HIGH SCHOOL EDITION
Journal of Student Research
Volume 10 Issue 4 (2021)

Current Level of Public Awareness of Antibiotic Resistance in Youth, Specifically Teens in High School

Emma Muir[1] and Kim Tetmeyer[#]

[1]Lapeer High School, Lapeer, MI, USA
[#]Advisor

ABSTRACT

Antibiotic resistance is a health crisis that is slowly growing throughout the world. The spread of antibiotic-resistant genes in bacteria is rendering antibiotics useless, and severe infections are running rampant. The only way to change this is for the public to take action, but how much do they know? Previous research has been conducted about the public's knowledge of antibiotic resistance, but younger age groups are generally left out of that data. This leads to the question what is the current level of public awareness of antibiotic resistance in youth, specifically teens in high school. I hypothesized that a large number of students won't know what antibiotic resistance is at all, and those who do know don't fully understand what it means. To test this hypothesis, an online survey was distributed to students from a rural southeastern high school via email and homeroom classes. From the survey, results showed that students don't understand what causes antibiotic resistance, what becomes resistant to antibiotics, and what antibiotics treat. With data from the survey, I concluded that High school students have a low to moderate level of understanding of antibiotic resistance and related topics.

Introduction

Medicine is frequently taken for granted in this day and age. When people go to take their prescription each morning, the thought of the years of research that went into creating it never crosses one's mind. Though a prescription pill on its own may seem small and trivial, medications are extremely powerful. This is especially true when it comes to antibiotics. Antibiotics were revolutionary when they were created, arriving at a time in which a simple infection such as pneumonia was life-threatening to all age groups. Antibiotics have helped quickly and effectively eliminate illnesses that were once a serious threat. But as many people have come to find out, too much of a good thing can lead to serious consequences.

Antibiotics are medications that are used to treat bacterial infections in the body by killing the pathogenic bacteria/stopping them from multiplying. When used properly, they save the lives of many. Unfortunately, the use of antibiotics is being taken advantage of. It is becoming increasingly common for antibiotics to be used for ailments that could be relieved by other treatments. In addition, people are not taking their prescriptions properly and many don't finish them at all. Both of these cause antibiotic resistance, which is when infection-causing bacteria mutate and evolve to become resistant to antibiotics, making them obsolete. This is a public health concern since we as a society have become dependent on antibiotics to maintain our health. Many researchers are trying to discover ways to combat this issue but in the meantime, our only option is to educate the public on the issue. Though there are many target audiences, the youth (specifically high school students) is a category in which education on antibiotic resistance is lacking due to limited exposure to such topics compared to adults. This raises a concern because high schoolers are in the age range where they gain more responsibility and therefore become in charge of taking their prescriptions on their

own. Therefore the only way we can make an impact on antibiotic resistance, we must build healthy antibiotic habits in the youth.

Literature Review

Before we can educate people on antibiotic resistance, we must fully understand it first. Gradmann, a professor at the University of Oslo stated that research into antibiotics began in the 1930s, starting with bacterial genetics. Since antibiotics and antibiotic resistance go hand in hand, antibiotic resistance shortly followed (Gradmann, 2009). Levy, a researcher, and physician at Tufts University explained that antibiotic resistance is generally caused by resistant genes that are spread through bacteria. These resistant genes can exist in several places such as the chromosomes of the bacteria or the plasmids of the bacteria, which are rings of DNA. These mutated genes are either transferred to other bacteria or randomly mutate, which spreads resistance (Levy, 1998). Yelin and another researcher at the Technion-Israel Institute of Technology say that the actual process of a bacterial cell defeating an antibiotic is a bit more complex. To simplify it, the mutated genes produce resistant mechanisms which attempt to stop the antibiotic when it enters, accumulates in the cell, and when they aim to bind to the bacteria cells. This is done via drug dedicated pumps in the cell membrane that remove the drug from the bacterial cell. Some enzymes modify the drug molecules and make them unviable (Yelin, 2018). Though mutated genes are what cause the biological existence of antibiotic resistance, humans are to blame for its prevalence and strength.

