What do College Undergraduates Know about Zika and What Precautions Are They Willing to Take to Prevent its Spread?

Michele E. Miller[1], William L. Romine[1], Megan A. Rúa[1],
[1]Environmental Sciences Program, Dept. Of Biological Sciences, Wright State University, 3640 Colonel Glenn Hwy, Dayton OH 45435

Abstract – *We describe the development and validation of a Zika knowledge assessment and a survey for measuring precautions about Zika. We use these to explore conceptions Midwest United States college undergraduates have concerning Zika, compliance with precautions to prevent Zika, how likely college undergraduates are to take different precautions, and analysis of sentiments about Zika prevention. We found that the median undergraduate is likely to comply with all precautions except using an insect fogger and avoiding casual contact. Specific sentiments tended to accompany different levels of compliance. For example, undergraduates with high compliance expressed concerns rooted in fear and morality.*

Keywords: Zika mitigation, health informatics, quantitative analysis, knowledge, misconceptions

Regular Research Paper

1 Introduction

There are currently no self-report assessments for determining what conceptions university undergraduates have about Zika or the likelihood of taking precautions against Zika. Since Zika's R_0 value (the number of new cases one case generates over its infectious period) for different countries ranges from 2.0-6.6 [1], it is essential to understand compliance with precautions in an effort to mitigate the spread of Zika. This is especially important in university settings where crowded conditions prevail in all countries. The purpose of this study was to develop and validate two instruments, the "Zika Knowledge Assessment" (ZiKA) [15] and the "Zika Prevention Survey" (ZiPS) [15], and use these to explore three questions: 1) what conceptions do college undergraduates have concerning Zika; 2) how likely are college undergraduates to take precautions to prevent the spread of Zika; and 3) what sentiments about Zika prevention accompany different levels of compliance?

2 Literature Review

2.1 Zika

Death due to Zika is rare and infection is often asymptomatic [2]. When people do have symptoms, they typically last a few days to a week and are mild. However, two serious conditions, Guillain-Barre syndrome and microcephaly, have been linked to Zika. The Zika virus is spread through vectors but can also be transmitted through contact with human fluids. The mosquito species that spread Zika, *Aedes aegypti* and *Aedes albopictus*, most aggressively bite during the daytime, but can also bite at night. Those most at risk of getting Zika include people that perform sexual acts with people that have Zika, fetuses of infected mothers, and people that live in or travel to an area with current Zika transmission who have been bitten by a mosquito. There is currently no medicine or vaccine to prevent or treat Zika. However, transmission can be prevented by abstaining from sexual activity or using protection, wearing long-sleeved shirts and long pants, staying in places with air conditioning, staying in places that have door and window screens, using an insect fogger, sleeping under a mosquito net, and using insect repellants.

2.2 Related Work

Public conceptions of Zika have been explored through supervised machine learning, survey, and topic modeling methodologies. Dredze, Broniatowski, and Hilyard [3] explored misconceptions about the Zika virus vaccine using Twitter. They identified tweets making pseudo-scientific, erroneous claims including that a mosquito larvicide, pyriproxyfen, is responsible for microcephaly even though scientists have found no link between microcephaly and larvicide. The second erroneous theory is that microcephaly is caused by side effects of existing vaccines, and by blaming Zika, pharmaceutical companies profit by having the opportunity to create new vaccines to sell. Another study [4] used a self-report survey methodology to measure the level of knowledge on symptoms, epidemiology and transmission of Zika in Colombia before and after a symposium on Zika in June-

July 2015. Knowledge improved significantly after the symposium. A study by Glowacki et al. [5] collected tweets during a live discussion about Zika on Twitter hosted by the CDC. Using topic modeling, they found some prevalent themes included symptoms, sexual transmission, consequences for infants and pregnant women, spread, and virology of Zika. A study by Miller *et al*. [13] used a combination of natural language processing and machine learning techniques to determine what people were tweeting about Zika. Tweets in each disease category (treatment, transmission, prevention, and symptoms) were then examined using latent Dirichlet allocation (LDA) to determine the five main tweet topics for each disease characteristic. The five topics for prevention were Zika control, money need, Zika prevention, legislative bill, and research. Vectors (mosquitoes), sexual transmission, infants, spread, and sports were the topics for transmission. Treatment topics were lack of treatment, Zika testing, vaccine development, blood testing, and lab test development. Finally, the five topics for symptoms were Zika symptoms, brain defects, confirmed defects, Zika is scarier than thought, and reports of Zika emergence and mortality. Finally, a study by Muppalla *et al*. [14] used text-based features, extracted with N-grams and Parts of Speech taggers, to build a better classifier to detect Zika related tweets from Twitter. They found that a simple logistic classifier was able to detect Zika tweets with 92% accuracy. Our assessment includes questions covering these topics to ascertain what misconceptions university undergraduates may have concerning these topics as well as compliance with precautions.

