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Assessing College Students' Knowledge and Misconceptions Concerning the Ebola Virus

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Abstract: As we have seen from the current COVID-19 pandemic, misconceptions concerning viruses can lead to disease spread and panic. Therefore, it is imperative to determine misconceptions held concerning epidemics and pandemics. One virus that warrants study of misconceptions, albeit given limited attention in the West, is the Ebola virus. An assessment of college students' knowledge and misconceptions about the Ebola virus was created and validated using data from 203 non-science majors at a Midwestern United States university. The data were analyzed using both classical and Rasch measurement methods to make a case for the validity of the assessment and to explore students' misconceptions. The assessment was shown to be a valid and useful measure for students' knowledge and misconceptions concerning Ebola. Integrating a confidence scale into students' responses made the scale more reliable and assisted in identifying students' tenacious misconceptions. Students displayed multiple misconceptions about viruses, including confusion between the characteristics of viruses and prokaryotes. Students also displayed misconceptions about Ebola itself, including the overestimation of the number of Ebola strains and the number of patients who experience massive blood loss, misunderstandings about the incubation period, and overestimation of the mortality in comparison to other diseases like Influenza and Anthrax. This assessment can be used as a starting point in future studies to determine what misconceptions people have about Ebola and which types of educational and behavioral interventions need to be undertaken.

Keywords: *Assessment, Ebola virus, knowledge, misconceptions, validation.*

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Introduction

Emerging infectious diseases are increasing at an unprecedented rate, the vast majority of which are viruses (Howard & Fletcher, 2012). Therefore, it is imperative to evaluate students' knowledge and misconceptions concerning viruses. Previous work has focused on factual knowledge about viruses in general (Simonneaux, 2000; Jones & Rua, 2008; Byrne & Grace, 2010), or about specific viruses (DiClemente, Zorn, & Temoshok, 1986; Ramirez et al., 1997; Romine, Barrow, & Folk, 2013), but there has been a dearth of research regarding misconceptions concerning Ebola in countries outside of Africa.

Even though research on Ebola misconceptions in Africa is well underway (Catholic Relief Services [CRS], 2014; Shittu et al., 2015; Centre for Media and Strategic Communications [CMSC], 2015), there is still a need for research to be initiated in Western countries (Rolison & Hanoch, 2015; Koralek, 2016). It is crucial to understand what misconceptions students have because these can lead to unnecessary panic in some cases and disease spread in others (World Health Organization [WHO], 2014; WHO, 2015). Previous research has identified a number of misconceptions which can lead to disease spread in Africa including: infectiousness stops after the infected individual dies, people are no longer infectious when they stop having symptoms, and some folk remedies like a saltwater bath can cure people infected with Ebola (CRS, 2014; Shittu et al., 2015; CMSC, 2015). All these misconceptions can lead to increased exposure to infectious individuals and prolonged illness, contributing to disease spread.

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Literature Review

Biology of Ebola

Ebola virus disease (EVD) is caused by the Ebola virus. There are currently five strains of Ebola including Zaire, Sudan, Reston, Taï Forest, and Bundibugyo. Bats are the suspected reservoir for Ebola (Leroy et al., 2005); however, apes and other mammalian species are vulnerable to EVD and able to transmit the virus to humans (Morvan et al., 1999). Time from exposure to displaying symptoms varies from 2 to 21 days (Guenno & Galabru, 1997).

Initial symptoms include fever, malaise, myalgia, and chills (Saijo et al., 2006). This is generally followed by nausea, vomiting, headache, abdominal pain, confusion, diarrhea, coma, chest pain, shortness of breath, cough, and nasal discharge with hemorrhages occurring in less than half of people infected with EVD (Saijo et al., 2006; Fauci, 2014). Infection can only be determined by blood tests or through an autopsy (Saijo et al., 2006). No Food and Drug Administration (FDA) approved cure or vaccine existed when this assessment was created (Feldmann & Geisbert, 2011).

EVD has a high case-fatality rate with 12,182 deaths between 1976 and 2014; however, it does not kill as many as influenza with over 36,000 deaths per year in the United States (US), Human Immunodeficiency Virus (HIV)/Acquired Immunodeficiency Syndrome (AIDS) with an estimated 1.1 million deaths worldwide in 2015, or malaria with an estimated 438,000 deaths worldwide in 2015 (Romine, Barrow, & Folk, 2013; Centers for Disease Control and Prevention CDC Cases of Ebola Virus Disease in Africa, 2015; The Joint United Nations Programme on HIV/AIDS UNAIDs, 2016; WHO, 2016). The case-fatality rate of the 2014/2015 Ebola outbreak was 51% (WHO, 2014). There are several other viruses and bacteria with higher case-fatality rates than Ebola's 2014/2015 outbreak including H5N1 influenza (~60%) and inhalation anthrax (80% or more) (WHO, 2011; FDA, 2015). Middle East Respiratory Syndrome (MERS)/Severe Acute Respiratory Syndrome (SARS) has a lower case-fatality rate (10%) than Ebola's 2014/2015 case-fatality rate (40%) (Kaye & Pollack, 2014).

People at risk for contracting EVD include those who have had direct contact with bodily fluids to their nose, eye, mouth, a break in the skin, or a needle stick with blood or bodily fluids from an infected person. Therefore, the people most likely to be infected are those who live with or care for someone with EVD or people who had direct contact with the body of an individual who passed away due to Ebola without proper personal protective equipment (CDC Ebola Guidance, 2015). There are several ways to prevent the spread of Ebola including wearing surgical masks, avoiding contact with infected dead bodies, avoiding bodily fluids of an infected person, quarantining people who are suspected of being infected, and avoiding contact with host animals (Guenno & Galabru, 1997; Feldmann & Geisbert, 2011; CDC Ebola Guidance, 2015).

Misconceptions in Africa

Most papers concerning Ebola misconceptions and knowledge focus on Africa, the epicenter of the outbreak. Early studies focused on Nigeria, Sierra Leone, and Yaounde which have all experienced outbreaks of EVD (CRS, 2014; Shittu et al., 2015; CMSC, 2015). Misconceptions concerning transmission and treatment included the belief Ebola was transmitted by air or mosquito bites, it can be treated with a spiritual healer, praying, or a hot saltwater bath (CRS, 2014; Shittu et al., 2015; CMSC, 2015), and it can be cured by drinking clean water or onion and Nescafe (CMSC, 2015). Other misconceptions include Ebola is a made-up story (CMSC, 2015), created by Whites (CMSC, 2015), transmitted by articles from Europe (CMSC, 2015), and caused by supernatural phenomena including God, evildoing, witchcraft, or a curse (CRS, 2014). Another major problem found in these studies was people either lacked knowledge concerning transmission or had been advised on how to prevent the spread of Ebola but would not follow the advice (CRS, 2014; Shittu et al., 2015).

Research on misconceptions outside of Africa

Student knowledge and misconceptions concerning Ebola have been studied across the world, not just in Africa. While types of knowledge and misconceptions varied by country, some common themes did emerge. While most students had heard of EVD, they had inadequate knowledge of Ebola (Aung, 2015; Salman, 2017; Abhinitha, 2017), especially where it got its name (Ebola River), when it was discovered (1976), and which strain caused the 2014/2015 outbreak (Zaire) (Abhinitha, 2017). Some studies also found most students had a general awareness of EVD, including its existence and severity (Aung, 2015; Abdullahi, 2018). Misconceptions varied by country but included the belief certain foods could prevent or cure EVD (Salman, 2017), and misconceptions concerning transmission, with students identifying mosquitos and food/water as vectors (Koralek, 2016).

