School of Public Health Independent
University, Bangladesh

Antibiotic resistance: A possible threat to achieving sustainable development goals, A systematic review

19 April 2022

A thesis submitted by

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in consideration of the partial fulfillment of the requirements for the degree of
Master of Public Health (MPH)

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Course Name: Thesis

Course ID: HSC 575

Declaration

I, Dr. Nusrat Jahan, declare that this systematic review is my own unaided work and that I have acknowledged all sources to the best of my knowledge. This systematic review is being submitted in partial fulfillment of the degree of Master of Public Health at the Independent University, Bangladesh. It has not been submitted before for any degree or examination at this or any other university.

_____

Dr. Nusrat Jahan

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Dedication

Bismillahir Rahmanir Rahim

I dedicate this research report affectionately to:

My Father, Engr, Md. Joynal Abedin

My Mother, Shahida Abedin

My Sisters, Jessy, Babu, Ratri, Tamjid

I also dedicate this work and give special thanks to my husband Tanweer Mahmud for being there for me throughout the entire this program. You have been my best cheerleader.

Acknowledgement

Alhamdulillah!! All praises to ALLAH (SWT). I am happy and grateful that my MPH journey is coming to an end with the completion of this thesis. It was a rough one, still worth remembering at certain points. I would like to thank wholeheartedly everyone who was involved in this journey and cared enough to make it memorable.

I would like to thank my supervisor **Dr. Md. Kamran Ul Baset**, Associate Director, Centre for Injury Prevention and Research, Bangladesh (CIPRB), for providing me constant guidance and valuable feedback required to complete my thesis. Dr. Baset has been a wonderful supervisor throughout the time. Despite his busy schedule, he has always found time to meet with me individually for discussion and guidance. I have rarely seen a compassionate person like him. I truly appreciate his guidance throughout the thesis preparation.

With pleasure, I do express my thanks to Dr. S. M. Raysul Haque, Asst. Professor and Course Coordinator, School of Public Health, IUB, for his support and encouragement during thesis period.

I would like to express my heartfelt gratitude towards all of my faculty teachers of the MPH program. Especially, Dr. Md. Sohel Shomik, Dr. Abdur Razak, Dr. M.A.Mabud, M Abu Sayeed,

Rajib Chowdhuri, Mahfuza Mubarak, Nafisa Huq. I had zero knowledge on public health. Whatever I am today, all credit goes to Almighty ALLAH (SWT) and all thanks to you all.

I really appreciate, SPH office manager, Mr. Imrul and housekeeper Shojol bhai for their logistic support. The warm greetings and smiling face of Shojol bhai in those early mornings were pure delights. I am also grateful to my batch mates, who were supportive and kind to me.

I would like to share my deepest gratitude towards my parents and extended family, who cared for me and my dreams. Who loved me enough to sacrifice themselves so that I can keep going. I am grateful to my Abbu (Engr. Md. Joynal Abedin) and Chacha (Dr. Dulal) for generating interest in reading here. I am thankful to my siblings for growing up so well.

Finally, my beloved husband, Engr. Tanweer Mahmud, I can never thank him enough for all the help and supports I received over the years. Thanks for being patient with me, bearing with me and keeping the promises. Without his tolerance, guidance, and supports, I could not have completed this thesis.

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This is to certify that Dr. Nusrat Jahan worked on “Antibiotic resistance: A possible threat to achieving sustainable development goals, A systematic review” under my supervision. I have gone through the paper. It is up to the mark and to my full satisfaction.

Dr. Md. Kamran Ul Baset

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ABSTRACT

Antibiotic resistance is one of the world's most serious public health threats. When bacteria acquire resistance to antibiotics that may have previously been used to treat them, this is known as antibiotic resistance. Drug-resistant diseases are expected to kill 2.4 million people in North America, Australia, and Europe alone by 2050, according to the Organization for Economic Co-operation and Development (OECD). Humans have become increasingly reliant on the effectiveness of antibiotics in treating bacterial diseases, making the possibility of resistance a major worldwide concern. The problem of antibiotic resistance to global health will be examined using a multidisciplinary approach in this research. Antibiotic resistance causes, the impact of widespread antibiotic resistance on social, economic, and political aspects, and current worldwide preventative actions/programs will all be discussed. Antibiotic resistance is a huge developing health threat, and the global community is underestimating its impact.

