborah Linder<sup>a,\*</sup>, Carie Cardamone<sup>b</sup>, Sean B. Cash<sup>c</sup>, John Castellot<sup>d</sup>, Deborah Kochevar<sup>e</sup>, Shuchi Dhadwal<sup>f</sup>, Ellen Patterson<sup>f</sup>

<sup>a</sup> Cummings School of Veterinary Medicine, Tufts Institute of Human-Animal Interaction, Tufts University, North Grafton, MA, USA

<sup>b</sup> Center for the Enhancement of Learning and Teaching, Tufts University, Medford, MA, USA

<sup>c</sup> Friedman School of Nutrition Science and Policy, Tufts University, Boston, MA, USA

<sup>d</sup> Tufts School of Medicine, Tufts University, Boston, MA, USA

<sup>e</sup> Dean Emerita, Cummings School of Veterinary Medicine, Tufts University, North Grafton, MA, USA

<sup>f</sup> Tufts Dental Health School, Tufts University, Boston, MA, USA

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## ABSTRACT

Today's collaborations across fields of health and wellness are insufficient to meet societies' challenges in combating disease and maintaining the ecosystem and public health. In this article, we present a One Health curriculum model designed to encourage undergraduate students of varying disciplines to value the connectedness of animals, humans, and the environment and to think innovatively about solutions to priority global health issues.

We present the design and implementation of a course that brought together multiple faculty from different fields of study, including the dental, medical, nutrition, and veterinary schools, in a curriculum designed for undergraduates primarily from Arts & Sciences fields. The curriculum was collaboratively designed around four key One Health categories: 1) Infectious zoonotic diseases and global health, 2) Naturally occurring shared disease in companion animals that can serve as models for human disease, 3) Human-animal interactions, and 4) Impact of environmental health on human and animal health.

We show this course successfully deepened students' understandings of One Health, its role in addressing high priority health issues and the overall benefits of a One Health approach to tackling societal problems. We also report a positive experience by the faculty working in collaboration to implement the curriculum model and the overall enthusiasm of students for the course, all of whom would recommend it to their peers.

We conclude by proposing the potential of the curriculum model underlying this course to fill the need for One Health Curricula in programs preparing future health professionals.

## 1. Introduction

The term One Health, previously known as “One Medicine,” was coined in the early 1900s to describe the collaboration between human medicine and veterinary medicine to combat zoonotic diseases. This term was chosen because both fields of medicine required common knowledge of the origin of disease, anatomy, pathology, and physiology. In the late 1900s the term One Medicine expanded to include ecosystem health and public health, thus becoming “One Health” [1–3]. The goal of One Health is to foster interdisciplinary, interinstitutional, and interprofessional collaboration locally, nationally, and globally to advance the well-being of people, animals and the environment [3–6].

Today's collaboration between fields is insufficient to meet societies'

challenges. For example, Fisman and Laupland noted that, in the realm of infectious diseases, there is a dearth of communication “between veterinary and medical professionals,” which, with the relatively recent spread of various infectious diseases such as West Nile Virus and SARS, is necessary to track and respond to zoonotic threats [20]. This problem is worsened by the isolation of the training and education within each profession, as well as the lack of zoonotic disease training in human medicine curricula [2,4,7,8]. In addition to the lack of zoonotic disease training, there is also a lack of environmental health information included in human medicine curricula [21]. Therefore, collaboration is essential to solving complex societal problems including climate change, toxic waste, water pollution, food safety, and food security [5,7,9].

\* Corresponding author at: Cummings School of Veterinary Medicine at Tufts University, 200 Westboro Road, North Grafton, MA 01536, United States of America.  
E-mail address: [Deborah.Linder@tufts.edu](mailto:Deborah.Linder@tufts.edu) (D. Linder).

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To address societal needs, curricula across professional schools are undergoing changes to embed introductions to One Health. The United States Centers for Disease Control and Prevention (CDC) has named One Health an essential focus area for higher education. In 2007, the American Medical Association House of Delegates accepted a One Health resolution and the American Veterinary Medical Association established a task force to implement One Health. In 2011 the North American Veterinary Medication Education Consortium (NAVMEC) listed One Health as a core requirement for all graduating veterinarians [2,9]. And as of January 2019, at least 105 organizations from around the world support the One Health initiative [10].

Even with the widespread support, One Health curricula are still in early phases of development. While some universities have established programs in One Health, this alone does not embed widespread change within the individual health professions. Individual courses are also being developed aimed at students across disciplines to increase their One Health knowledge. For example, the Western Institute for Food Safety and Security designed a curriculum focused on food safety and security from a One Health perspective [5]. The University of Sydney developed a field trip experience to local parkland areas for veterinary students to participate in five One Health activities [8]. The University of Geneva and University of Basel worked together to design three Massive Open Online Courses (MOOCs) to teach One Health-One Medicine, One Health connecting humans, animals, and the environment, and Global Health at the Human-Animal-Ecosystem interface [11]. At UC Davis, medical and veterinary students worked collaboratively to develop case-based One Health exercises [7].