Misconceptions in the United States

Few studies focused on college students in the US. Two studies found students had heard of EVD. However, Ebola knowledge was low, and students accurately perceived their risk of infection as low (Rolison & Hanoch, 2015; Koralek et al., 2016). A study by Koralek et al. (2016) consisted of 53 items covering attitudes concerning EVD, beliefs towards the US government's association with the 2014 outbreak, EVD victim stigma, and EVD knowledge. The study by Rolison and Hanoch (2015) focused on EVD knowledge and perceptions and with an assessment consisting of 32 items. Answer

options for the Koralek et al. (2016) questions were "False," "True," and "Not sure", and a four-point Likert scale (Koralek et al., 2016). Answer choices for the Rolison and Hanoch (2015) study consisted of multiple-choice, open-ended, and 10-point Likert scales. The analysis of Koralek et al. (2016) centered on basic descriptive statistics. They found students had low levels of knowledge concerning EVD (mean score was 49%). Examples of gaps in knowledge and misinformation included only 25% of students knowing how long Ebola can remain active in semen (3 months), 34% knowing it cannot be spread through mosquitoes, and 31% were aware asymptomatic carriers on an airplane cannot transmit EVD (Koralek et al. 2016). Rolison and Hanoch (2015) found knowledge gaps concerning symptoms, such as only 37% knowing coughing was a symptom and only 13% knowing patients can develop pneumonia from EVD. Perceived personal risk of contracting Ebola was higher than HIV and malaria but lower than diabetes, common cold, and heart disease. Ebola was perceived as less serious than HIV and having a heart attack but more serious than diabetes, the common cold, and malaria.

These papers provide a foundation for possible knowledge gaps and misconceptions related to transmission, symptoms, and comparing Ebola to other viruses. However, only one mentioned statistical validity (Koralek et al. 2016). It is essential to work toward using statistically validated assessments to measure students' knowledge and misconceptions to make results more comparable. Virus and Ebola Misconceptions Assessment (VirEMiA) contained questions concerning Ebola symptoms, transmission, diagnosis, disease prevention, risk, and comparisons to other viruses and bacteria. Rasch methodologies were utilized to determine students' knowledge and misconceptions about the topics mentioned as well as the validity and reliability of VirEMiA. These analyses were used to identify misconceptions and knowledge gaps. The data were used to discuss how teachers and community health officials can address these misconceptions.

Methodology

Research Goal

In this study, an Ebola knowledge assessment was developed, validated, and used to investigate misconceptions of Midwestern US college students concerning Ebola. College students were selected since 18 to 22 is generally the age people start paying attention to the news and begin to feel civic accountability (Vincent & Basil, 1997). To initiate and facilitate future research on misconceptions about Ebola held by college-aged students, the focus of this study was on the development and validation of VirEMiA. Once validated, the assessment was then used to explore the most persistent misconceptions with these students. In this study the following research questions were addressed:

1. In what ways is VirEMiA useful in measuring college students' knowledge about Ebola?
2. How well does VirEMiA delimit misconceptions about Ebola in these students, and
3. What are the most persistent misconceptions held by these students?

Pilot Assessment

Sampling of Participants

This study was given exempt status by our Institution's Review Board (SC 6011), and informed consent was obtained from participants. The assessment was first given to a pilot group before being revised and given to the final group. Students were recruited by having professors forward the online survey link to their students.

The pilot test consisted of 27 students from a research university in the Midwestern US. Students were recruited from a freshman biology class and a microbiology class. Most students were Caucasian females (Table 1).

Table 1. Demographic information for students that took the pilot assessment

Sex	Male	8 (30%)
	Female	19 (70%)
Ethnicity	Caucasian	19 (70%)
	African American	6 (22%)
	Other	2 (7%)

Item Development

Before writing the pilot assessment, propositional knowledge statements were created based on the literature review (Table 2). These elaborate the types of understandings that students need to have about EVD. The pilot assessment consisted of twenty multiple-choice questions and twenty-one open-ended questions based on information concerning the Ebola outbreak at the time the assessment was written. Some of the multiple-choice questions had more than one correct answer and students were instructed: 'You may choose any, all, or none of the answers.' The multiple-choice questions were followed by an open-ended question prompting students to explain why they chose their answer.

Table 2. Propositional knowledge statements required for understanding the Ebola virus.

#	Propositional Knowledge Statements
1.	Ebola virus disease is caused by a virus.
2.	Viruses are produced from the assembly of pre-formed components, don't grow or undergo division, and lack the genetic information necessary for energy generation or protein synthesis.
3.	Five strains of the Ebola virus have currently been identified.
4.	Four out of the five strains of Ebola can cause EVD in humans.
5.	Ebolavirus symptoms include fever, headache, diarrhea, bleeding, and a cough.
6.	Less than half of the patients with Ebola experienced massive blood loss.
7.	Some ways to test if someone is infected with Ebolavirus include testing their blood, performing an autopsy, and testing for antibodies.
8.	You cannot tell if someone is infected with Ebola just by looking at them.
9.	As of 2015, there was no FDA approved treatment that neutralizes Ebola. However, a few treatments for Ebolavirus are undergoing evaluation for FDA approval.
10.	Ways to prevent the spread of Ebolavirus include wearing a surgical mask, avoiding contact with infected dead bodies, avoiding bodily fluids of an infected person, quarantining people suspected of being infected with Ebolavirus, avoiding contact with infected host animals, and washing hands.
11.	Ebola can spread through blood, secretions, and other bodily fluids.
12.	Ebola cannot be spread through mosquitos, air, or casual contact like touching.
13.	The length of time between exposure and symptoms is 2-21 days.
14.	The mortality rate of the 2014/2015 Ebola outbreak is estimated at around 51%.
15.	Ebola has a low survival rate.
16.	Ebola causes cell death, shock, and multi-organ failure.
17.	Humans, bats, monkeys, and apes are all able to infect humans with Ebola.
18.	People who have had direct contact with infected blood or bodily fluids to the nose, eye, mouth, break in the skin, or a needlestick are at risk of contracting Ebola.
19.	People who care for someone showing Ebola symptoms, but have not taken precautions to prevent transmission, are at risk of contracting Ebola.
20.	Touching a person or food from Africa does not carry a high risk of contracting EVD.
21.	People are contagious if their blood and secretions contain Ebola.
22.	Influenza, HIV/AIDS, and Malaria kill more people per year than Ebola.
23.	Anthrax, HIV/AIDS and H5N1 influenza have a lower survival rate than 2014/2015 Ebola.
24.	The chances of the average US citizen getting infected with Ebola is almost zero.

Incorrect multiple-choice responses were scored with a '0'. Correct responses to multiple-choice questions with one correct answer were scored with a '1'. Multiple choice questions with more than one correct answer were scored by each possible choice. For example, question nineteen "Why is Ebola so dangerous? You may choose any or all of the answers" had five possible choices as seen in the table below (Table 3). Choice "A" has a score of "0" because it is a correct statement and the participant did not select it. "C" has a score of "1" because the statement was incorrect, and the participant did not select it as a correct statement. "E" has a score of "0" because the statement is incorrect, but the participant selected it as a correct statement.

Table 3. Example of the scoring procedure used for the "choose any, all, or some of the answers" items. A response was scored "correct" if students selected a correct answer or did not select an incorrect answer. A filled-in circle indicates a student selected the answer while a blank circle indicates an unselected answer.

Option	Correct Answer	Participant Answer	Score
a. It causes cell death, shock, and multi-organ failure	●	○	0
b. There is no treatment or cure	●	●	1
c. The only way to tell if someone has it is to quarantine them and see if they hemorrhage, and if they do, it is too late to save them	○	○	1
d. It has a low survival rate (for example if 100 people get an illness and only 10 survive)	●	●	1
e. It is just a myth that Ebola is dangerous	○	●	0

Since open-ended questions were used to ensure all misconceptions had been covered, they did not receive a score. Rather, the qualitative information these questions provided were used to inform the development of the final multiple-choice questionnaire.

To reduce the effect of guessing and facilitate analysis of misconceptions, a Certainty of Response Index (CRI) was integrated into the assessment (Romine, Schaffer, & Barrow, 2015). The CRI asked students to rate their certainty in their answer on each item as: 'Complete Guess', 'Uncertain', 'Certain', and 'Very Confident'. Anytime a student answered a question correctly but indicated guessing, the 1 was recoded as a 0 since guessing signified they did not understand the concept targeted by the question.

Validity of VirEMiA

It is imperative to test validity to ensure the assessment measures what it is supposed to measure, thereby ensuring inferences drawn from the assessment are accurate and repeatable. In the scope of this study, both content and construct validity were explored. Content validity involves ensuring the items of the assessment are accurate according to scientifically accepted understandings. Construct validity involves ensuring the assessment items are useful toward quantifying knowledge along a defined scale. Content validity was established through expert review of the assessment. Construct validity, including internal consistency, was demonstrated through both classical and Rasch methodologies. VirEMiA was validated using a two-stage process within this framework.