Bacterial resistance has been on a steady incline since its creation. As an RN and MSN in the Atlantic Health System, Emanuele said this is mostly due to the misuse and overuse of antibiotics. Antibiotics are commonly overprescribed by doctors, or improperly taken by the patients receiving the prescriptions (Emanuele, 2010). This illustrates the direct impact humans have on the spread of antibiotic resistance. The World Health Organization qualifies antibiotic resistance as one of the biggest threats to global health, which they also credit to misuse and overuse of antibiotics. The growing number of infections is becoming harder and harder to treat, leading to longer hospital stays and more exposure to bacteria overall (World Health Organization, 2020). Ventola, a medical writer at the National Institute of Health, says there is currently a lack of antibiotic developments due to low economic incentives, as well as a challenging regulatory environment (Ventola, 2015). This means that people can no longer sit idle and wait for a miracle cure. We as people need to take action in order to slow down antibiotic resistance until breakthroughs can be made. Because antibiotic resistance cannot be prevented, it can be controlled (Emanuele, 2010). Controlling antibiotic resistance can not be done by a small group of people, it must be a worldwide effort. Therefore the only way to successfully slow down antibiotic resistance is to educate the public on the issue. But, the levels of knowledge about antibiotic resistance vary drastically.

Familiarity with the subject of antibiotic resistance is important because it is the only way that antibiotic resistance can be slowed down. Faculty at a pharmacy at the Eastern Mediterranean University found that unfortunately, the level of knowledge varies a great deal. This can be due to many things such as education level, age, socioeconomic status, region of residence, and multiple other factors. Overall, it has been determined that the public is moderately aware of antibiotic resistance (Ilktac, 2020). Though this is better than what it had been in the past, the knowledge is not equally distributed. This is especially noticeable in the younger generations. Lack of knowledge on antibiotic resistance is disproportionately found in students. In a study in New Delhi conducted by researchers in medicine, pharmacy, and other science fields, they found that students had a very poor understanding, while their teachers had a very basic understanding (Kotwani, 2016). This presents us with a clear gap in the knowledge of younger generations that must be filled. This is because the more knowledge people have about antibiotic resistance, the more likely they are to feel a personal responsibility to take them correctly. This was determined by researchers at the Centre for Research Ethics (Ancillotti, 2018). To promote healthy antibiotic use habits, we must educate people accordingly. But, the method for educating the general public is very much debated.

There are a multitude of ways educators may choose to teach people about antibiotic resistance and the importance of it. But, the best type of method to educate people is constantly questioned. Researchers at BMC Public

Health argue that using individual methods of education each time they teach a group is the most successful (Burstein, 2019). Others suggest that using a multidisciplinary approach is the best when it comes to informing people about antibiotic resistance. According to researchers at The University of Gothenburg, this is because antibiotic resistance is fixated in many realms of the science community (Kvint, 2020). No matter which way the public is educated, all that matters is that the information gets across to the audience because educational interventions can change someone's perspective regarding antibiotic use (Burstein, 2019). Research done at the Marshfield Clinic Research Institute determined that since education about antibiotic resistance is targeted towards the older generations, adults are the ones who are most educated on the subject. Adults then pass this information down to their children to inform them about the subject (Trepka, 2001). But what if this information is not being passed down? Without consistent direct education to youth about antibiotic resistance, how much do they know about the subject? Not much is known about how much the youth truly understands antibiotic resistance.

Antibiotic resistance is a biological mutation that is inevitable no matter what people try to do. But with our current antibiotic habits, as they are, we are doing nothing to even attempt to slow down its spread. Whether it is from the over-prescription of antibiotics by doctors or improper use of antibiotics by patients, the privilege of having antibiotics is being abused. Due to our irresponsible antibiotic habits, mutated genes in bacteria are spreading and multiplying at an increasing rate. This is a reflection of people's direct impact on antibiotic resistance. We as a society may not have the power to stop antibiotic resistance, but we do have the power to control it. But, everyone must participate to make that happen. The only way that is possible is through educating people on the subject of antibiotic resistance. Unfortunately, the current level of public awareness is not up to par, being moderate across the board. This could be due to multiple factors, but one up for debate is how we educate people. Though that is a valuable topic, I believe who we are trying to educate should be the priority. While antibiotic resistance education is generally taught to a more mature audience, shouldn't the youth be our priority?

I will be researching the current level of public awareness of antibiotic resistance in youth, specifically teens in high school. Though there is plenty of research regarding public awareness of antibiotic resistance in the world as a whole, rarely is the research focused on the teenage age group. I hypothesize that a large amount of students won't know what antibiotic resistance is at all, and those who do know don't fully understand what it means. The only way for us as a society to slow down antibiotic resistance is to teach healthy antibiotic habits and teach them young. Therefore, we need to get a grasp on what our youth currently understands about the subject. Once this information can be gathered, we will be able to cater antibiotic resistance education to the youth to boost their knowledge on the subject. In doing so we will finally raise a generation that will have the power of knowledge over antibiotic resistance, making the change past generations failed to do.