While each of these courses introduces one health concepts within an individual curriculum or professional development opportunity, holistic changes across fields of professionals require sustainable models embedded in their professional preparation. Therefore, holistic sustainable changes for future professionals require transferable models of multidisciplinary courses taught by faculty from fields as diverse as human medicine, veterinary medicine, nutrition, dental medicine, environment, and public policy. In other words, similar One Health courses may be too rigid in their preparation of their curricula and may not be able to account for changes that come across naturally during the evolution of an emerging field across multiple disciplines. This course, on the other hand, is unique in that it incorporates a diverse array of faculty working in various professional fields, which ensures changes in any one field will not invalidate the content of the course.

In this article we introduce the curriculum model collaboratively developed to produce an undergraduate One Health course at Tufts University. The definition of One Health and the categories used for our course came out of a working group from the Tufts University-wide One Health Committee consisting of faculty from medical, dental, nutrition, and veterinary schools at the University. In this article, we describe how we implemented a course to support this working definition of One Health in our current curricula. However, the field of One Health is an ever-evolving area and this is only possible definition of One Health so we intend our curriculum to be modified as needed to accommodate the varying definitions of One Health at other institutions. Our specific course builds on a previously developed a method of “mapping assets” of a university to determine how the university could promote One Health education [12]. The course was designed to encourage undergraduate students of varying disciplines to value the connectedness of animals, humans, and the environment and to think innovatively about solutions to priority global health issues. We present the design and implantation of the course and demonstrate its success. Finally, we propose ways that this curriculum model can be adapted and transferred to a multitude of contexts in undergraduate, professional and graduate degree programs.

## 2. Methods - one health: animal, human, and environmental connections

### 2.1. Course goals

One goal of the curriculum model was to bring together multiple faculty from different fields of study. The course was run by the Co-Associate Director of the Tufts Institute of Human-Animal Interaction, who worked collaboratively with members of the Tufts University-wide One Health Committee. The curriculum blended these diverse perspectives into a cohesive theme focused on the ways in which animals, people, and the environment have shared health. Course learning objectives presented to students focused on their understanding of One Health approaches and their ability to apply them through evidence-based discourse and an understanding of the context and backgrounds of the various issues. Underlying the learning objectives was the goal for students to recognize the value of animal, human, and environmental connectedness. Ultimately, the curriculum sought to develop in students the ability to articulate the benefits of the One Health approach and apply it in the development of innovative approaches to priority global health issues.

### 2.2. Course framework

This course was implemented under the auspices of the Tufts University ExCollege, a program to foster interdisciplinary education, engaged leadership, and active citizenship in Tufts undergraduates. It took place on the Tufts University main campus in Medford, MA. This course ran for 13 weeks with a single 150 min meeting each week. Depending on the weekly topic, each session was developed and guided by selected faculty from the dental, medical, nutrition, and veterinary schools at Tufts University, with additional input from staff at the Tufts Institute of the Environment and the Tufts Center for the Enhancement of Learning and Teaching. An online management system (Canvas) was used to distribute readings and collect and grade student work, and the course director attended all classes to facilitate consistency of the student experience in face of the team-taught approach.

The course was open to Tufts University undergraduate students of any major. The enrollment in this pilot year included 24 students drawn primarily from Arts & Sciences fields, including the following majors: International Relations (8), Biology (3), English (2), Economics (2), Biopsychology (2), Community Health (1), Film and Media Studies (1), Biochemistry (1), Peace and Justice Studies (1), Political Science (1), Computer Science(1), and Undecided (1). Represented were 20 Seniors, 2 Juniors, and 2 Sophomores.

In addition to the myriad student majors represented, the faculty who developed and taught in the course come from numerous different fields and schools. Deborah Linder is a Research Assistant Professor at the Cummings School of Veterinary Medicine and a Co-Director at the Tufts Institute of Human-Animal Interaction. Carie Cardamone is the Associate Director for STEM & Professional Schools at the Center for the Enhancement of Learning and Teaching. Sean B. Cash is an Associate Professor at the Friedman School of Nutrition Science and Policy. John Castellot is a Professor of Medical Education at the Tufts School of Medicine. Deborah Kochevar is Dean Emerita at the Cummings School of Veterinary Medicine. Shuchi Dhadwal is an Assistant Professor at the Tufts Dental Health School. Ellen Patterson is an Assistant Professor at the Tufts Dental Health School.