Content Validity

The cognitive framework for VirEMiA is shown in Figure 1. Before understanding anything about Ebola, students must understand the definition of a virus. If students know what a virus is, they can then understand that Ebola is a virus. Some important information to know about any virus is the incubation period, how many strains there are, what (if any) treatments are available, symptoms, and how it is transmitted. It is important to know there are different strains of Ebola because each strain has a different mortality rate and symptom severity (Fauci, 2014). Knowing mortality rate also helps students understand how deadly Ebola is compared to many other illnesses. If students understand how Ebola is transmitted, they can understand who would be at risk of contracting the virus. When students understand how Ebola is transmitted and what the symptoms are, they can think of ways to prevent its spread. Students can think of ways to tell if someone is infected if they understand the symptoms. To understand why Ebola is considered so dangerous, students must understand the symptoms, that there is currently no FDA approved treatment, and it has a relatively high mortality rate compared to many other viruses. Trivia about Ebola such as its discovery date, where it got its name, and who discovered it, is not within the scope of VirEMiA.

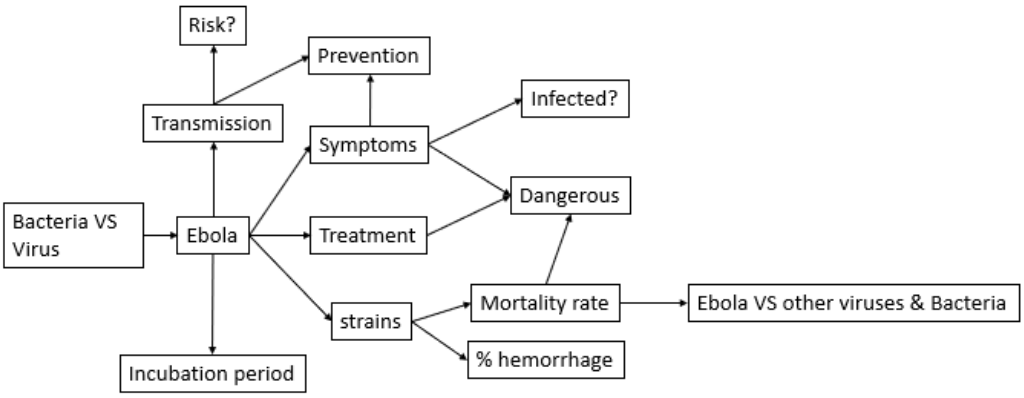

Figure 1. Cognitive framework for VirEMiA.

VirEMiA was reviewed by five experts in fields related to infectious disease: An Ebola virus researcher at the US Army Medical Research Institute of Infectious Disease, a science education researcher at a Midwestern university with a focus on infectious disease, a vaccine researcher at Battelle, and two virology professors at Midwestern US universities. After initial development of the pilot assessment, these experts reviewed the items to evaluate their alignment with scientifically accepted understandings. VirEMiA was revised based on the experts' suggestions. Based on the pilot data, VirEMiA was revised, and the final version was again sent to these experts for their approval. After integrating their suggestions into the final version (Appendix B), data were collected.

Construct validity using Rasch methods

The Rasch model quantifies the probability a person has of getting an answer correct on a test taking both the student's ability and the difficulty of the question into account (Uekawa, 2005). This method reflects the ability of the person while controlling for the difficulty of the item. The validity of this scale depends upon the conformity of items to the Rasch model, which was assessed based on mean squares fit with the model (Uekawa, 2005). Mean squares fit is the

ratio of the actual error between a student's actual responses concerning the model's predictions, and the expected error (Wilson, 2005). Items with mean squares estimates greater than 1.3 underfit the Rasch model, meaning the item favors low ability students, while items with estimates less than 0.7 overfit the data, meaning the item favors high ability students more than expected. Items with mean squares fit indices between 0.7 and 1.3 fit the Rasch model adequately and are considered productive for measurement (Bond & Fox, 2007). Infit and outfit were used to evaluate the concordance of students' responses with the model's predictions.

In addition to the fit of individual items, fit of the entire Rasch scale is also useful to explore, getting at the question of whether or not the Rasch model captures the important variation in test responses, or if there are peripheral dimensions to be considered. Principal Components Analysis (PCA) on residuals is a straightforward way to inspect this. Simulation studies suggest that a first eigenvalue around or below 2 items of variance is indicative the test can be treated as unidimensional (Linacre & Tennant, 2009).

A person-item map (Wright map) was constructed by mapping person ability and item difficulty measures on a common scale in order to understand the comparative difficulty of different ideas and the most persistent misconceptions. An item is best suited for students with an ability matching its difficulty (DeAyala, 2013), so inspection of the overlap of the item difficulty distribution with students' ability distribution is diagnostic of the usefulness of an assessment for a group of students; in our case, college students. Rasch analysis was performed using the eRM package in R (Mair & Hatzinger, 2007) and Winsteps (Linacre, 2010).

Misconception Analysis

To do the misconception analysis, a CRI was used in conjunction with each item on VirEMiA to determine if an incorrect answer was due to a lack of knowledge or a misconception (Hasan et al., 1999). Taking confidence into account is important when analyzing misconceptions since a tenacious misconception is defined as a confidently held incorrect understanding (Romine, Schaffer, & Barrow, 2015). Four degrees of certainty were used so the CRI could not only be used to change correct answers due to guessing to "incorrect," but also to determine whether a wrong answer was due to guessing or incorrect knowledge. A low degree of certainty (0 to 1) suggests guessing which means a lack of knowledge while a high degree of certainty (2 to 3) suggests a high degree of confidence in the incorrect answer. A misconception was defined as an incorrect answer with a CRI greater than two. When a student expressed a misconception on an item, this was coded with a "1" while no misconception was coded with a "0." This changed the Rasch model to express the likelihood a student had a misconception, where an item lower on the scale was more likely to reveal misconceptions than an item higher on the scale. As with the scale derived from the traditionally coded responses, the Wright map was used as a visual tool for predicting what misconceptions particular students harbored.

A distractor analysis was performed on items at the low end of the misconception scale (i.e. those which revealed misconceptions most easily) to determine the exact misconception(s) expressed within the item. The analysis was performed by calculating the percentage of students choosing each answer choice on the item of interest.

Final Assessment

The pilot questionnaire was then revised based on responses and psychometric analysis and sent to the same experts as the pilot version. After integrating their suggestions into the final version consisting of twenty-five multiple-choice items (Appendix B), data were collected.

For the final assessment, data were collected from 301 university students from two life science courses at the same university. In total 254 non-science majors and 46 science majors took the final assessment. Most students who took the final assessment were Caucasian females (Table 4).

Table 4. Demographic information for students that took the final assessment

Sex	Male	103 (34%)
	Female	198 (66%)
Ethnicity	Caucasian	221 (74%)
	African American	55 (18%)
	Other	25 (8%)

The data were scored and analyzed using the same methodology as the pilot version.

Results

Analysis of the Pilot Assessment

Most of the items had infit and outfit values between 0.7 and 1.3. However, items 10a (outfit=1.35), 13 (outfit=1.56), 15a (outfit=1.40), 19b (outfit=1.30), and 19c (outfit=1.57, infit=1.37) (Table 6; Appendix A) all had infit and/or outfit values greater than 1.3, indicating these items underfit the Rasch model and the items favored low ability students. Items 6a (outfit=0.57), 6c (outfit=0.64), 8a (outfit=0.64), 10c (outfit=0.38), and 16a (outfit=0.67) (Table 6; Appendix A) all overfit the Rasch model, indicating the items favored high-ability students more than expected. Principal component analysis on Rasch residuals indicated a first eigenvalue of 3.93 for the first component, indicating it is not a unidimensional assessment.