Methodology

My research question is what is the current level of public awareness of antibiotic resistance in youth, specifically teens in high school? To answer this question, I chose a majority quantitative but partially qualitative, non-experimental method. Through this, I was able to determine the best research instrument for me to use as a survey. This was because a survey would allow me to cater the questions exactly to my question and the type of data I want to collect. It also allowed me to include a majority of quantitative questions, but also include a few qualitative ones. A source that had a goal of determining public awareness of antibiotic habits in Cyprus (which somewhat mirrors the goal of my research) used a survey for their method, which supported the idea that I use one as well (Ilktac, M.). In addition, a survey is simple and easy to take, as well as easy to distribute making it easier to collect a large number of responses. There are 4 main steps to my method: 1) Develop survey questions, 2) Contact teachers to gain access to their i-connect/homeroom (Sampling) and distribute the survey via email as well to gain more responses, 3) Distribute/Give subjects the survey, and 4) Remove any responses that don't meet subject criteria. In following these steps the data received should be ready to analyze.

Developing Survey/Survey Questions

To develop survey questions, I had to start by determining what style of survey I would do. Google Forms was the platform I decided to use because it would be easy for students to access via email or QR code. Through the google form, the answers to the questions will be put into pie charts and bar graphs to display the data. In addition, the google form will automatically generate a google spreadsheet with the data already in it. When selecting the content of questions, I used my background knowledge of antibiotic resistance, as well as reference questions from antibiotic resistance surveys conducted by the World Health Organization (World Health Organization, 2016). At the beginning of my survey, I wrote a statement explaining what my research was, why I was conducting it, what would be done with their responses, and how they would remain anonymous. For my subjects to indicate that they consented to be a part of my research, I included a question asking if they agreed to the conditions in my paragraph above. Once the subject selected agreed, the beginning questions covered a variety of demographic subjects such as age, gender, grade, etc. After that questions were catered more towards the subject's personal experience with antibiotics (have you taken them, who gives them to you, etc). And the majority of the survey was used to determine how much students understand about antibiotic resistance as a whole. To determine the format and stylistic word choices of my questions, I referenced the World Health Organization Antibiotic Resistance: Multi-Country Public Awareness Survey once again (World Health Organization, 2016). Questions ranged from true or false/yes or no responses to multiple-choice to check-all-that-apply. Also, most questions had an "I'm not sure" option and those that were multiple choice or check-all-that-apply included an "other" option where students could type in a response. To end the survey, I included a question asking students about their opinion on antibiotic resistance, as well as a question asking if they would like to learn more about the subject in the future. Once the survey was complete I had a link to distribute it, as well as a QR code created from the link.

Sampling

In this study, I had a goal of sampling 120 subjects (30 per grade) from a high school in rural southeastern Michigan. To qualify as a subject, one must be in 9th-12th grade at that particular high school and within the accompanying age range (approximately 14-19). Once my survey was distributed, I ended up sampling 189 students, the sample was made up of 62 freshmen (33.2%), 40 sophomores (21.4%), 46 juniors (24.6%), and 39 Seniors (20.9%). Then, to keep the representation of each grade equal and attempt to reduce possible biases, I used a random number generator to select 30 per class from my responses (120 responses total). I used the numbers assigned in the spreadsheet generated and used the random number generator until I had 30 per class, and deleted responses that weren't selected. I got my sample of students through multiple medians. To gain initial responses, my survey was distributed to the school emails of all students of this particular high school via the high school's administration. This was done due to a lack of face-to-face contact because this district was switched to online learning temporarily during my data collection period. Once face-to-face learning resumed, I was able to contact teachers at the school and was permitted to give the survey to their i-connect classes. At this particular high school, i-connect is what they call a homeroom class where students have a small free period throughout the day. Because the i-connects are sorted in alphabetical order, they are somewhat randomized. The i-connects I chose to sample were selected at random, therefore I used random sampling to produce results that more accurately depicted the population I was surveying (high school students). Once plans were made with the teachers of those i-connects, I was able to provide my survey to each class.