A consistent framework was developed and applied to each class session. While the faculty directing the week's content and material were drawn from a variety of schools, each class was organized into three sections of activity: interactive presentations of background material, small group activities, and a summative discussion or presentation. Supporting materials were provided weekly, including readings, supplementary bibliographies, and slides from in-class presentations.

### 2.3. Course activities

Each week, class activities were broken down into three sections separated by two short breaks. This design was chosen to provide both the opportunity to learn from and interact with expert faculty around each week's topic and to allow for students to experience deeper learning through the creation of their own positions, arguments and presentations.

Each class session began with an interactive presentation from the expert faculty to introduce key questions and ideas related to the topic. The presentation included questions to prompt reflection on what they were learning and make connections to the background readings for the session. Students were also encouraged to use this time to ask questions and probe the experiences of the instructors, who came from a diverse array of professional schools and fields. The selection of the background readings and the format of the presentations allowed for the experts to share disciplinary conventions of study and communication.

Following the presentations, small group activities and discussions were designed to encourage full participation by the students. These group activities targeted students' intrinsic motivation by providing opportunities for self-directed learning and ownership over the material [13]. The format varied from week to week, but examples of in-class activities included: developing an affirmative or negative position on a stated resolution and supporting the position with no fewer than three lines of reasoning, writing a brief recommendation for a solution to a stated dilemma or problem presented in class, and creating visual products conveying high priority ideas from small group discussions. A consistent rubric was used to evaluate the materials each group developed on a given week. The rubrics were consistent across all the assignments in class to be used by the various faculty (see Fig. 1). The rubric emphasized the importance of integrating ideas from the class discussions and readings. It also highlighted the importance of professional presentation of ideas, whether the medium was a group in-class presentation or individual written commentary. The rubric and consistency of grading from week to week provided transparency for the students, an important inclusive teaching practice [14]. The consistency of grading was important to emphasize due to the different faculty members grading assignments every week. The nature of the group activities in class also allowed for a significant cooperative learning component to the curriculum design [15].

Finally, the last portion of the class encouraged students to synthesize their learning. Led by the course director and the faculty expert lecturer, this concluding section provided a forum for sharing ideas, recommendations, and evidence-based assessment of the week's topic. Activities varied and included summative whole-class discussion, student group presentation, or other moderated sharing of the students' developing ideas.

### 2.4. Curriculum topics & overview

Within the course, session topics were organized around four key categories relevant to One Health: 1) Infectious zoonotic diseases and global health. 2) Naturally occurring shared disease in companion animals that can serve as models for human disease 3) Human-animal interactions, and 4) Impact of environmental health on human and animal health. These key categories were chosen both because of their relevance to One Health and because each emphasized a slightly different element of the One Health framework, which fostered student understanding of the wide-reaching implications of One Health. The categories were selected based on a similar framework to that laid forth by Lebov et al. [16]. Additionally, while each of the categories emphasizes a different aspect of One Health, they all address each of the three major domains within One Health. For example, human-animal interactions are discussed during the course in terms of their impact on human health and psychological well-being [17] (human health), the potential proliferation of infectious diseases due to the improper

implementation of animal-assisted interventions [18] (environmental health), and the potential challenges to animal welfare due to improper preparation or care on the part of the handlers [19] (animal health). During week one, students were introduced to the topic of One Health and the course. Weeks two through nine covered these four topics. Then Weeks 10 and 11 broadened the application of these concepts through communication and public policy of One Health concepts and application of One Health in an example priority health issue, the pet food industry. Finally, weeks 12 and 13 were used for presentation and peer review of class projects.

The individual sessions focused on key questions, challenges, and opportunities in each of these four categories and considered the positive impact of inter-disciplinary and inter-professional One Health approaches. Faculty took leadership roles in the curriculum where their expertise intersected with the topical subject, allowing for a diverse array of perspectives throughout the curriculum. Table 1 presents a week by week overview of the curriculum, showing location of topics along with the associated student activities. The complete readings assigned are provided in Appendix B.

### 2.5. Grading & student feedback

Students' grades were based on attendance, in-class participation, class presentations, and completion of online surveys. Attendance at all classes was required. Assignments were posted online to the learning management system Canvas, where students could view their grades and the rubric that was completed by the week's faculty leader and/or the course director.

The class assignments were primarily completed in groups, except for position papers that were required from each individual before each of two in-class debates. These focused on One Health solutions for health challenges that impacted people, animals or the environment. The course culminated in a summative capstone presentation, which students could also complete in groups. The capstone presentations allowed the students to directly apply what they learned in the course to a specific challenge. Students submitted preliminary outlines, identifying sources, groups and topics. At the capstone presentations, teams received feedback from peers through a threaded discussion forum on Canvas in addition to the more formal grade from a rubric completed by the course director.