Based on misfit with the Rasch model, items 4, 8d, 8f, 15a, 18d, 18e, 19c, 19d, and 19e were removed. Item 4 was removed because it addressed whether viruses are living or not, which is still debated by scientists. Items 8d and 8f were removed because introductory biology students may not know what antibodies are and may not have understood what the words 'quarantine' and 'monitor' really mean. Item 15a was removed because 100% of students were expected to get it correct, and it was highly correlated with item 15c, meaning it provided little unique information. Item 19c was removed because it misfit the Rasch model and was highly correlated with 19d, meaning it provided little unique information. Items 18d, 18e, and 19e were removed since less than 25% of students got the items correct, suggesting they were inordinately difficult. The Rasch model predicted that all students were expected to get 18d (people are only contagious with a virus only when they have a fever) and 18e (people are only contagious with a virus up to two weeks after they start showing symptoms) incorrect, meaning that these items were not useful in discriminating between different levels of understanding. Items 19c (Smallpox) and 19d (Bubonic plague) were changed since students indicated not knowing much about them and saying they are no longer prevalent. Since many items were removed, Rasch analysis had to be re-run.

After eliminating the above items in the first round of analysis, the Rasch model fit of the remaining 41 items was explored. Items 5 (outfit=1.48), 13 (outfit=1.86, infit=1.34), and 19b (outfit=1.56, infit=1.44) (Appendix B) all underfit the Rasch model, indicating guessing, or items favored low ability students (Table 6). Even though item 5 now misfit the Rasch model, it was retained since people need to know there are different strains of Ebola. Item 13 was retained since the mortality of the 2014/2015 outbreak is expected to be a misconception. Item 19b was retained since it is the only incorrect answer in the set of "choose any or all" responses accompanying Item 19. Since these items are an important part of the construct, it was decided more data were needed before justifying a decision for removal.

PCA on residuals from the second Rasch analysis indicated an eigenvalue of 4.10 for the first component, indicating the assessment retained its multidimensionality. Rasch separation reliability was found to be 0.69 for students and 0.80 for items. Item reliability was still at a level indicative that locations of the items on the Rasch scale were determined with reasonable precision; this was expected to increase in the final round of data collection due to a higher number of participants.

Analysis of the Final Assessment

Rasch Analysis on the final version of VirEMiA before CRI integration

The separation reliability for person estimates before integration of the CRI was 0.73, which is sufficient for group comparisons. The separation reliability for the items was 0.98, indicating the sample size allows precise estimates of item difficulty locations along the Rasch scale. PCA on Rasch residuals revealed an eigenvalue of 2.64 for the first residual factor, indicating the revisions improved the usefulness of the test for measuring knowledge of Ebola as a single dimension.

All but three items displayed expected fit with the Rasch model before confidence was considered (Table 6). Item 24b underfit the Rasch model (outfit=1.34) while items 12c and 19e overfit the Rasch model (outfit=0.57 and 0.68, respectively) (Table 6; Appendix B). Item 24b, 'MERS/SARS has a lower survival rate than Ebola's 2014/2015 survival rate may be easier for low ability students because high ability students may remember talking about MERS/SARS in class or hearing about it on the news and thought it had a higher mortality rate than Ebola. Item 12c, 'Avoiding bodily fluids of an infected person is a means of preventing the spread of Ebola' may be unduly easy for high-ability students because they know other viruses, such as HIV and the flu, are spread through bodily fluids and assumed Ebola would be spread that way as well. Item 19e, 'It is just a myth that Ebola is dangerous' may favor high ability students because they understand the terminology used to describe Ebola (i.e. mortality rate, hemorrhaging, etc.) better than low-ability students, leading them to deduce that Ebola is dangerous.

In addition to unidimensionality, local independence is a key underlying assumption of Rasch models, stating items should be independent after accounting for the latent variable. Although this is rarely explored in Rasch studies, it is particularly pertinent to VirEMiA due to our inclusion of multiple responses within certain items (Table 2) which can lead to item-based dependency which is not captured by the student's measure. Local independence is quantified by measuring the correlation of item residuals after accounting for knowledge of Ebola. If items are truly locally

independent, then item residuals should be uncorrelated. While it is seldom the case that these extraneous dependencies between items are completely nonexistent, item residual correlations below 0.7 (indicating less than 50% shared variance) are considered to indicate reasonable conformity with the local independence assumption (Linacre, 2010). In Table 5, the highest item response residual correlation (Item 14 and 20e) was 0.61, indicating 37% shared variance between these responses which was not accounted for by students' knowledge of Ebola. There is a general trend in Table 5 that putting multiple responses within a single item does indeed introduce local dependency into VirEMiA (i.e. residual correlation of 0.51 between responses 21c and 21d), but this is sufficiently low as to not significantly affect the efficacy of the test in providing a useful measure for knowledge of Ebola (Linacre, 2010).

Table 5. Residual correlations for the final version of VirEMiA.

Residual Correl.	Items
0.61	14 and 20e
0.51	20c and 20d
0.31	5b and 5e
0.30	23c and 23d
0.28	24d and 24e
0.27	12a and 12d; 23a and 23b
0.25	12b and 12c
0.24	11 and 19b; 24c and 24e

Table 6. Rasch Item Fit and Estimates for responses with no CRI, CRI Integrated, and Misconception Data. Out of bound indices (less than 0.7 or greater than 1.3) indicated by bold font.

	Item Difficulty Measures (SE)			MSQ Outfit Measures			MSQ Infit Measures		
Item	No CRI	CRI	Misc.	No CRI	CRI	Misc.	No CRI	CRI	Misc.
1	0.12(0.13)	-0.34(0.13)	-0.58(0.15)	0.98	**1.36**	1.15	1.00	1.12	1.07
2	1.08(0.12)	0.85(0.12)	-1.48(0.13)	0.96	**1.67**	**1.55**	0.97	1.07	1.25
3	1.66(0.12)	1.33(0.13)	-0.05(0.17)	1.11	**1.79**	1.25	1.08	1.21	1.08
4	2.32(0.13)	2.38(0.15)	-1.86(0.13)	1.19	**1.32**	1.08	1.10	1.12	1.05
5a	-2.24(0.28)	-1.47(0.17)	2.31(0.41)	0.97	0.81	**0.61**	0.97	0.96	0.98
5b	-0.13(0.13)	-0.30(0.13)	0.21(0.18)	0.96	1.00	0.81	0.99	1.01	0.98
5c	-0.48(0.15)	-0.54(0.14)	0.35(0.19)	0.97	0.99	0.84	0.98	0.99	0.93
5d	-0.32(0.14)	-0.45(0.13)	0.12(0.17)	0.86	0.86	**0.69**	0.94	0.93	0.88
5e	0.74(0.12)	0.55(0.12)	-0.11(0.16)	1.11	**1.31**	0.88	1.10	1.21	0.93
6	1.76(0.12)	1.94(0.14)	-1.69(0.13)	1.09	1.07	0.99	1.07	1.03	1.02
7	-1.05(0.17)	-1.22(0.16	0.90(0.23)	1.05	1.16	**1.31**	1.01	1.12	1.07
8	-1.95(0.25)	-1.73(0.18)	1.67(0.31)	0.91	1.06	**1.61**	0.99	1.18	1.06
9	-0.42(0.14)	-0.25(0.13)	-0.03(0.17)	0.99	1.06	**1.54**	1.00	1.03	1.05
10	0.28(0.12)	0.42(0.12)	-0.66(0.14)	1.19	1.20	**1.83**	1.13	1.17	1.24
11	0.23(0.12)	0.21(0.12)	-0.58(0.15)	0.91	0.91	1.07	0.96	0.97	1.07
12a	0.12(0.13)	-0.23(0.13)	0.42(0.19)	1.03	1.07	**0.59**	0.99	1.04	0.90
12b	-0.53(0.15)	-0.93(0.15)	0.62(0.20)	0.77	0.79	**0.64**	0.88	0.87	0.86
12c	-1.72(0.23)	-1.84(0.19)	1.48(0.29)	**0.57**	**0.48**	**0.43**	0.87	0.73	0.87
12d	-0.90(0.17)	-1.10(0.15)	0.90(0.23)	0.90	0.81	**0.63**	0.92	0.84	0.90
12e	-0.48(0.15)	-0.80(0.14)	0.66(0.21)	0.74	0.74	**0.56**	0.86	0.84	0.88
12f	-1.18(0.18)	-1.42(0.17)	1.40(0.28)	0.75	0.74	**0.45**	0.90	0.85	0.86
13	-0.09(0.13)	-0.34(0.13)	0.03(0.17)	0.94	1.13	0.83	1.00	1.04	1.01
14	0.47(0.12)	0.16(0.12)	-0.26(0.16)	0.90	0.98	0.94	0.94	0.95	0.98
15	0.57(0.12)	0.28(0.12)	0.00(0.17)	1.19	1.19	1.12	1.15	1.16	1.09
16	-2.32(0.29)	-2.37(0.23)	2.31(0.41)	0.66	**0.69**	**0.34**	0.94	0.88	0.92
17	1.49(0.12)	1.17(0.12)	-1.57(0.13)	0.89	0.90	0.80	0.91	0.90	0.87
18	1.63(0.12)	1.50(0.13)	-1.82(0.13)	1.10	1.09	1.17	1.01	1.04	1.05
19a	-0.59(0.15)	-0.37(0.13)	0.35(0.19)	0.88	0.85	0.90	0.93	0.91	0.93
19b	0.39(0.12)	0.34(0.12)	-0.74(0.14)	0.94	0.88	0.93	0.97	0.95	1.01
19c	0.70(0.12)	0.75(0.12)	-0.58(0.15)	1.12	1.01	0.89	1.11	1.03	1.01
19d	0.77(0.12)	0.82(0.12)	-0.72(0.14)	1.25	1.22	**1.36**	1.19	1.23	1.16
19e	-1.95(0.25)	-0.87(0.15)	2.01(0.36)	**0.68**	**0.66**	**0.69**	0.89	0.82	0.87
20a	-0.15(0.13)	-0.10(0.13)	0.46(0.19)	0.98	0.94	0.89	1.00	0.98	1.00
20b	0.63(0.12)	0.42(0.12)	-0.86(0.14)	0.87	0.71	0.73	0.90	0.79	0.87
20c	0.83(0.12)	0.57(0.12)	-0.72(0.14)	0.87	0.82	**0.67**	0.90	0.87	0.85