Distributing the Survey

As previously stated, the survey was partially distributed via students' emails through the high school's administration. But, the majority of data was collected in person. Once a teacher permitted me to visit their i-connect classroom, I came with a paper that featured the link to my survey, as well as (and more importantly) the QR code that takes you directly to the survey. Once arriving in the classroom, I gave a short description of myself, my research, why it is important, and what exactly they would do to contribute to my research. I explained that I was conducting a quick

survey and that their responses would be very much appreciated, though not required. Once I was done explaining, teachers allowed me to put my QR code under the document camera for students to scan with their phones, or I directly gave students the paper to scan the QR code off of. Students who could not scan the QR code but still wanted to take the survey had the survey directly emailed to them. I visited as many i-connects as possible until I received an adequate amount of data per grade. Due to the setup of this particular high school, the 9th grade class does not reside in the actual high school building, therefore I was unable to go into their i-connects in person. To overcome this obstacle I was able to email multiple freshman i-connect teachers and have them distribute the survey to their classes, making sure they understood that the students were not required to take it.

Removing Responses that Didn't Meet Subject Criteria

Though the survey was only intended for 9th-12th graders at this particular high school, I received a few responses that could not qualify as a subject. This may have been due to confusion from teachers or other adults who saw the survey on whether they were able to take it because I received multiple responses that were significantly outside the age range. Any response that was significantly outside the age range was removed to keep the data accurate. Responses that did not indicate age or grade were removed as well. Also, any subjects who selected that they disagreed with the terms in my description of the survey had their responses removed as well, as they did not provide consent. I removed the necessary responses by going to the individual response section of the google form and deleting out each one.

Results/Findings

The survey I created for my research had questions that fell into 5 categories: Demographics, Antibiotic Consumption Behaviors, Knowledge of Antibiotics and the Use of Them, Knowledge of Antibiotics Resistance, and Final Opinions on Antibiotic Resistance. To more clearly display my results, I separated each one of those categories. The questions were quantitative with "other" options on some questions to allow for qualitative responses. It is also important to note that for most questions, I included an "I don't know" or "maybe" option for those who may not know about the subject of the questions at all.

Demographics

As previously stated in the methods sections, 120 out of the 189 responses received were included in the results. This was done to increase the randomness as well as ensure equal representation of each grade. Once the necessary responses were removed, the grades were equally represented with 30 per grade and ages ranging from ages 14 to 19. Though more data on demographics were collected, it was not necessary to include it in the findings.

Antibiotic Consumption Behaviors

When it came to students' antibiotic consumption habits, a majority of the 120 students surveyed had taken antibiotics before (91.7%) and 46.7% of the students had taken them in the last 12 months. A majority of students take their antibiotics on their own (37.2%), while a close second was taking them on their own and their parents giving them (31.9%). 89.9% of the students follow the exact instructions given by their doctor, with only 4.2% saying they don't. When asked if they always finish their prescriptions, responses were mixed (Figure 1).