Students received frequent focused feedback on their learning through in-class interactions with the faculty and their peers. The nature of the peer-learning environment allowed for students to continually develop and test ideas in the company of peers with different backgrounds. The faculty were present to provide guidance and support. The last portion of each class period provided opportunities for the faculty to check in with the students developing understanding of issues related to the week's topic.

### 2.6. Data: surveys, student work & faculty reflections

The goal of the curriculum model was to bring together faculty to blend diverse perspectives into a cohesive theme of shared health among animals, people, and the environment. Success of the model is ultimately evaluated through student ability to articulate the benefits of the One Health approach and apply it in the development of innovated approaches to priority global health issues.

### 2.7. Surveys

Three online surveys were used to solicit student feedback on the course and to probe their understanding of One Health. These surveys were not graded, but were used by the instructor to inform the course design and for the research purposes in this article. A single survey was administered in the first week of the class and again at the end of the semester to assess changes in students' confidence and understanding of

**Student Evaluation and Grading Rubrics:**

Success in this course depends upon attendance, completion of reading and other assignments, and participation in group activities and assignments.

*Weekly in-class, group discussion write-ups.*

The class will be divided into groups. Group rosters will be provided to encourage interaction and cross-group dialogue. Criteria for evaluation will include cogent written presentation of ideas, recommendations and/or evidence for supporting or refuting a position. Maximum length of assignment is typically 1 - 2 pages with one group assignment per group per class period.

Grading Rubric Criteria	Possible Points	Points Earned
Student uses the prompt to guide their writing.	1	
Student uses the assigned reading(s) and/or class discussion (if assignment done during class) in their writing. For example: The student analyzes how the ideas presented in the readings/discussions compare and/or contrast to their own views and/or experiences.	6	
Paper is edited and free of grammatical and spelling errors.	2	
Assignment is completed on time.	1	

*Class attendance and individual preparation for and participation in class discussion.*

It is a priority for students to prepare for and participate in classroom discussion and assignments.

Grading Rubric Criteria	Yes/No
Student attends class.	
Student demonstrates understanding of the reading through comment(s) in group discussion.	
Student contributes to group discussion by posing a question or responding to a peer's question or discussion point.	

*Preliminary outline of presentation.*

Presentations will be focused on One Health solutions for health challenges that impact people, animals, and the environment. Preliminary summary, references to consult, and outline for each presentation will be required by end of week 4 for review and feedback.

Capstone Presentation Outline Criteria	Possible Points	Points Earned
Student identifies a health challenge that impacts people, animals, and/or the environment.	3	
Student describes an approach to address the chosen health challenge and provides a rationale for why it would be considered a One Health approach.	3	
Student provides at least three references in proper MLA format and at least one is a primary source from a peer-reviewed academic journal.	3	
Assignment is completed on time.	1	

*Capstone presentation.*

Final two sessions of semester. Presentations (10-15 min in length) will be focused on One Health solutions for health challenges that impact people, animals, and the environment.

Capstone Presentation Criteria	Possible Points	Points Earned
Student(s) identified a health challenge that impacts people, animals, and/or the environment.	2	
Student(s) described an approach to address the chosen health challenge and provides a rationale for why it would be considered a One Health approach.	2	
Each member of the group participated (if group presentation) and spoke clearly and at an understandable pace.	2	
Student(s) used visuals to enhance the presentation and balanced slides between words and visuals.	2	
Student(s) are able to answer questions professionally and utilize references to answer accurately.	2	