3 Experiments and Analysis

3.1 Study Context

One hundred fifty-eight undergraduates in a general education college biology class in the Midwestern United States participated in the study. Of those, 23% were male. Sixteen percent of the undergraduates were enrolled in STEM majors.

3.2 The Rasch Validity Model

The Rasch model was used to provide a philosophical framework for validity of the items on both the ZiKA and ZiPS assessments. The Rasch model proposes that the likelihood of an undergraduate answering an item in the affirmative should be proportional only to the difference between the undergraduate's and item's locations on the latent scale. Like many latent variable models, Rasch models assume that all of the variables measure a single latent dimension, and that the items are independent after accounting for that latent dimension. Validity of items for measuring the constructs of knowledge about Zika and precautions against Zika was evaluated based on mean squares fit with the Rasch model. We used infit, which is information-weighted to reduce the influence of outliers, and outfit, which is more outlier-sensitive. Expected values for these measures is 1.00. With respect to validity, we were primarily concerned with items with mean squares fit values above 1.30; such misfit indicates that the item favors undergraduates lower on the latent scale, implying a potential validity concern [6]. Precision of undergraduate and item locations along the latent scale was quantified with the Rasch reliability index, which ranges between 0 (no precision) and 1 (perfect precision).

3.3 The Zika Knowledge Assessment (ZiKA)

Analysis of ZiKA focused on fourteen multiple choice items along with their Certainty of Response (CRI) values. Four degrees of certainty were used in this assessment: "Complete Guess" was coded as 0, "Uncertain" was coded as 1, "Certain" was coded as 2, and "Very Confident" was coded as 3. A correct answer was diagnosed when an undergraduate made a correct answer selection and indicated a degree of confidence above guessing on the item [7]. An incorrect answer was coded as "0". If a person got an answer correct but the CRI indicated guessing, the score was changed from a "1" to a "0" since guessing indicates that they do not actually know this information. Coded answers were then analyzed using the Rasch model.

3.4 The Zika Prevention Survey (ZiPS)

The analysis of ZiPS focused on compliance with nine precautions (Table 1). Undergraduate self-reports were gathered using a Likert survey methodology (Table 1). An open-ended question asking undergraduates to explain reasons for compliance or non-compliance was also included.

Undergraduate reports were coded as follows: extremely unlikely=0, unlikely=1, likely=2, and extremely likely=3. The Rasch Rating Scale model (RSM) was used to model compliance with Zika prevention and difficulty of precautions on a common latent scale (in log-odds, or "logit," units). The RSM was used to provide validity and reliability evidence for the assessment as well as to generate a model that is useful toward predicting the extent of college undergraduates' compliance with precautions against Zika (Figure 2). Using qualitative open response data, we explored how undergraduates' sentiments on Zika prevention related to their compliance levels.