CHAPTER 1

Introduction

1.1 Background

Access to effective antibiotics has been taken for granted by people all over the world since the introduction of antibiotics in the mid-nineteenth century, but the rising trend of antibiotic resistance threatens to take it away. Antibiotic resistance is the word for when harmful microorganisms acquire resistance to antibiotics that are used to treat them. Antibiotic resistance is on the rise across the world as a result of widespread overuse and abuse of antibiotics (American Academy of Pediatrics, 2018; Aminov, 2010; Center for Disease Control and Prevention, 2018c; European Commission, n.d.-a; Government of Canada, 2018a; Klingeberg et al., 2018; World Health Organization, n.d.-d; World Health Organization, 2018a). Antibiotic resistance is "threaten[ing] contemporary medicine's achievements," according to the World Health Organization (WHO, 2018a, para. 17), but the consequences are projected to extend beyond human health, affecting the animal industry as well as global food security (World Health Organization, 2018a).

Antibiotics are becoming almost worthless against illnesses that they could formerly treat due to rising rates of resistance. Super gonorrhea, a drug-resistant form of gonorrhea, has been identified in nations all over the world, including France, Japan, Spain, Australia, and the United Kingdom (World Health Organization, n.d.-d). Bacteria have already started to develop resistance to colistin, a last-resort antibiotic dubbed "the last cannon remaining in the medical arsenal for treating bacterial infections" (Agarwal et al., 2018, p. 78). Worse, according to the World Health Organization, there is a shortage of new, effective antibiotics in development (World Health Organization, 2017b). If resistance rates continue to rise, the mortality toll from antimicrobial resistance in the United States alone is anticipated to reach about 30,000 per year by 2050. (OECD, 2018). Furthermore, it is estimated that antimicrobial resistance would cause 10 million fatalities per year between 2015 and 2050, primarily in Africa and Asia, based on present trends (European Commission, n.d.-a). The repercussions of widespread worldwide antibiotic resistance are so

catastrophic that some have compared our destiny to reverting to a pre-antibiotic age (World Health Organization, 2018a).

1.2 Rationality

The largest drawback of the SDGs in terms of antibiotic resistance is that they don't even mention it, unless you consider the overarching aim to battle all communicable illnesses. Another illustration of how we are grossly underestimating the possibility of widespread antibiotic resistance is this omission. Others have recognized this gap, and some have gone on to explain how antibiotic resistance has a significant impact on our ability to achieve the SDGs, including more visible targets like universal health coverage or communicable diseases, as well as less visible targets like no poverty or sustainable economic growth (Jasovsk et al., 2016; Cars and Jasovsk, 2015). "The world urgently needs to modify how antibiotics are prescribed and used." Antibiotic resistance will continue to be a serious problem even if new medications are produced. Vaccination, hand washing, safer sex, and proper food hygiene are all examples of behavior modifications that might help prevent the transmission of illnesses" (World Health Organization, 2018a, para. 5). While the latter may be addressed by accomplishing the SDGs, none of the targets specifically mention antibiotic prescription and usage, suggesting that this danger may be overlooked in favor of other issues. We continue to underestimate the magnitude of the consequences of widespread antibiotic resistance, and our time with effective medicines is rapidly running out.

CHAPTER 2

Research Question and Research Objective

2.1 Research questions

One research question has been defined by me based on a possible threat to achieving sustainable development goals for antibiotic resistance based on question answer problem solution that has been presented in below in where those questions are set in such a way to find out a crystal visions of the present situations that would have used in antibiotic resistance issue, the pattern type to cover up the aspect of the goal of the study which will help us to understand to find out the correct case study and methodological approach as which tends the mechanism of verification and also validation about the overall article.

Research Question

1. What are the possible threat of antibiotic to achieving sustainable development goals?

2.2 Research Objective

General objective: To search the possible threats of antibiotic from every aspects and come to a conclusion to determine the ways for getting out of it.

Specific objective: To determine the possible difficulties to reach the goal.