**Fig. 1.** Grading Rubrics for Various Assignments and Basis of Student Evaluation

**Table 1**  
Curriculum topics & overview.

Topics	Weeks	Faculty disciplines	Student activities
Introduction to One Health	1	Veterinary Medicine	<u>Small group activity:</u> 1) brainstorming for capstone presentation
Infectious Zoonotic Diseases and Global Health	2–3	Human Medicine, Veterinary Medicine	<b>Session 1:</b> Zoonotic Diseases cases (eg, SARS, Ebola, Zika)  <u>Small group activity:</u> 1) group discussion of cases & in-class presentation. <b>Session 2:</b> Global Health Security Agenda: antimicrobial resistance, zoonotic disease, workforce development <u>Small group activity:</u> 1) take a position on the statement: “The GHSA strives to decrease the impact of zoonotic disease on global health. Is organization of this effort across multiple country-partners a strength or a weakness? Or both?” 2) prepare a one-page set of recommendations for enhancing the structure of the Global Health Security Agenda (GHSA). <b>Session 1:</b> naturally occurring animal diseases that also occur in people <u>Small group activity:</u> 1) Take a position in class: Is comparative oncology helping to win the war on cancer? Why or why not? 2) Outline for capstone presentation <b>Session 2:</b> periodontal disease in humans and canines. <u>Small group activity:</u> 1) Group discussion write up, interactive brainstorming session with peer review
Naturally Occurring Shared Disease in companion Animals that can Serve as Models for Human Disease	4–5	Human Dental, Veterinary Dental, Veterinary Medicine	<b>Session 1:</b> human-animal interaction, defining assistance animals, how media portrays HAI <u>Small group activity:</u> 1) Group discussion & debate human -animal interactions & media portrayal; group write ups submitted <b>Session 2:</b> animal assisted interventions <u>Small group activity:</u> 1) demonstration of therapy animal visitation, group discussion therapy animals and the various interventions that exist 2) Persuasive commentary from a stakeholder position in each category: animal, handler, participant, facility <b>Session 1:</b> world food supply and livestock production <u>Pre-Class Activity:</u> 1) one to two-page reading reflection: should you change your diet based on the concerns introduced by the readings? <b>Session 2:</b> climate change and impacts on nutrient content <u>Pre-Class Activity:</u> 1) from readings prepare pros and cons/positive and negative arguments for the statement: Declining nutrient quality due to climate change is a global public health concern. <u>Small group activity:</u> 1) in-class debate “for” and “against” positions will be assigned in class randomly.
Human-Animal Interaction	6–7	Human-Animal Interaction, Veterinary Medicine	<b>Session 1:</b> applications of One Health in pet food <u>Small group activity:</u> 1) participate in interactive session exploring how many aspects of One Health are needed to address pet food <b>Session 2:</b> communication and public policy of One Health <u>Small group activity:</u> 1) group discussion write ups 2) students to meet and discuss final preparations for presentations
Impact of Environmental Health on Human and Animal Health	8–9	Human Nutrition & Agricultural Economics	<b>Session 1:</b> world food supply and livestock production <u>Pre-Class Activity:</u> 1) one to two-page reading reflection: should you change your diet based on the concerns introduced by the readings? <b>Session 2:</b> climate change and impacts on nutrient content <u>Pre-Class Activity:</u> 1) from readings prepare pros and cons/positive and negative arguments for the statement: Declining nutrient quality due to climate change is a global public health concern. <u>Small group activity:</u> 1) in-class debate “for” and “against” positions will be assigned in class randomly.
Applications of One Health	10–11	Veterinary Medicine, Public Health and Community Medicine, Human Nutrition, Center for Animals and Public Policy	<b>Session 1:</b> world food supply and livestock production <u>Pre-Class Activity:</u> 1) one to two-page reading reflection: should you change your diet based on the concerns introduced by the readings? <b>Session 2:</b> climate change and impacts on nutrient content <u>Pre-Class Activity:</u> 1) from readings prepare pros and cons/positive and negative arguments for the statement: Declining nutrient quality due to climate change is a global public health concern. <u>Small group activity:</u> 1) in-class debate “for” and “against” positions will be assigned in class randomly.

the One Health approach. Additionally, mid-way through the semester a survey was administered to seek feedback about the course logistics and the student's experiences, which was only qualitative and open-ended in nature. The pre- and post- course surveys asked students to define One Health and describe how they would apply it to high priority health issues. After each question, students were asked to indicate their confidence in their answers on a Likert scale with the options ('Not at all confident', 'Somewhat Confident', 'Fairly Confident', and 'Very Confident'). The full survey questions are included in [Appendix A](#). For expert comparisons, the surveys were also given to Tufts One Health Committee faculty members who served as co-faculty for developing and providing the course. The surveys were taken by these faculty members to compare the student responses to content expert responses.

## 2.8. Ethics

This research was conducted under the approval of the Tufts University Social, Behavioral & Educational Research Institutional Review Board (SBER IRB). At the completion of the final survey, students were redirected to a consent form. This introduced the nature of the study the authors wished to conduct and allowed students to consent to their work being used for research purposes. Students were informed that neither their involvement nor their answers would impact their grade. Of the 24 students enrolled in the course, 92% (22) provided consent for us to use their responses from surveys. These are the data considered in the remainder of the paper.



**Table 2**  
Student survey responses on their perceived confidence in various aspects of one health before and after taking the one health course.