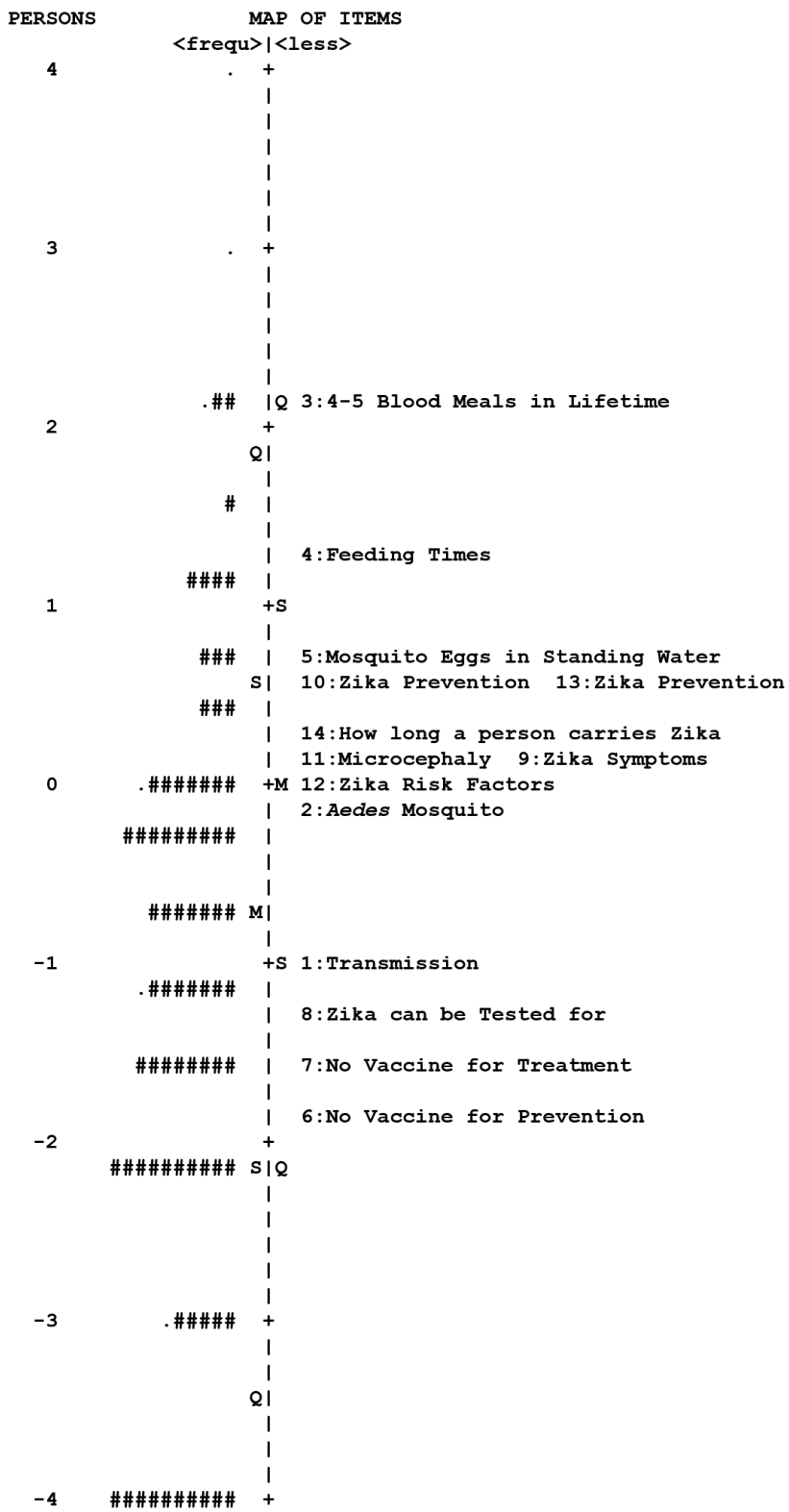

Figure 1: Person-item map for concepts about Zika tested in the ZiKA assessment. Undergraduates (denoted by "#") located above the item are predicted to have mastered the associated concept; those located below the item have not mastered the associated concept.

3.5 ZiKA Validity

Accuracy and precision were of primary concern when validating both ZiKA and ZiPS. For ZiKA, accuracy was checked by having a virology expert and a science education researcher evaluate the assessment for correct content. Items which both experts agreed were accurate and important with respect to prevention of Zika were retained for data collection and analysis. Rasch analysis indicated that all items fit well with validity expectations ($0.77<MNSQ<1.25$). We obtained an item separation reliability value of 0.96 and a person separation reliability of 0.73, indicating the undergraduates' locations along the latent scale are sufficiently precise to warrant valid inferences regarding the concepts about Zika that undergraduates have mastered or not mastered.

3.6 ZiPS Validity with Respect to the Rasch Model

All items fit the RSM satisfactorily ($0.80<MNSQ<1.18$), indicating that the wording of questions does not favor low or high ability undergraduates. Rasch logit measures produced by the instrument were also reliable (item reliability = 0.95, person reliability = 0.75), meaning the scale can be used to draw valid inferences about undergraduates' precautions against Zika.