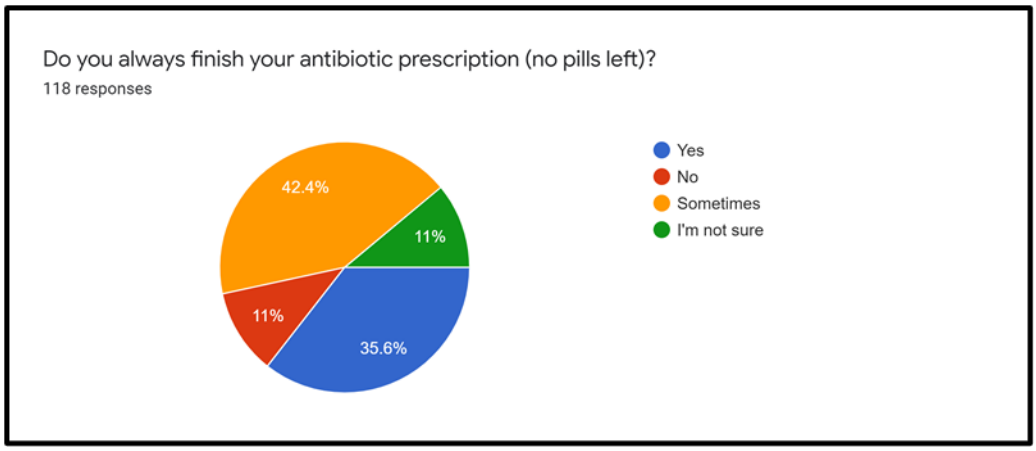

Figure 1

Knowledge of Antibiotics and the Use of Them

To find out how much students understand about what Antibiotics were used for, they were asked questions specific to the use of antibiotics. From those questions, it was determined that 55.8% of the students surveyed believe you should stop taking antibiotic prescriptions when you finish the entire prescription (all pills) which is the correct answer. But, 29.2% of students believe that you stop taking the prescriptions once symptoms stop and you feel better. 70.8% of students believe that you cannot take the antibiotics of a friend/family member (as long as it's being used to treat the same illness), yet 14.2% of students believe that is alright, which is incorrect. When asked what antibiotics are used to treat, I provided a list of possible options (with specific examples) and left an "other" option for students to fill in. The student-generated answers appear below the "none of these" section along with the rest of the answers. Though there was a large variety of options, the only correct answer was bacterial infections. But students who put "acne" or something related (not the response that says "oil") in the student-generated response option were correct as well because acne is caused by bacteria (Figure 2).

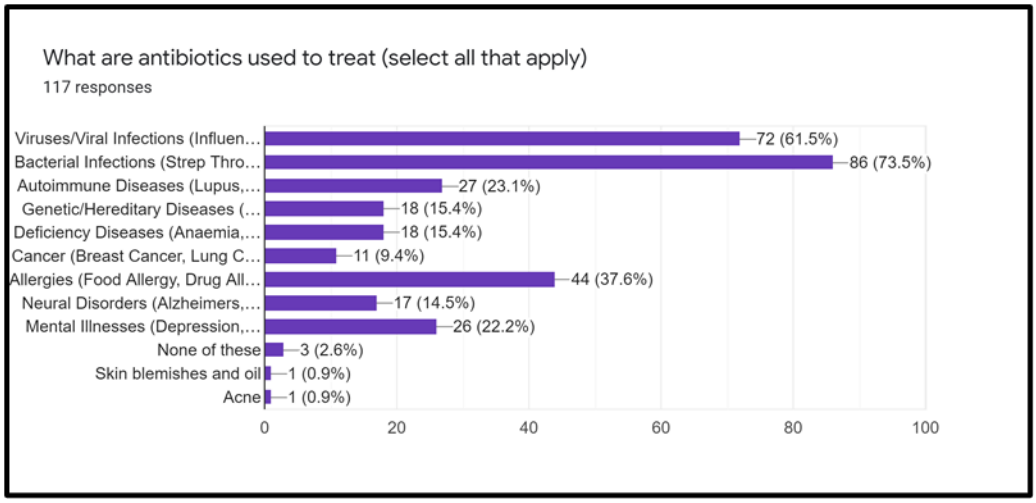

Figure 2

Knowledge of Antibiotics Resistance

The majority of my questions were related to the concept of antibiotic resistance, as it will help answer my research question the most. I began by listing words related to antibiotic resistance and asking the students to select any they recognized (Figure 3). To determine where students learned these terms, I listed possible sources of information, as well as an "other" option for students to fill in answers. The student-generated responses appear below the "Can't Remember" option. And due to a spacing issue, the 1st option that appears to lack a title is "Specifically taught about it through a campaign/presentation" and the 2nd was a student-generated response saying they learned the terms through youtube videos (Figure 4).