	Pre-course # of students %	Post-course # of students %
How confident do you feel in your ability to define One Health?	5/22 23%	21/22 95%
How confident do you feel in your ability to describe the role of a One Health approach?	1/22 5%	21/22 95%
How confident do you feel in your ability to describe the benefits of a One Health approach?	3/22 14%	22/22 100%
How confident do you feel in your ability to describe how a One Health approach would be applied?	2/22 9%	22/22 100%

## 2.9. Statistics

For the Likert scale questions, a sign test was used to test for differences between pre and post responses. This method is a nonparametric test which compares the number of responses that improved after treatment to those that did not improve and uses a standard binomial test to determine significance. Small sample counts within each combination of pre and post responses hinders the utilization of more powerful tests that rely on large-sample properties; the sign test was therefore deemed most appropriate with these data.

## 3. Results

### 3.1. Student confidence

In the pre and post surveys, students were asked about their confidence in their ability to define One Health, a One Health approach and its benefits. Over the course in all categories, students gained confidence in their abilities (see Table 2). There was significant improvement in student confidence from 50% (11/22) of the students reported feeling not at all confident in their ability to define One Health prior to starting the course to 68% (15/22) of students reporting the highest confidence on their ability to define One Health after the course ( $p < .001$ ). Similarly, students' confidence also improved in their ability to describe the benefits of One Health ( $p < .001$ ) and in their ability to describe the role of a One Health approach in addressing high priority health issues ( $p < .001$ ). See Table 2 for the percent of students Fairly or Very Confident in their answers to four survey questions.

### 3.2. Student evaluations

Students were very positive about the course. All responding students were likely to recommend the course to their peers, with 76% (16/21) very likely and 24% (5/21) fairly likely, with one student not responding. When asked what about the course enhanced their learning, student responses included “the structure of the classes and the emphasis on group work and discussion afterwards!”, “The presentations by a wide range of professionals in different fields did a good job of offering different aspects and perspectives of One Health,” and “The interactive and discussion-based components were super helpful and I loved the final presentations.” The themes of each of these representative quotes were echoed in over 1/3rd of the student responses. The course also provided an unexpected benefit for one student who stated, “I got a job through the networking/connections I made.”

### 3.3. Feasibility & key design features

Overall, the faculty found the course feasible, but felt that to

successfully facilitate a truly multidisciplinary course, a cohesive faculty team was required with a strong leader and coordinator to provide consistency and continuity throughout. With many faculty rotating in to teach sessions each week, having a strong course director attend all sessions allowed for continuity between those sessions and bridged topics with overarching themes. When asked what features of the course most enhanced their learning, students most frequently mentioned the multiple lecturers and the group discussions and activities. As one student wrote, “having each group present in some small [way] each week and discussing afterwards forced me to think a lot more about the topics at hand”. Similarly, when asked to name the most important and effective features of the course design, faculty mentioned the combination of lecturers from multiple disciplines and the logistical format, including the student discussions and application of ideas to case studies and real world problems.

## 4. Discussion

Student feedback and course evaluations supported that this multidisciplinary One Health course was feasible with a strong course director and demonstrated improved student confidence in the ability to define, describe, and apply One Health principles in priority health issues. With a unique and strong interdisciplinary faculty base, this course is the first of its kind to include faculty from over four different professional schools that was successfully implemented at Tufts with these positive outcomes.

Future directions for this course could incorporate components from other One Health courses described in the literature. Case-based One Health exercises created by students and faculty as described in Wilkes et al. [7] could be added to give real life examples of One Health problems that the students may face in the future. In addition, the field trip approach [8] would be an interesting application of content to help reinforce the concepts taught in class. To promote dissemination of this curriculum model (as described in Ruiz de Castaneda et al. [11]), development of a MOOC for One Health could be considered as well.

This model could easily be adapted and expanded for graduate or professional student participants with the students themselves taking additional ownership of the weekly activities. For example, students with expertise in a discipline could take leadership roles in designing and leading activities during topics that intersect with their background and interests. The curriculum could also be expanded to address this more experienced student body through the selection of more advanced readings. This course would be further strengthened by faculty from additional fields and could be modified based on the varying strengths of faculty at differing institutions with departments and fields such as sociology, community health, earth and ocean science, economics, urban and environmental policy and planning.

Overall, the evaluations and feedback suggest that a multidisciplinary One Health course could be implemented successfully at other institutions with the caveats of employing a cohesive faculty team, a strong course director to provide consistency and with a focus on continuity throughout the sessions to provide context and structure for students in the interrelatedness of One Health concepts throughout a variety of fields. A number of students mentioned in their evaluations and feedback that they appreciated the wide-ranging interests of the cohesive faculty team and additionally that a consistent leader was essential to put the diverse fields into a singular perspective. Additional challenges to consider include potential institutional barriers to developing and delivering such a course including teaching credit, shared resources, and support to develop partnerships across fields, departments, and schools. At Tufts University, these challenges were overcome through the creation of a university-wide One Health Committee that provided a foundation for working relationships across schools as well as an institutional NIH grant which included One Health as a priority area and provided support for the course to be developed.