3.7 Analysis of Knowledge of Zika

The Rasch model indicated (Figure 1) that items 1, 6, 7, and 8 were the easiest items. This shows that many undergraduates understood that while Zika can be tested for (item 8), there is no vaccine to prevent or treat Zika (items 6 & 7). Further, many of the undergraduates displayed understanding about ways that Zika is transmitted (item 1).

The most difficult items (3, 4, 5, 10, & 13) indicate university undergraduates have poor understanding about *Aedes* mosquito, the primary vector behind the transmission of Zika. Participants could not identify important aspects of the mosquito's reproductive cycle which is pertinent to the transmission of Zika, including the extent to which the *Aedes* mosquito feeds across its lifetime (item 3), that it feeds both during the day and at night (item 4), and it lays its eggs in standing water (item 5). It is therefore no surprise these undergraduates also had limited understanding of ways the transmission of Zika can be prevented (items 10 & 13). This warrants an analysis of compliance with preventative behaviors, which is discussed in the next section.

3.8 Analysis of Preventative Measures

The majority of undergraduates were either "likely" to "extremely likely" to take precautions against Zika except for avoiding casual contact with people (the importance of which is debatable [8]) (Table 1).

Toward building a more generalizable model, the RSM was used to predict undergraduates' levels of compliance with each precaution based on their logit measures. This model is illustrated in Figure 2, where the precautions are ordered from easiest at the bottom to most difficult at the top. Therefore, it follows that using insect repellant was the easiest precaution for undergraduates to take, while avoiding casual contact was the most difficult. Other precautions undergraduates found difficult included using an insect fogger (indicated lack of familiarity), canceling travel plans (indicated that this precaution seemed drastic), and wearing long sleeved clothing (indicated concern with the summer heat).

In Figure 2, the range from -4 to 3 along the top and the bottom of the figure represent the Rasch Logit Scale. The numbers 0, 1, 2, and 3 in the middle of the figure represent the Likert coding described in section 3.4. The number to the left of the Min, Median, or Max line in Figure 2 indicates how likely students at the level indicated are to comply with the precaution. Therefore, the RSM predicts that the median undergraduate is not "extremely likely" to do any of the precautions (indicated by the line representing a median student being to the left of "3" for all precautions). However, they are "likely" to comply with all precautions except using an insect fogger (median line is to the left of "2" meaning they are predicted to be at a "1," "unlikely") and avoiding casual contact (median line is to the left of "1" meaning they are predicted to be at a "0," "extremely unlikely"). Undergraduates in the first quartile fall below a "2" level on cancelling travel plans, wearing long sleeved shirts and pants, washing hands, and postponing pregnancy, indicating that, unlike a median undergraduate, undergraduates near the bottom of the scale are "unlikely" to take these precautions. Undergraduates at the third quartile have higher predicted compliance levels than the median group on four precautions: "likely" to avoid casual contact, and "extremely likely" to use insect repellent, dump standing water, and wear condoms to prevent Zika.

Open-ended comments from undergraduates on the ZiPS showed that distinct sentiments tended to accompany different levels of compliance with precautions. Concern about Zika provided the sharpest demarcation between undergraduates of high and low compliance. Undergraduates at the bottom of the scale tended to indicate that since Zika has not yet hit the Midwest, there is no need to take precautions.

Representative statements include: "I haven't been told about this outbreak, therefore don't need to feel like I need to take precautions" and "I am not in an area of an outbreak, but if I was I would be taking all precautions!" Undergraduates on the high end of the scale stated that people should take precautions regardless of whether or not Zika has been reported in the area. Statements include: "I want to prevent the spread of disease," and "It is important to think of what could actually happen and be aware that this is a serious disease."

Table 1. Proportion of undergraduates reporting each compliance level. Bold values indicate the likelihood to comply the majority of the students indicated.