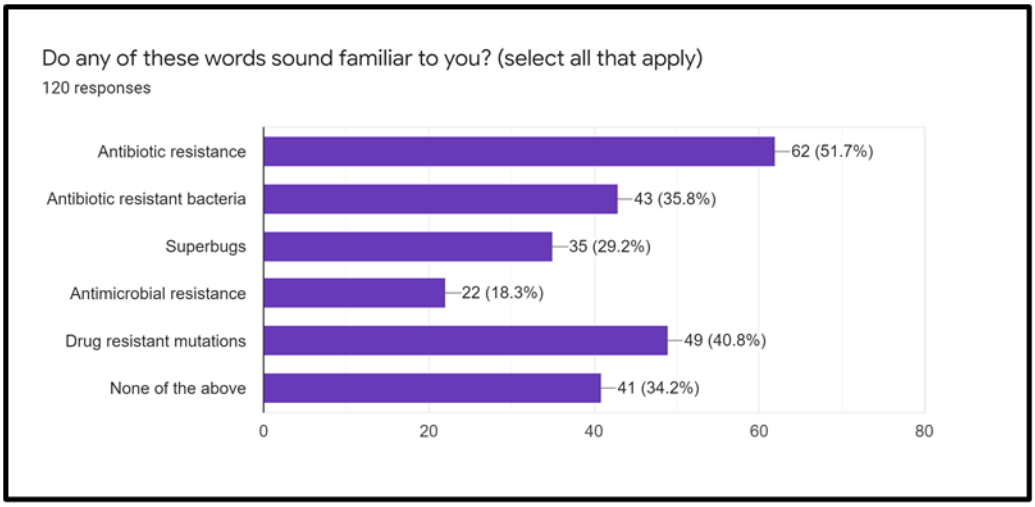

Figure 3

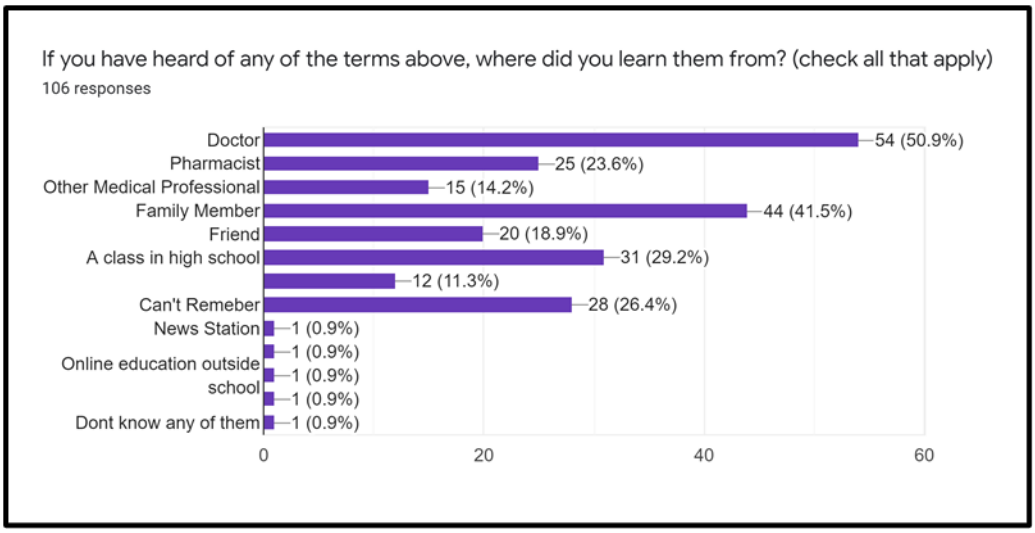

Figure 4

Because this category has some of the most important answers, it is important to include most of the questions from the survey in the results to have a clear picture of how much the students understood. The rest of the questions in this category are True/False style questions, with an "I'm not sure option" for those who need it. I displayed the percentages of students who selected each option. Answers that are featured in the regular box are correct, while answers that are featured in the shaded in box are incorrect (Figure 5).

Statement	True	False	I'm not sure
Antibiotic resistance is when your body becomes resistant to an antibiotic, causing the antibiotic to work less effectively or not at all	42.4%	17.8%	39.8%
Antibiotic resistance is when the bacteria that causes an infection becomes resistant to an antibiotic, causing the antibiotic to work less effectively or not at all	41.5%	14.4%	44.1%
Antibiotics are currently being overprescribed by doctors	44.1%	6.8%	49.2%
Taking an antibiotic prescription improperly (not listening to instructions from your doctor/pharmacist) contributes to antibiotic resistance	44.9%	5.9%	49.2%
Use of antibiotics for agricultural purposes contributes to antibiotic resistance	22.2%	4.3%	73.5%
I am not at risk to contract an antibiotic resistance infection as long as I take my antibiotics properly	16.4%	43.1%	40.5%
Continuing to finish your antibiotic prescription though symptoms have resided contributes to antibiotic resistance	19.7%	17.1%	63.2%

Figure 5

The majority of students said that antibiotic resistance is when the body becomes resistant to antibiotics, when in reality it is the infection causing bacteria that become resistant. A majority of students also assumed that taking meds when symptoms stop contributes to antibiotic resistance, even though you are supposed to take them until your prescription is done whether there are symptoms or not. This section also included questions asking students if people can control antibiotic resistance or if they could be contributing to the issue. The majority of students in both sections did not know the answer to either of those questions (62.4% and 49.2%). Finally, when asked if the students themselves could help prevent antibiotic resistance the majority answer was once again "maybe" (53.4%).

Final Opinions on Antibiotic Resistance

The final 3 questions of the survey wrapped up the students' overall opinion towards antibiotics/antibiotic resistance as a whole. 76.3% of students thought that it is important for people to know about antibiotics resistance, and after completing the survey, 33.9% of the students said they would like to learn more about antibiotics resistance. When asked to describe their attitude towards antibiotic resistance, students were given 5 options ranging from "Antibiotic resistance is a health crisis that must be addressed immediately" to "Antibiotic resistance is not an issue". In addition, there was an option saying "I didn't know about it until now so I do not know what my opinion is" and an "other" option where students could type in responses (Figure 6).