Table 6. Continued

	Item Difficulty Measures (SE)			MSQ Outfit Measures			MSQ Infit Measures		
Item	**No CRI**	**CRI**	**Misc.**	**No CRI**	**CRI**	**Misc.**	**No CRI**	**CRI**	**Misc.**
20d	1.55(0.12)	1.29(0.12)	-1.05(0.14)	0.93	0.89	0.74	0.95	0.96	0.86
20e	0.47(0.12)	0.25(0.12)	-0.64(0.14)	0.88	0.78	0.77	0.92	0.85	0.92
20f	-3.04(0.41)	-1.33(0.16)	2.31(0.41)	1.06	**0.66**	0.81	0.94	0.85	0.92
21a	-1.28(0.19)	-1.36(0.17)	1.12(0.25)	0.73	0.70	0.82	0.91	0.91	0.90
21b	-0.62(0.15)	-0.87(0.15)	0.90(0.23)	0.81	0.83	**0.57**	0.88	0.89	0.94
21c	-0.59(0.15)	-0.82(0.15)	0.85(0.22)	1.14	1.15	0.82	1.04	1.07	0.98
22	1.08(0.12)	0.97(0.12)	-0.76(0.14)	1.16	**1.49**	1.00	1.13	1.24	1.09
23a	0.44(0.12)	0.16(0.12)	-0.24(0.16)	0.86	0.78	**0.67**	0.91	0.87	0.89
23b	0.81(0.12)	0.61(0.12)	-0.26(0.16)	0.94	0.90	**0.67**	0.96	0.97	0.88
23c	-0.13(0.13)	-0.37(0.13)	0.12(0.17)	0.95	0.98	0.74	0.98	1.03	0.93
23d	-2.24(0.28)	-1.47(0.17)	2.15(0.38)	0.71	**0.62**	**0.40**	0.90	0.83	0.87
24a	1.58(0.12)	1.64(0.13)	-1.96(0.13)	0.96	0.87	1.02	0.97	0.93	1.03
24b	0.50(0.12)	0.85(0.12)	-0.86(0.14)	**1.34**	1.29	**1.58**	1.24	1.18	1.30
24c	1.55(0.12)	1.74(0.13)	-1.74(0.13)	1.09	1.12	1.16	1.05	1.04	1.15
24d	1.22(0.12)	1.33(0.13)	-1.56(0.13)	1.03	1.04	0.97	1.02	0.99	1.04
24e	-1.32(0.19)	-0.02(0.13)	1.01(0.24)	1.02	0.92	0.90	0.98	0.97	1.01
25	0.73(0.12)	0.37(0.12)	-1.22(0.13)	0.90	0.88	0.79	0.92	0.93	0.88

Rasch Analysis with CRI Integrated

The item separation reliability for the Rasch model with the CRI integrated was 0.98, while the person separation reliability increased to 0.92 (from 0.73 without the CRI). This indicates integration of the CRI drastically improved the precision of students' measures. While test reliability increased, PCA on residuals yielded a first eigenvalue of 3.13, indicating integrating confidence added some multidimensionality to the scale. The correlation between item measures calculated with and without the CRI was 0.94, corresponding to an adjusted r^2 of 0.88, meaning the functioning of items was consistent whether or not the CRI was integrated.

Most items fit the Rasch model with the CRI integrated, but misfit increased somewhat (Table 6). Items 1, 2, 3, 4, 5e, and 22 all fit the Rasch model with the traditionally coded data (no CRI) but underfit the model when CRI was integrated, indicating the integration of confidence tends to bias the item against high ability students. This shift in bias indicates the tendency for the lower-ability students to express more confidence in their responses to these items. Items 12c and 19e overfit the Rasch model both with traditional coding and with the CRI integrated, indicating the wording of the items may favor high ability students and/or high-ability students have more confidence in their answers. Items 16, 20f, and 23d all had expected fit with the Rasch model with traditionally coded data but overfit the Rasch model with the CRI integrated. This shift in bias results from high-ability students having more confidence in their correct answers than the low-ability students. In sum, these items required students to know the definition of a virus, how many strains of Ebola there are, how long people are contagious, information about Ebola transmission (i.e. spread through bodily fluids; how to prevent transmission; suspected reservoirs), and the mortality rates of viruses. Unless a student has taken a class discussing the morbidity of various viruses or discussing viruses to any extent, it may not be surprising that lower-ability students would not be as confident in their answers. The students most likely to have learned about viruses in the past are science majors, who would have a higher ability to answer items correctly since they know more about not just viruses, but also health and disease in general. Finally, item 24b underfit the Rasch model when traditionally coded but fit the Rasch model with CRI integrated, indicating the validity of this item is reduced by guessing, which was corrected when confidence was integrated.

Based on the Wright map, all item measures fell within the ability range of the students, meaning there were no items all students were expected to get correct or miss (Figure 2). Item difficulty increases as one moves up the scale. Therefore, item 16 (Ebola is confirmed to be transmitted through blood, secretions, and other bodily fluids) is the easiest item while item 4 (How many strains of Ebola have currently been identified?) is the most difficult.

Rasch analysis of misconceptions

Most items fit the Rasch model (Table 6) after the CRI was integrated to generate an affirmative score when a student displayed a misconception (incorrect answer plus a CRI greater than 2). Items 2, 7, 8, 9, 10, 19d, and 24b all underfit concerning the Rasch misconceptions scale. Items 5a, 5d, 12a, 12b, 12c, 12d, 12e, 12f, 16, 19e, 20c, 21b, 23a, 23b, and 23d were overfitting. The separation reliability for the items was 0.97 and the reliability for the person misconception estimates was 0.86. This indicates item and student measures were estimated precisely along the scale. It is important to restate that in this analysis, students higher on the scale have a greater tendency to display misconceptions, while items lower on the scale have a greater tendency to reveal students' misconceptions.

Based on the Wright map (Figure 2), students had the greatest tendency to display misconceptions on items 2, 4, 6, 17, 18, 24a, 24c, and 24d. The first misconception (item 2) had to do with the definition of a virus. Most of the students understood 'Virus' is the correct answer for item 2 '_____ are produced from the assembly of pre-formed components, don't grow or undergo division, and lack the genetic information necessary for energy generation or protein synthesis'. However, 22% of the students had the misconception the correct answer was 'Prokaryote'. Item 4 addressed Ebola transmission. Forty percent of the students had the misconception that there are about five strains of Ebola, only one of which can cause Ebola disease in people, when in fact four of the five can cause disease in people.