	Extremely Unlikely (0)	Unlikely (1)	Likely (2)	Extremely Likely (3)
1. Wear long sleeved shirts and pants	6(4%)	35(22%)	**64(41%)**	53(34%)
2. Use insect repellants	5(3%)	15(9%)	56(35%)	**82(52%)**
3. Dump containers with standing water	8(5%)	21(13%)	59(37%)	**70(44%)**
4. Use condoms during sexual intercourse	14(%)	18(11%)	50(32%)	**76(48%)**
5. Use insect fogger in your house	19(12%)	50(32%)	**55(35%)**	34(22%)
6. Cancel travel plans due to the outbreak	17(11%)	26(16%)	57(36%)	**58(37%)**
7. Postpone getting pregnant	15(9%)	30(19%)	44(28%)	**69(44%)**
8. Avoid casual contact with people[a]	39(25%)	**55(35%)**	42(27%)	22(14%)
9. Wash hands more frequently[b]	16(10%)	25(16%)	54(34%)	**63(40%)**

[a]Not directly linked to Zika prevention, but used as a measure of distancing.
[b]Not directly linked to Zika prevention, but used as a measure of hygiene.

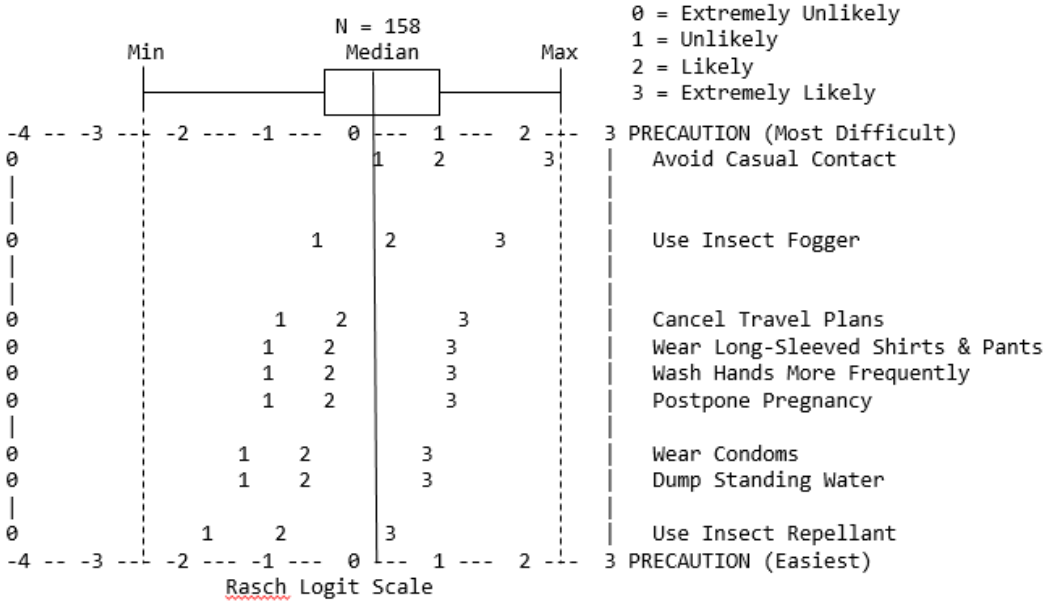

Figure 2. A map of undergraduates' predicted compliance levels as a function of their ability distribution (the box plot above the map). Extremely unlikely=0, unlikely=1, likely=2, and extremely likely=3. An undergraduate must be located above a certain level to be predicted to be at that level. For example, a median undergraduate's location is below a "1" level for "Avoid Casual Contact," so this person is most likely to be at a "0" (extremely unlikely) level.

In many undergraduates, these concerns manifested in more specific ways. Undergraduates who were resistant to take precautions often expressed sentiments of inconvenience through statements like: "I am not putting my life on hold because of a scare," and "I understand taking precautions, but you can't stop living your life due

to fear." This gave way to a sentiment of minimalism at the middle of the scale. Participants expressed a concern for taking precautions as long as they are easy to take. Another undergraduate stated, "These are all easy things to adhere to aside from casual contact." Participants with high compliance (at the top of the scale) expressed their concerns in terms of fear and morality. Two undergraduates stated, "I don't want to catch Zika." Another at the top of the scale stated, "Its better safe than sorry." Other undergraduates with high compliance expressed a moral obligation to take these precautions with statements like, "It seems like the right thing to do," and "we should be doing these things already."