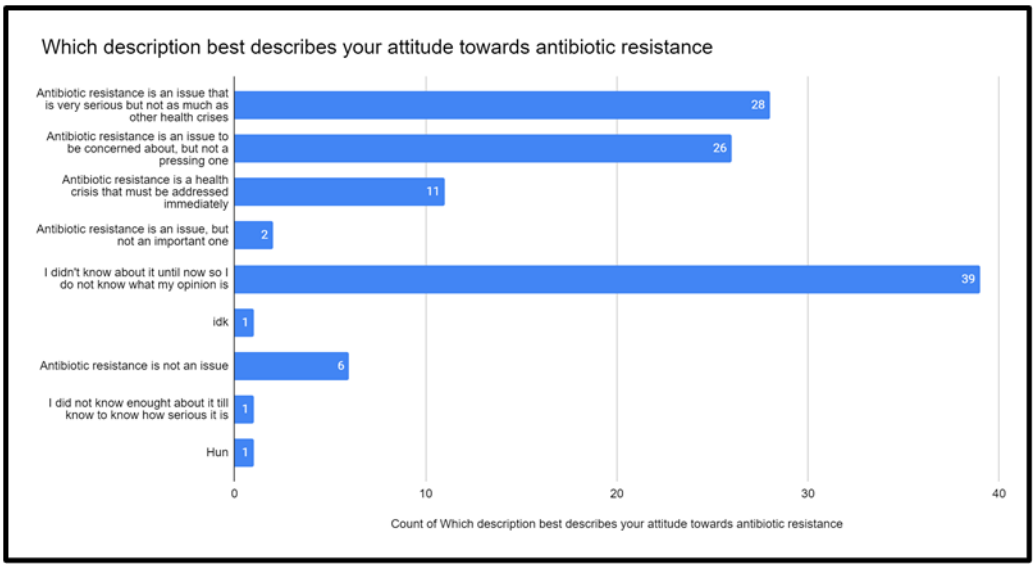

Figure 6

Discussion

The results suggest that my initial hypothesis was correct: there were a large number of students who did not know what antibiotic resistance is. But what my hypothesis didn't capture was the extent of the student's lack of knowledge, nor their misunderstanding of the subject.

Questions involving antibiotic resistance displayed both misunderstanding and lack of knowledge at all. The percentage of students who selected the "I'm not sure" option was never lower than 39.8%. Figure 5 also indicates misconceptions about whether bacteria or the body become resistant to antibiotics, and when you should stop taking your antibiotics. Students also didn't understand what caused antibiotic resistance, as the answers to the questions regarding over prescription, prescription abuse, and agriculture contributions had a large amount of "I'm not sure" answers. This shows a lack of knowledge on how antibiotics work and may explain the casual nature of the students' antibiotic consumption behaviors, as many students indicated that they only sometimes finish their prescription.

It is difficult for one to expect students to understand antibiotic resistance when they don't understand how antibiotics work in the first place. The survey indicated high levels of misconception involving what antibiotics are used to treat. In Figure 2, bacterial infections were the highest answer at 86 students and the only correct one, but viruses/viral infections were a close second at 72. This is an extremely common and concerning misconception, as people confuse antibiotics with vaccines, which treat viruses. Other diseases were chosen as well, but that could be due to a lack of understanding of the diseases as well as lack of understanding of antibiotics.

Conclusion

Through this research, a gap of knowledge surrounding student's knowledge of antibiotic resistance has begun to be filled. High school students have a low to moderate level of understanding of antibiotic resistance and related topics. They especially lack knowledge about what antibiotics treat, how to take an antibiotic prescription, and what antibiotic resistance is and its implications. This lack of knowledge on antibiotics and antibiotic resistance as a whole is a block on our road to slowing antibiotic resistance, and efforts must be made to improve it.

Limitations

One limitation of my research was that I was unable to sample a larger number of high schools. Though it would be valuable to do so and would better reflect the target population, it was not feasible for the researcher to reach multiple high schools in a variety of states. It would be especially difficult this year due to the pandemic. Another limitation is that in retrospect, having separate surveys for each grade and combining the results later would have been beneficial. There is bound to be a difference between the knowledge of freshmen in high school and seniors who may have taken advanced science courses. Having the data split by grade could have given a more in-depth view of high school students' knowledge of antibiotic resistance, and at which age/in which age they tend to acquire it.