CHAPTER 3

Methods

By using questions proposed by the researcher is one of the best ways to analysis the present antibiotic resistance. One of the common and recommended methodologies is SLR for such kind of studies. It provides a pre-define review technique to demolish the possibilities of biasness specially for the researcher, in where it describes some kind of protocol to review the objectives by defining the review motivations which tends to a set of questionnaires that's leads to the research. By searching relevant articles by using automated keyword search which actually provides the initial articles and then after refreshing those articles by using manual selection that also suggests finding many more articles that are relevant using reference checking in where the whole process leads to the final set of articles. Generalizing the initial articles, we can construct the final set of articles that can be assigned for characterization from all the articles where researcher tend to answer those particular research questions. To draw the conclusion an open discussion has been made where the whole protocol procedures have been discussed in the subsections subsequently. However, a qualitative research method also has been used in this paper as it is well known technique in the discipline of antibiotic resistance which has ability to confirm the behavior of the different models that are used by the researchers. Antibiotic resistance includes the qualitatively more quickly and also gives a procedure for the validation of the findings by using ethnographical, case study and content analysis research. In general, it will help us to understand our literature review such as the content analysis gives a constructive and very controlled analysis within context to use step-by-step models to re-arrange and explore the meaning form the information that are being collected by categorizing, completion and analyzing of those finding data.

3.1 Search strategy

3.1.1 Keywords and Search String

How the article selection has been done will be discussed in this section. We use keyword and using string search methods with the help of research questions which already has described in above. The subject area of the articles which basically reveal the strong focus of different threats to achieving sustainable development goals has been made sure by us. The target of the original

focus of the study and accumulated details of the proposed methodology for the antibiotic resistance has been stated by the authors. Antibiotic resistance impacts on our daily life is one of our main concerns in where an approach of keywords, string search, title and abstract have been described for the fitness of the articles which are controlled against the mentioned criteria throughout the study. The research questions have been broken down in different particular parts with synonyms, alternative spelling or abbreviations. They are as follows:

Upgrade or improve or refine or better or enhance or ameliorate or boost and Issue or problem or trouble or difficulty or complication and to explain or solving or decode or solve or crack and for and achieving sustainable development goals and feature or regard or respect or way or aspect or sense of Antibiotic resistance.

3.1.2 Digital Libraries to Search

We have used automated keyword search for digital library searching. It is widely used and also a very popular strategy in literature surveys which is the responsibility of the first author of this paper to perform such kind of pattern searching. We have searched four digital libraries for this prospect: Springer Link, ACM, Google Scholars and IEEE in where those libraries are very well known and famous and also distinguished for open-source research platforms. The search terms are defined according to the necessity and questions to acquire the knowledge. To construct the whole strings, we then merged the search terms in such a manner which could accumulate our guideline for the digital library search which are as follows:

Terms representing Improve: “ameliorate”, “upgrade”, “refine”, “enhance”, “revamp”, “perk up”
Terms representing Issue: “affair”, “matter in question”, “thing”, “case”,” matter”, “point”, “concern”
Terms representing Solve: “puzzle out”, “decode”, “clear up”, “decipher”
Terms representing Sustainable: “defendable”, “defensible”,” justifiable”, “maintainable”, “supportable”, “tenable”
Terms representing Antibiotic: “drug”, “medicament”, “medication”, “medicinal”, “medicine”, “pharmaceutical”
Terms representing Resistance: “opposition to”, “hostility to, aversion to”, “refusal to accept”, “unwillingness to accept”, “disinclination to accept”, “reluctance to accept”, “lack of enthusiasm for”

3.1.3 Keyword search and Manual Selection

Report dictated that automated keyword search for digital libraries sometimes do not give a good and suitable papers which are necessary for SLR review as because lack of set of keywords. Also,

these abstract of the articles which are not good enough to support for collecting many other disciplines. So, the 10 articles which are collected from digital libraries may have contained topics which are not relevant for the appropriate designated SLR review. In this situation, I have performed a manual search also to obtain necessary articles throughout the titles, keywords and abstract to minimize the biasness of the researcher by the mentioned selection process and cross checked the above selected articles to make sure the selection is appropriate which basically end up with 6 articles.

3.1.4 Final set of Articles

At the very end, we sum up 10 articles by the selection process and the complete list of the articles has been discussed in the Reference section.

3.2 Eligibility criteria

Studies meeting the following criteria were included:

1. Study participants aged less than 5 years who are at risk of developmental delay
2. Original studies (both observational and experimental)
3. Study where single, as well as multiple developmental domains, were examined

We excluded studies considering the following factors:

1. Studies conducted on diagnosed cases of developmental delay
2. Studies focusing on autism spectrum disorder (ASD) and other behavioral disorders
3. Studies on developmental delay among children aged more than 5 years.
4. Interventional studies on developmental delay.
5. Studies on developmental delay published before 2005.
6. Article published in languages other than English.