Items 6, 17, and 18 all addressed symptoms. A common misconception (38% of students) was that about 20% of patients experience massive blood loss when in reality it is about 50%. Forty-three percent of students also had the misconception the average length of time between exposure to Ebola and appearance of symptoms is 2-10 days when in fact it is 2-21 days. A quarter of students had the misconception the mortality rate of the 2014/2015 Ebola outbreak was 73% when the actual mortality rate has been 51%. The last two misconceptions pertained to comparison of Ebola with other viruses. Students had the misconception that Ebola has a lower mortality rate than H5N1 influenza (61%) and anthrax (>80%).

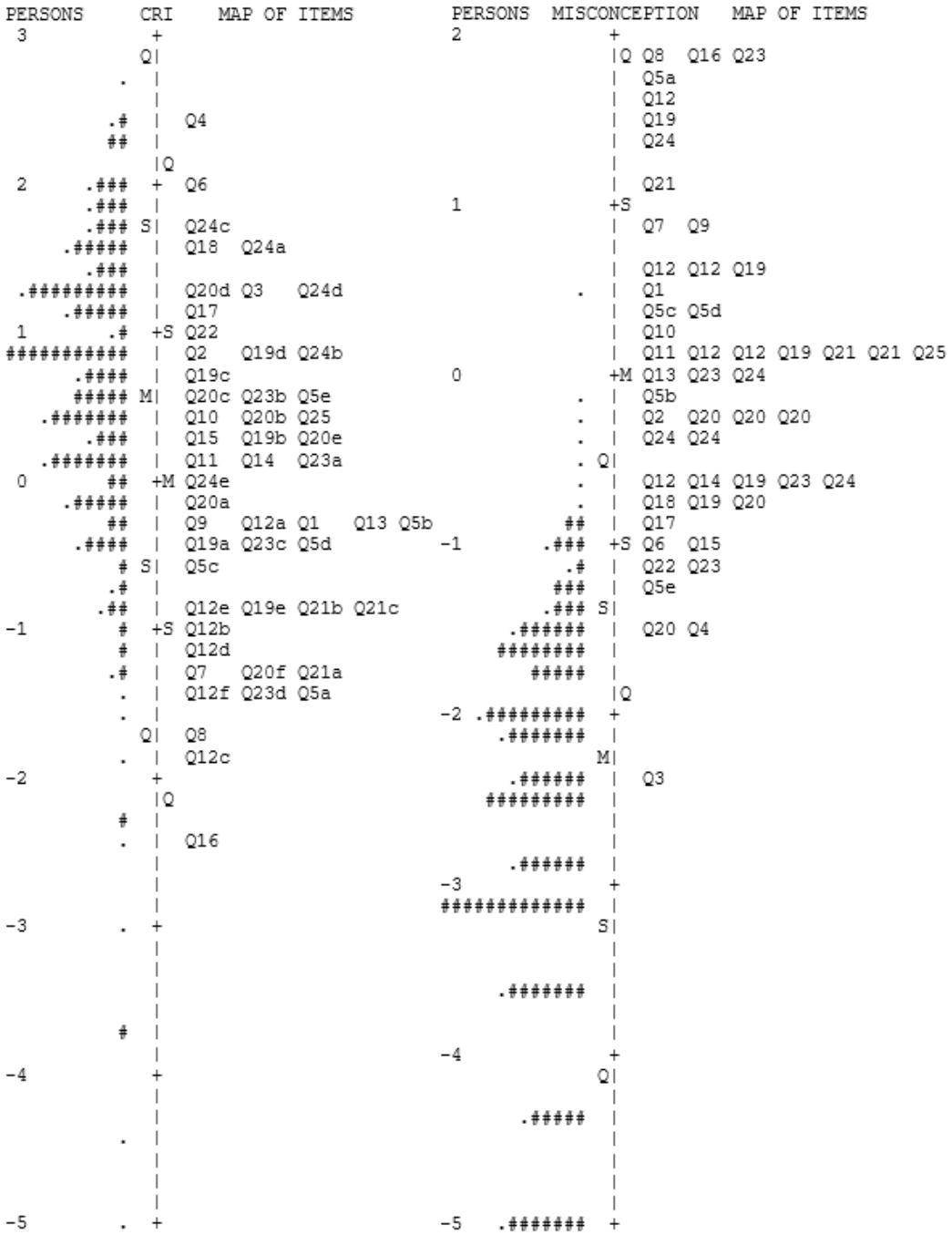

Figure 2. Wright map of student's ability and item difficulty with CRI integrated (left) and Wright map of students' misconceptions (right).

Discussion

Using VirEMiA, several misconceptions about Ebola and one about the definition of a virus were identified. While this assessment focused on Ebola, the misconceptions found can be applied to numerous viruses. The first misconception found was there is only one strain of Ebola that can cause EVD in humans when in fact there are four (Item 4). The most likely reason for this misconception is whenever Ebola is mentioned, it was just called Ebola, and not by the strain of Ebola that was causing the outbreak. This leads people to believe there is only one infectious strain. Many people know there are different strains of the flu because it is discussed every year in the context of the flu vaccine and major outbreaks. However, different strains of other viruses are seldom mentioned, which may cause people to believe there is only one strain of most viruses. This is problematic given many viruses have different strains and these strains can have various symptoms, mortality rates, and virulence (Tscherne & Garcia-Sastre, 2011). The best way to mitigate this misconception is for classroom instructors to mention the strains with the viruses just like they do with major flu outbreaks like H5N1 Avian Flu or H1N1 Swine Flu.

The fact students had a misconception about how many patients experience massive blood loss was not surprising since movies and television shows about viruses dramatically show patients hemorrhaging (Item 6) (Peterson, 1995; Soderbergh, 2011; Plec, 2016). What was surprising was the misconception was 'about 20% of patients experience massive blood loss,' indicating many students knew massive blood loss did not happen in all cases of EVD. When the assessment was designed, the students were expected to overestimate how many of those infected experience massive blood loss. It is currently unclear why students underestimated the percent of patients experiencing massive blood loss and should be further explored in the future. By under-estimating how many patients hemorrhage, people may not be as fearful of hemorrhagic viruses as they should which may lead them to not take all the necessary precautions which could lead to disease spread.

While the average US student may not need to worry about Ebola, students volunteering to help with the crisis or those traveling to Africa for other reasons do need to be aware. Someone could easily travel to a Western country and spread the virus. To illustrate how close to home Ebola can sit, many are not aware that the Reston virus was discovered in Reston, Virginia. While this virus did not infect humans, this could mutate into another strain which could jump from apes that are pets or kept at zoos to humans in Western countries. Therefore, proper understanding and vigilance is crucial regardless of where someone lives. The best way to mitigate this underestimation of symptom severity is to mention the percent of patients experiencing massive blood loss during a viral hemorrhagic fever outbreak, the mortality rate, and that these vary due to factors like the strain of the virus, preventative measures, availability of treatments for those infected, and availability of a vaccine to prevent future outbreaks.

The next misconception involved the average length of time for the incubation period, with most students choosing 2 to 10 days. This is within the correct range but not as long as the actual incubation time of 2 to 21 days (Item 17). Underestimation of Ebola's incubation period is a dangerous misconception because people may not take proper precautions to prevent spread when one is not showing symptoms, causing the virus to spread even more. Therefore, it is crucial teachers work to address this misconception in the future to help mitigate spread through behavioral means. The best way to address this misconception is to talk explicitly about the 2 to 21-day incubation period and the implications this has regarding the spread of viruses including Ebola. A reason for this misconception may be due to the fact the most common viruses are the flu which has an incubation period of one to four days (CDC, 2009), and the common cold which has an incubation period of 7 to 10 days (CDC, 2016). It is natural that without additional information, students would infer Ebola to be similar.