4 Discussion

This is the first study to develop and validate a self-report assessment for determining college undergraduates' knowledge about Zika. We found that the primary persistent misunderstandings were related to the life cycle of the *Aedes* mosquito and methods for prevention of Zika. With respect to prevention, inspection of incorrect responses demonstrated prevalent belief that sexual acts are not a way to become infected with Zika. This is an important misconception to address for a couple of reasons. The first is that if people do not abstain from sexual acts or use protection and are in an area with a Zika outbreak or went to an area with an outbreak, they are at risk of becoming infected or spreading the infection to their partner. This especially becomes problematic if the couple is pregnant since if the mother is infected the fetus is at risk of developing microcephaly. Also, adults are at a slight risk of developing Guillain-Barre syndrome, a serious autoimmune disorder of the nervous system which can be caused by the body's immune response to infection. Another misconception is that since Zika is spread by mosquitoes, there is nothing people can do to prevent it spreading when, in fact, there are a lot of things people can do. For example, staying in places with air conditioning, wearing long-sleeved shirts and long pants, using insect repellants, sleeping under a mosquito net, staying in places that have door and window screens, and using an insect fogger, can all reduce the risk of Zika spreading.

Another misconception that emerged from the responses was that Zika can be spread through direct contact. This misconception may have been spread after the publication of a paper in the New England Journal of Medicine about a man that seemed to get Zika after visiting someone with Zika but did not participate in sexual acts with the infected, had not travelled to a Zika infected area, and did not seem to have been bitten by a mosquito [8]. This led researchers to suggest the only viable route of transmission is direct contact with sweat or tears from the infected man. Newspapers picked this story up and spread it [9, 10]. However, the CDC is now suggesting that Zika is not spread through casual contact [10]. Finally, the most prevalent misconception related to the *Aedes* mosquito is that it mostly bites during the night but, in fact, these mosquitoes bite during the day, too. This misconception is easily addressed by including this information in public announcements, such as tweets by the CDC.

This is also the first study to develop and validate a self-report instrument for determining compliance with precautions to prevent getting Zika, to determine how likely college undergraduates are to take different precautions to prevent the spread of Zika, and to analyze sentiments about Zika prevention which accompany different levels of compliance. Using an insect repellant was the easiest precaution for undergraduates, while using an insect fogger or cancelling travel plans were the most difficult relevant precautions with the remaining seven precautions falling in between. We would like to note here that avoiding casual contact was the most difficult precaution, but the influence of casual contact on the spread of Zika is currently debatable [8-10].

Through open response data, we found that undergraduates at the low end of the scale did not believe Zika would affect them and were therefore less likely to comply with suggested precautions. Undergraduates at the high end of the scale were not only thinking of themselves when complying with precautions but also how different precautions could help others. The median undergraduates would only take the precautions they felt were worth the effort.

Based on these results, those at the top of the scale are already doing everything they can so officials simply need to keep them informed of the current situation regarding Zika. To make the people in the middle more compliant, they either need to be convinced taking the precautions is worth the effort, or instructed on how these precautions can be taken with less effort. Those at the low end need to be better informed about Zika, where it will reach, and that it is not just a threat to pregnant women. If they are made aware that they will be in an area affected by Zika or their knowledge about Zika is increased, their compliance will likely increase.

4.1 Limitations

One limitation in our approach is that data were only collected in the context of a university setting. While we argue that the social and age structure of university environments heightens the risk of Zika transmission, additional data and validity analyses will be needed

before application of our inferences to other settings. Similar results may be found elsewhere; however, if future studies wish to use these assessments, it is recommended they test the validity of their measures with respect to classical or Rasch measurement theory. We would also like to emphasize that this survey was conducted before Zika hit the United States and it still has yet to hit the Midwest where this survey was conducted. In light of protection motivation theory [11], people may be more likely to take precautions after Zika is epidemic in their area. It will be interesting to see how compliance with these precautions changes as immediate concern heightens.