Implications

Now that it is clear that high school students do not understand antibiotic resistance, the only way we can impact their antibiotic consumption habits is to teach them about it. At this impressionable age, students need to be introduced to the idea of antibiotic resistance in a setting where they have to listen. If antibiotic resistance was to be taught in required classes in high schools, far more students would learn about the issue compared to the few who electively take advanced science courses. Teaching about it in school would also demand the attention of far more students, as many may not listen in other scenarios. Doctors must also continue to reiterate how to properly take antibiotics to the child and not the parents, as many in this age group are becoming more independent and taking their medications on their own. If both of these were to happen, far more students would understand antibiotic resistance and therefore hopefully make positive changes in their antibiotic consumption behaviors.

Future Research

Following this research, I would suggest that if someone has the resources they should try to conduct the same research like this study, but reach a much wider audience. This would give a better understanding of what all high school students know about antibiotic resistance rather than just the 1 school sampled from in this study. Future research should also be done focusing on what students know about antibiotics rather than antibiotic resistance. This would be important, as the only way to truly understand antibiotic resistance is to understand how antibiotics work in the first place. It would also be beneficial to research confusion between vaccines and antibiotics. It was clear through my research that students mixed up the 2, which could cause the spread of misinformation on both treatments. This could tie into research involving distrust and spreading of misinformation surrounding vaccines, which is an extremely relevant topic during the COVID-19 pandemic.

Acknowledgments

I would like to thank my advisor Mrs. Kim Tetmeyer for helping me with this project.

References

1. Ancillotti, M., Eriksson, S., Veldwijk, J., Fahlquist, J. N., Andersson, D. I., & Godskesen, T. (2018). Public awareness and individual responsibility needed for judicious use of antibiotics: A qualitative study of public beliefs and perceptions. *BMC Public Health, 18*(1). doi:10.1186/s12889-018-6047-8

2. Burstein, V. R., Trajano, R. P., Kravitz, R. L., Bell, R. A., Vora, D., & May, L. S. (2019). Communication interventions to promote the public's awareness of antibiotics: A systematic review. *BMC Public Health, 19*(1). doi:10.1186/s12889-019-7258-3

3. Emanuele, P. (2010). Antibiotic Resistance. *AAOHN Journal, 58*(9), 363-365. doi:10.3928/08910162-20100826-03

4. Gradmann, C. (june 2009). Exploring the 'Therapeutic Biology of the Parasite' Antibiotic Resistance and Experimental Pharmacology 1900 – 1940. *European Science Foundation,* 5-22. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.688.5676&rep=rep1&type=pdf#page=5

5. Ilktac, M., Tarabishi, M. T., Ozbirtan, P., Gulcan, C., & Celik, G. (2020). A public awareness study about antibiotic consumption habits and antibacterial resistance in north-eastern region of Cyprus. *The Journal of Infection in Developing Countries, 14*(05), 463-470. doi:10.3855/jidc.11936

6. Kotwani, A., Wattal, C., Joshi, P., & Holloway, K. (2016). Knowledge and perceptions on antibiotic use and resistance among high school students and teachers in New Delhi, India: A qualitative study. *Indian Journal of Pharmacology, 48*(4), 365. doi:10.4103/0253-7613.186208

7. Kvint, K., Palm, M., & Farewell, A. (2020). Teaching about antibiotic resistance to a broad audience: A multidisciplinary approach. *FEMS Microbiology Letters, 367*(14). doi:10.1093/femsle/fnaa111

8. Levy, S. B. (1998). The Challenge of Antibiotic Resistance. *Scientific American, 278*(3), 46-53. doi:10.1038/scientificamerican0398-46

9. Trepka, M. J., Belongia, E. A., Chyou, P., Davis, J. P., & Schwartz, B. (2001). The Effect of a Community Intervention Trial on Parental Knowledge and Awareness of Antibiotic Resistance and Appropriate Antibiotic Use in Children. *Pediatrics, 107*(1). doi:10.1542/peds.107.1.e6

10. Ventola, C. L. (2015, April). The antibiotic resistance crisis: Part 1: Causes and threats. Retrieved from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4378521/

11. World Health Organization. (2020, July 20). Antibiotic resistance. Retrieved from https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

12. World Health Organization. (2016, January 11). Antibiotic resistance: Multi-country public awareness survey. Retrieved from https://www.who.int/drugresistance/documents/baselinesurveynov2015/en/