Thirty-five percent of the students knew the mortality rate of the 2014/2015 Ebola outbreak was about 51%; however, 37% of students thought the mortality rate was higher (Item 18). There are two main reasons students may have a misconception about the mortality rate of Ebola. The first is the mortality rates of the different strains vary widely, from 25 to 90% (WHO, 2014). The second reason is the reports on mortality rates fluctuate slightly while cases are being validated and new cases are being found. The best way to address this misconception is to discuss that mortality rate can be different for each outbreak, even if it is the same strain of virus, and that the reported mortality rate may fluctuate as the disease progresses or more cases are found. Mortality rate will also change based on availability of medical facilities to assist those who are infected. The current COVID-19 pandemic provides an illustrative example of mortality rates from the same infection can differ across the world (Onder et al., 2020). Misconceptions on mortality rate can either cause undue panic if the mortality rate is overestimated, or cause people to not be as concerned as they should if it is underestimated. If people are not as concerned as they should be, they may not follow all prevention advice, leading to disease spread. Misconceptions about mortality and transmission could also lead to discrimination against friends and family of someone with Ebola or health workers who have worked in Ebola-prone areas. One example of this occurred in Texas where a bridal shop had to close due to an Ebola-infected nurse visiting (Cardona, 2016). Across the Atlantic, a nurse in the United Kingdom almost faced criminal charges for concealing a fever (British Broadcasting Corporation, 2016). A way for teachers to start a discussion on stigmas against people possibly infected with Ebola is to play a Saturday Night Live (SNL) skit titled "The Fault in Our Stars 2". This skit pokes fun at our fearful reaction to those infected with Ebola by showing a teen trying to find love after being diagnosed with Ebola (SNL,

2014). This video is a lighthearted way to start a serious discussion on what stigmas students have concerning Ebola and why those stigmas are problematic.

A related misconception was certain viral and bacterial infections had a lower survival rate than Ebola, with students believing that influenza (H5N1) and anthrax both had higher survival rates (Item 24). Studies have shown people do not consider the flu to be deadly even though the annual death toll from the flu in the US is in the tens of thousands, which is tens of thousands of times higher than the death toll in the US due to Ebola (Hollmeyer et al., 2009; Virseda et al., 2010). Students may believe anthrax has a lower mortality rate than Ebola because most of the discussion around anthrax centers around terrorism. The best way to address these misconceptions is for teachers to simply compare the mortality rate of Ebola to these viruses during discussions of risks and preventative strategies for infectious diseases.

Suggestions for Future Research

While college students were targeted in this study, it would be interesting and important to target the general public to see what misconceptions persist. To do such a study, a researcher would need to assess many people across the country using a stratified sampling technique of gender, ethnicity, and age group to ensure representativeness. Once the data were collected, the researcher would re-quantify the reliability and validity of the assessment and compare measures across groups.

Future research should also explore the extent to which people in other developed countries have the same misconceptions people in the US have. The researchers would expect that many misconceptions would be the same between the US and Western Europe, for example, but there may also be some important cross-cultural differences. This may be especially true when comparing areas that are differentially impacted by Ebola. For example, prior studies in Africa indicate greater prevalence of misconceptions originating from superstition or folk medicine. On the other hand, misunderstandings about symptoms and transmission, and fear and panic associated with these misunderstandings, are likely to persist across cultures.

Limitations

This study has some limitations readers should consider before using our assessment. First, our target population was Midwestern college students, most of whom may never be at a significant risk of contracting EVD. The assessment, on the other hand, was based off of available research on misconceptions about EVD, most of which targeted developing countries (CRS, 2014; Shittu et al., 2015; CMSC, 2015). It is likely that this assessment could be useful in research contexts positioned more closely to the epicenters for EVD providing that cultural validity is considered. For example, if VirEMiA were used in Africa, differential item functioning (DIF) techniques should be used to investigate the effect of cultural context on item difficulty and fit with the Rasch model. This would be especially important when looking at misconceptions since those expressed by students in Africa would likely be different than the most persistent misconceptions expressed in the US or Europe. One may also consider including additional items on the assessment that address misconceptions unique to the cultural context; in particular those involving supernatural explanations for EVD and uses of folk medicine for its treatment.

Conclusion

During the 2014/2015 Ebola outbreak, there was a lot of unnecessary fear and panic about Ebola here in the US and other countries (British Broadcasting Corporation, 2016; Boseley, 2016; Cardona, 2016). However, the need to reduce panic should not result in reduction of vigilance; indeed, Ebola could mutate or leap across continents at any time (Boseley, 2016; Cardona, 2016) through a similar process that has happened with the coronavirus, which has caused the current COVID-19 pandemic (Onder et al., 2020). This assessment can be used as a starting point in future studies to determine what misconceptions people have about Ebola and which types of educational and behavioral interventions need to be undertaken; for example, making efforts to mitigate the fear and panic during the current outbreak as detailed above. Many of the misconceptions can apply to other viruses such as influenza or the coronavirus. If the misconceptions about Ebola had been better addressed, nurses and doctors that cared for Ebola patients may not have experienced all the discrimination they had faced, and still do face, and the bridal shop in Texas may still be open. During Ebola outbreaks, and even the current COVID-19 outbreak, practitioners should use VirEMiA, or an adaptation of it, from the start to determine misconceptions held by the public and immediately start addressing those issues through the news and social media to prevent the backlash similar to the 2014/2015 outbreak from happening again.

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Appendix A

Pilot Virus and Ebola Misconceptions Assessment (VirEMiA)

Sex: M/F Ethnicity: _____ Major: _____

Please select the answer choice you think is the best answer to the question. For some questions, more than one answer may be correct. Following each multiple-choice question, there will be a follow-up question that will require a short written response. For each answer selected, click one of the confidence level choices based on how confident you feel the answer you selected is correct:

1) What causes Ebola disease?
   a) Bacteria
   b) Prokaryote
   c) Virus
   d) Eukaryote
   e) Bacteriophage
   f) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

2) _____ are produced from the assembly of pre-formed components, don't grow or undergo division, and lack the genetic information necessary for energy generation or protein synthesis.
   a) Bacteria
   b) Prokaryote
   c) Virus
   d) Eukaryote
   e) Bacteriophage
   f) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

3) _____ are living single celled organisms that contain no nucleus or membrane bound organelles, typically have circular DNA, and can be beneficial or harmful to people.
   a) Bacteria
   b) Prokaryote
   c) Virus
   d) Eukaryote
   e) Bacteriophage
   f) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

4) Is a virus alive?
   a) No, it is never alive
   b) Yes, it is alive
   c) It is alive inside a cell but non-living outside a cell
   d) It is alive outside a cell but non-living inside a cell
   e) Other

CRI:

   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

5) How many strains of Ebola are there?
   a) 1
   b) 2
   c) 3
   d) 4
   e) 5

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

What is/are the name(s) of the strain(s)?

6) Which of the following is/are symptom(s) of Ebola? You may choose any or all of the answers.
   a) Fever
   b) Headache
   c) Diarrhea
   d) Bleeding
   e) Cough

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

If you know any other symptoms of Ebola, please list them here.

7) How many Ebola patients bleed out?
   a) All patients, even those that live
   b) All patients that die
   c) About 90% of patients
   d) Less than half of the patients
   e) None, this is just a myth

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

8) Which of the following is a way to tell if someone is infected with Ebola? You may choose any or all of the answers.
   a) By looking at them
   b) Testing their blood
   c) Autopsy
   d) Quarantine and monitor
   e) **Test for antibodies**
   f) All are ways to tell if someone is infected with Ebola.

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

9) At this time, is there a medically proven and FDA approved treatment that neutralizes Ebola?
   a) Yes, there is a vaccine
   b) Yes, there are small molecule drug therapies
   c) Yes there are antibiotics
   d) No, there are no FDA approved treatments, but there are a few treatments undergoing evaluation
   e) No, there are no FDA approved treatments or treatments undergoing evaluation

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

Please list any vaccines or treatments you have heard of and if possible, briefly describe what you know about how they work. If you have heard of a vaccine or treatment but don't know how it works, please still list it.

10) Which of the following is a means of preventing the spread of Ebola? You may choose any or all of the answers.
a) Wearing surgical masks
b) Avoiding contact with infected dead bodies
c) Avoiding bodily fluids of an infected person
d) Quarantining people who are suspected of being infected
e) **Avoiding contact with infected host animals**

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

List any other means of preventing the spread of Ebola.