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## Declaration of Competing Interest

The authors certify that they have no affiliations with or involvement in any organization or entity with any financial or non-financial interest in the subject matter or materials discussed in this manuscript.

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## Appendix A. Student Survey

### Pre-Course Survey

1. Student Name:
2. What is One Health?
3. How confident do you feel in your ability to define One Health?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
4. What is the role of a One Health approach in addressing high priority health issues?
5. How confident do you feel in your ability to describe the role of a One Health approach?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
6. What are the benefits of a One Health approach in addressing high priority health issues?
7. How confident do you feel in your ability to describe the benefits of a One Health approach?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
8. How would you apply a One Health approach in addressing high priority health issues?
9. How confident do you feel in your ability to describe how a One Health approach would be applied?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
10. How would you describe One Health to an intelligent layperson?
11. How confident do you feel in your ability to explain One Health to an intelligent layperson?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
12. What (if any) is the difference between One Health and One Medicine?
13. How confident do you feel in your ability to describe any difference between One Health and One Medicine?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
14. What about this course made you want to sign up for it?
15. What do you hope to achieve from this course?

### Post-Course Survey

1. Student Name:
2. What is One Health?
3. How confident do you feel in your ability to define One Health?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
4. What is the role of a One Health approach in addressing high priority health issues?
5. How confident do you feel in your ability to describe the role of a One Health approach?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
6. What are the benefits of a One Health approach in addressing high priority health issues?
7. How confident do you feel in your ability to describe the benefits of a One Health approach?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
8. How would you apply a One Health approach in addressing high priority health issues?
9. How confident do you feel in your ability to describe how a One Health approach would be applied?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
10. How would you describe One Health to an intelligent layperson?
11. How confident do you feel in your ability to explain One Health to an intelligent layperson?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
12. What (if any) is the difference between One Health and One Medicine?
13. How confident do you feel in your ability to describe any difference between One Health and One Medicine?  
Likert Scale (select one):  
1 (not at all confident) 2 (somewhat confident) 3 (fairly confident) 4 (very confident)
14. How well did this course meet your expectations?  
Likert Scale (select one):  
1 (not at all) 2 (somewhat) 3 (fairly well) 4 (very well)
15. Would you recommend this course to your peers?  
Likert Scale (select one):  
1 (not at all likely) 2 (somewhat likely) 3 (fairly likely) 4 (very likely)
16. Which students would this course benefit most? (e.g., class year, major, interests, etc.)
17. What did you like most about this course?
18. What would you change about this course?

## Appendix B. Readings by Topic

The amount of preparatory material for each class period is variable. Required readings for each class are intended to provide a context for the lecture or to supplement lecture content. Some material may be included in the readings that will not be specifically addressed in the lecture, although it may all be included in discussion. Students will get the most out of this course if readings are completed prior to the class for which they are assigned.

### **Week 1 Introduction to One Health & Course**

1. No required reading for the first session.

### **Week 2 Infectious and Zoonotic Disease**

- Rabinowitz et al. “One Health and emerging infectious diseases: clinical perspectives.” <https://www.ncbi.nlm.nih.gov/pubmed/22976348> (Links to an external site.)Links to an external site.
- Fisman et al. “The ‘One Health’ paradigm: Time for infectious diseases clinicians to take note?” <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2951799/> (Links to an external site.)Links to an external site.
- Glossary provided

### Week 3 One Health and the Global Health Security Agenda

- Global Health Security Agenda (<https://www.ghsagenda.org/>) (Links to an external site.)Links to an external site.)
  1. Explore the GHSA website to develop an overview of the GHSA
- GHSA Action Packages:
  1. Prevent 1: Antimicrobial Resistance (<https://www.ghsagenda.org/packages/p1-antimicrobial-resistance>) (Links to an external site.)Links to an external site.)
  2. Prevent 2: Zoonotic Disease (<https://www.ghsagenda.org/packages/p2-zoonotic-disease>) (Links to an external site.)Links to an external site.)
  3. Detect 5: Workforce Development (<https://www.ghsagenda.org/packages/d5-workforce-development>) (Links to an external site.)Links to an external site.)