4.2 Future Research

This work can be expanded in several ways. We first recommend that our instruments be given to populations in areas where Zika epidemics are happening. A future study could be done comparing misconceptions and precaution compliance in an area without Zika, in an area with some Zika infections, and in an area where there is a Zika epidemic. Twitter tweets concerning Zika can also be analyzed to determine the main topics people tweet about which build on this study and [13, 14]. Tweets are useful in that they provide real-time information. Additionally, sentiment about Zika can be analyzed using social media data. A study examining Twitter tweets between public health officials, such as the CDC or WHO, and the public, could be done to see how well public health officials are answering questions and addressing misconceptions in real-time.

5 References

[1] H. Nishiura, K. Mizumoto, W. E. Villamil-Gomez, A. J. Rodriguez-Morales. "Preliminary estimation of the basic reproduction number of Zika virus infection during Colombia epidemic, 2015-2016." *Travel Medicine and Infectious Disease.* (2016). Retrieved from: http://www.sciencedirect.com/science/article/pii/S1477893916300084

[2] Center for Disease Control (CDC). "Zika Virus." 2016. Retrieved from: https://www.cdc.gov/zika

[3] M. Dredze, D. A. Broniatowski, & K. M. Hilyard. Zika vaccine misconceptions: A social media analysis. *Vaccine*, vol 34, pp. 3441, 2016.

[4] J. A. Sabogal-Roman, D. R. Murillo-García, M. C. Yepes-Echeverri, J. D. Restrepo-Mejia, S. Granados-Álvarez, A. E. Paniz-Mondolfi, ... & A. J. Rodríguez-Morales. Healthcare undergraduates and workers' knowledge about transmission, epidemiology and symptoms of Zika fever in four cities of Colombia. *Travel Med Infect Dis*, vol 14, pp. 52-4, 2016.

[5] E. M. Glowacki, A. J. Lazard, G. B. Wilcox, M. Mackert, J. M. Bernhardt. Identifying the public's concerns and the Centers for Disease Control and Prevention's reactions during a health crisis: An analysis of a Zika live Twitter chat. *Am J Infect Control*, vol 44, pp. 1709-1711, 2016.

[6] B. D. Wright, & M. H. Stone. *Best Test Design*. Chicago: MESA Press. 1979.

[7] W. L. Romine, D. L. Schaffer, & L. Barrow. Development and Application of a Novel Rasch-based Methodology for Evaluating Multi-Tiered Assessment Instruments: Validation and utilization of an undergraduate diagnostic test of the water cycle. *International Journal of Science Education*, vol 37, pp. 2740-2768, 2015.

[8] S. Swaminathan, R. Schlaberg, J. Lewis, K. E. Hanson, M. R. Couturier. (2016). Fatal Zika Virus Infection with Secondary Nonsexual Transmission. *New England Journal of Medicine*, vol 375, pp. 1907-1909, 2016.

[9] J. Beck. The first documented case of Zika spread by physical contact. *The Atlantic*, 2016 Retrieved from: https://www.theatlantic.com/health/archive/2016/09/the-first-documented-case-of-zika-spread-by-physical-contact/501923/

[10] A. Almendrala. Utah Zika case shows physical contact can spread the virus. *The Huffington Post*, 2016. Retrieved from: http://www.huffingtonpost.com/entry/utah-zika-virus-physical-contact_us_57ed5e0fe4b024a52d2da2c4.

[11] E. J. Dziuban, J. L. Franks, M. So, A. J. Hall, H. J. Menzies, S. L. Hills, M. Fischer. Zika virus response planning: Interim guidance for district and school administrators in the Continental United States and Hawaii. Retrieved from: https://www.cdc.gov/zika/schools.html

[12] R. W. Rogers. (1975). A protection motivation theory of fear appeals and attitude change. *The Journal of Psychology*, vol 91, pp. 93-114, 1975.

[13] M. Miller, T. Banerjee, R. Muppalla, W. Romine, & A. Sheth. What are people tweeting about Zika? An exploratory study concerning symptoms, treatment, transmission, and prevention. *Journal of Medical Internet Research*, accepted.

[14] R. Muppalla, M. Miller, T. Banerjee, & W. Romine. Discovering explanatory models to identify relevant tweets on Zika. *EMBS*, accepted.

[15] Ohio Center for Knowledge Enabled Computing (Kno.e.sis). Zika knowledge and perception studies. Retrieved from: http://wiki.knoesis.org/index.php/Zika_Knowledge_and_Perception_Studies