11) Which of the following is/are a confirmed way Ebola is transmitted? You may choose any or all of the answers.
a) Through the air
b) From a mosquito bite
c) Through casual contact like shaking hands with someone who is infected
d) Through blood, secretions, and other bodily fluids
e) Other _____

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

Briefly explain why you chose that answer.

12) What is the average length of time between exposure to Ebola and when symptoms first appear (incubation period)?
a) 2-10 days
b) 1 month
c) 6 months
d) 1 year
e) 2-21 days

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

Based on your answer, how long would you recommend someone suspected of having Ebola be quarantined and why?

13) What is the mortality rate of the 2014/2015 Ebola outbreak?
a) 100%
b) 51%
c) 87%
d) 74%
e) 92%

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

Briefly explain why you chose that answer.

14) Why is Ebola so dangerous? You may choose any or all of the answers.
   a) It disables the immune system
   b) There is no treatment or cure
   c) The only way to tell if someone has it is to quarantine them and see if they hemorrhage, and if they do, it is too late to save them
   d) It has a high case/fatality rate
   e) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

15) Which of the following is a suspected host or reservoir for Ebola? You may choose any or all of the answers.
   a) Humans
   b) Bats
   c) Monkeys
   d) Apes
   e) Mosquitos
   f) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

16) Who is at risk of contracting Ebola? You may choose any or all of the answers.
   a) People who have had direct contact with blood or bodily fluids from someone with symptoms through splashes to nose, eye, mouth, break in the skin, or a needlestick
   b) People who care for someone showing Ebola symptoms, but have not taken precautions to prevent transmission
   c) Anyone who comes into contact with a person or food from an African country
   d) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

17) How long are people contagious with a virus?
   a) As long as they are showing symptoms
   b) As long as their blood and secretions contain the virus
   c) The rest of their life
   d) Only when they have a fever
   e) Up to two weeks after they start showing symptoms
   f) Other _____

CRI:
   a) Complete Guess
   b) Uncertain
   c) Certain
   d) Very confident

Briefly explain why you chose that answer.

18) Which kills more people on average per year than Ebola? You may choose any or all of the answers.
   a) Influenza (all strains together)
   b) HIV/AIDS
   c) Malaria
   d) Dengue
   e) Rabies

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident
Briefly explain why you chose that answer.

19) Which has a higher case/fatality rate than Ebola's 2014/2015 case/fatality rate? You may choose any, all, or none of the answers.
a) Influenza (H5N1)
b) MERS/SARS
c) Smallpox
d) Bubonic plague
e) Rabies

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident
Briefly explain why you chose that answer.

20) What are the chances of the average US citizen getting infected with Ebola?
a) Very High (80-100%)
b) High (50-79%)
c) Low (20-49%)
d) Very Low (5-19%)
e) Almost zero (0-4.9%)
CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident
Briefly explain why you chose that answer.

20) Is there anything else you know about Ebola that wasn't covered in the above questions?

Appendix B

Final Virus and Ebola Misconceptions Assessment (VirEMiA)

Sex: M/F Ethnicity: _____ Major: _____

Please select the answer choice you think is the best answer to the question. For some questions, more than one answer may be correct. For each answer selected, click one of the confidence level choices based on how confident you feel the answer you selected is correct:

1) What causes Ebola disease?
a) Bacteria
b) Prokaryote
c) Virus
d) Eukaryote
e) Bacteriophage

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

2) _____ are produced from the assembly of pre-formed components, don't grow or undergo division, and lack the genetic information necessary for energy generation or protein synthesis.
a) Bacteria
b) Prokaryote
c) Virus
d) Eukaryote

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

3) _____ are living single celled organisms that contain no nucleus or membrane bound organelles, typically have circular DNA, and can be beneficial or harmful to people.

a) Bacteria
b) Prokaryote
c) Virus
d) Eukaryote

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

4) How many strains of Ebola have currently been identified?

a) There is only one strain of Ebola
b) There are about five strains of Ebola, all of which can cause Ebola disease in people
c) There are about five strains of Ebola, most of which can cause Ebola disease in people
d) There are about five strains of Ebola, one of which can cause Ebola disease in people

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

5) Which of the following is/are symptom(s) of Ebola? You may choose any or all of the answers.

a) Fever
b) Headache
c) Diarrhea
d) Bleeding
e) Cough

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

6) How many Ebola patients experience massive blood loss?

a) All patients, even those that live
b) All patients that die
c) About 50% of patients
d) About 20% of patients
e) None, this is just a myth

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

7) You can tell if someone is infected with Ebola by looking at them.

a) True
b) False

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

8) You can tell if someone is infected with Ebola by testing their blood.

a) True
b) False

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

9) You can tell if someone was infected with Ebola by performing an autopsy.
a) True
b) False

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

10) You can tell if someone has been infected with Ebola by testing for antibodies.
a) True
b) False

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

11) At this time, is there a medically proven and FDA approved treatment that neutralizes Ebola?
a) Yes, there is a vaccine
b) Yes, there are small molecule drug therapies
c) Yes, there are antibiotics
d) No, there are no FDA approved treatments, but there are a few treatments undergoing evaluation
e) No, there are no FDA approved treatments or treatments undergoing evaluation

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

12) Which of the following is a means of preventing the spread of Ebola? You may choose any or all of the answers.
a) Wearing surgical masks
b) Avoiding contact with infected dead bodies
c) Avoiding bodily fluids of an infected person
d) Quarantining people who are suspected of being infected
e) **Avoiding contact with infected host animals**
f) **Washing Hands**

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

13) Ebola is confirmed to be transmitted through the air.
a) True
b) False

CRI:

a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

14) Ebola is confirmed to be transmitted from a mosquito bite.
a) True
b) False

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

15) Ebola is confirmed to be transmitted through casual contact like shaking hands with someone who is infected.
a) True
b) False

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

16) Ebola is confirmed to be transmitted through blood, secretions, and other bodily fluids.
a) True
b) False

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

17) What is the average length of time between exposure to Ebola and when symptoms first appear (incubation period)?
a) 2-10 days
b) 1 month
c) 6 months
d) 12-48 hours
e) 2-21 days

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

18) What is the mortality rate of the 2014/2015 Ebola outbreak?
a) 94%
b) 73%
c) 51%
d) 21%
e) 2%

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

19) Why is Ebola so dangerous? You may choose any or all of the answers.
a) It causes cell death, shock, and multi-organ failure
b) There is no treatment or cure
c) The only way to tell if someone has it is to quarantine them and see if they hemorrhage, and if they do, it is too late to save them
d) It has a low survival rate
e) It is just a myth that Ebola is dangerous

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

20) Which of the following are suspected of being able to infect humans with Ebola? You may choose any or all of the answers.
a) Humans
b) Bats
c) Monkeys
d) Apes
e) Mosquitos
f) None of the above

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

21) Who has a high risk of contracting Ebola? You may choose any or all of the answers.
a) People who have had direct contact with blood or bodily fluids from someone with symptoms through splashes to nose, eye, mouth, break in the skin, or a needlestick
b) People who care for someone showing Ebola symptoms, but have not taken precautions to prevent transmission
c) Anyone who comes into contact with a person or food from an African country

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

22) How long are people contagious with a virus?
a) As long as they are showing symptoms
b) As long as their blood and secretions contain the virus
c) The rest of their life
d) Only when they have a fever
e) Up to two weeks after they start showing symptoms

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

23) Which kills more people on average per year than Ebola? You may choose any or all of the answers.
a) Influenza (all strains together)
b) HIV/AIDS
c) Malaria
d) None of the above

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

24) Which has a lower survival rate than Ebola's 2014/2015 survival rate? You may choose any, all, or none of the answers.
a) Influenza (H5N1)
b) MERS/SARS
c) Anthrax
d) HIV/AIDS
e) None of the above

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident

45) What are the chances of the average US citizen getting infected with Ebola?
a) Very High (80-100%)
b) High (50-79%)
c) Low (20-49%)
d) Very Low (5-19%)
e) Almost zero (0-4.9%)

CRI:
a) Complete Guess
b) Uncertain
c) Certain
d) Very confident