### Week 4 Naturally Occurring Disease: Introduction/Cancer

- Why The War On Cancer Hasn't Been Won: Shots - Health News: NPR; <https://www.npr.org/sections/health-shots/2015/03/23/394132747/why-the-war-on-cancer-hasnt-been-won> (Links to an external site.)Links to an external site.
- Stats Split on Progress Against Cancer; <https://www.npr.org/sections/health-shots/2015/03/23/394332315/stats-split-on-progress-against-cancer> (Links to an external site.)Links to an external site.
- Of Mice, Dogs and Men, Tedx OhioStateUniversity 2015;Dr. Cheryl London - TEDxOhioStateUniversity 2015

### Week 5 Naturally Occurring Disease: Periodontal disease and shared health

- Batchelor, P. “Is periodontal disease a public health problem?” <https://www.nature.com/articles/sj.bdj.2014.912> (Links to an external site.)Links to an external site.
- Williams, L. “One Health and Dentistry.” [https://www.researchgate.net/publication/281483340\\_One\\_Health\\_and\\_dentistry](https://www.researchgate.net/publication/281483340_One_Health_and_dentistry) (Links to an external site.)Links to an external site.

### Week 6 HAI: Human-Animal Interaction

- Harold Herzog, The Impact of Pets on Human Health and Psychological Well-Being: Fact, Fiction, or Hypothesis? <http://journals.sagepub.com/doi/full/10.1177/0963721411415220> (Links to an external site.)Links to an external site.
- McCune, et al., Evolution of research into the mutual benefits of human-animal interaction, [https://www.researchgate.net/publication/269429785\\_Evolution\\_of\\_research\\_into\\_the\\_mutual\\_benefits\\_of\\_human-animal\\_interaction](https://www.researchgate.net/publication/269429785_Evolution_of_research_into_the_mutual_benefits_of_human-animal_interaction) (Links to an external site.)Links to an external site.

### Week 7 HAI: Animal-Assisted Interventions

- Linder et al., Amer J. Infect Cont: [http://www.ajicjournal.org/article/S0196-6553\(17\)30633-8/abstract](http://www.ajicjournal.org/article/S0196-6553(17)30633-8/abstract) (Links to an external site.)Links to an external site.
- TIHAI Manual for Facilities: <http://hai.tufts.edu/paws/download-the-manual/>

[the-manual/](http://hai.tufts.edu/paws/download-the-manual/)

### Week 8 ENV: One Health and the Environment: Introduction to global food supply: Livestock, Diets, and Climate Change

- Clark, et al. “Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice.” (2017).<http://iopscience.iop.org/article/10.1088/1748-9326/aa6cd5/meta> (Links to an external site.)Links to an external site.
- McMichael, et al. “Food, livestock production, energy, climate change, and health.” *The lancet*370, no. 9594 (2007): 1253–1263. <http://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2807%2961256-2/abstract> (Links to an external site.)Links to an external site.

Suggested Reading:

- Rebecca Boehm, Parke E. Wilde, Michele Ver Ploeg, Christine Costello, Sean B. Cash. A Comprehensive Life Cycle Assessment of Greenhouse Gas Emissions from U.S. Household Food Choices. *Food Policy*, 2018; DOI: 1016/j.foodpol.2018.05.004 (Links to an external site.)Links to an external site.

### Week 9 ENV: One Health and the Environment: Climate Change and Nutrient Change

- Evich, Helena B. “The great nutrient collapse” Politico (2017). <https://www.politico.com/agenda/story/2017/09/13/food-nutrients-carbon-dioxide-000511> (Links to an external site.)Links to an external site.
- Myers et al. “Increasing CO2 threatens human nutrition.” *Nature* 510, no. 7503 (2014): 139–142. <https://www.nature.com/articles/nature13179> (Links to an external site.)Links to an external site.

### Week 10 Applications of One Health in Pet Food

- Heinze article: <https://theconversation.com/a-big-pawprint-the-environmental-impact-of-pet-food-74004> (Links to an external site.)Links to an external site.
- Cash, et al. Available here: CVJ Pet Food 2018.pdf

### Week 11 One Health Communication and Public Policy

- Cippola et al. “From ‘One Health’ to ‘One Communication’: The Contribution of Communication in Veterinary Medicine to Public Health.” *Vet Sci.* 2015; 2(3): 135–149. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5644635/> (Links to an external site.)Links to an external site.
- CDC What is Health Communications?; Available online:<http://www.cdc.gov/healthcommunication/healthbasics/whatishc.html> (Links to an external site.)Links to an external site..
- GAO 2010. Live Animal Imports: Agencies Need Better Collaboration to Reduce the Risk of Animal-Related Diseases, Report to the Committee on Homeland Security and Governmental Affairs, U.S. Senate. GAO 11–9.
- Wood et al. Biodiversity and disease: a synthesis of ecological perspectives on Lyme disease transmission. *Trends in Ecology and Evolution* 28(4):239–247. <https://www.ncbi.nlm.nih.gov/pubmed/23182683> (Links to an external site.)Links to an external site.

### Weeks 12–13 Celebrating One Health – presentation of class projects.



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