Selection criteria for this systematic review has been further explained in terms of key study elements and presented in the Table 3.1

Table 3.1: Selection Criteria for Systematic Review in terms of Study Elements

Variable	Inclusion	Exclusion
Population	Humans All ages	Animals Plants

	All genders Infection with antimicrobial resistant organism	
Intervention	N/A	N/A
Comparator	N/A	N/A
Outcomes	Associated heath burden, to include but not restricted to: Morbidity, for example excess length of stay in hospital Mortality Associated Healthcare cost burden, to include but not restricted to: Resource use Opportunity cost Economic burden, to include but not restricted to: Costs associated with loss of productivity and reduced labor force Work-loss hours per/case episode Secondary burden from not being able to use antibiotics in ways previously or currently used in healthcare, to include but not restricted to: Reduced surgery Reduced use in chemotherapy and similar therapies	Health related quality of life only Molecular biology only Epidemiology only Outcomes associated with the evaluation of an intervention such as clinical cure rate only
Study design	Case control studies Cohort studies Cross sectional studies Longitudinal studies Randomized controlled trials Modelling studies Modelling studies Economic evaluations	Editorials Letters Case series report Conference abstracts Evaluation of treatments Reviews
Other	English language	Article published in languages other than English

3.3 Prisma model

To illustrate the study selection process, a PRISMA flow diagram has been prepared (as shown in Fig. 3.1)

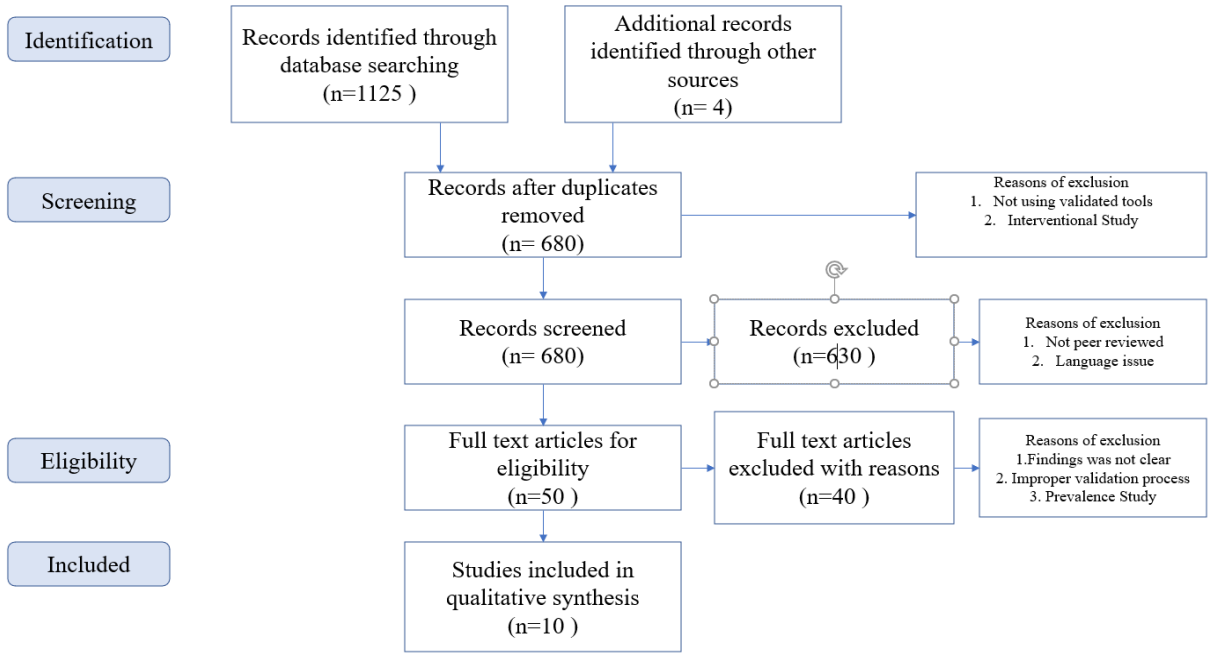

Figure 3.1: PRISMA Flow Diagram of the Study Selection Process

3.4 Validity Threat:

To conduct the literature review is totally up to human point of view and there may occur researcher bias threat and falsification inclusively. I have maintained some rules and regulations to overcome these types of errors. The general validation threats on data collection, article selection and methodology have been discussed as follows:

3.4.1 Data Collection

At the very beginning for collecting data, I created some research questions. I set the questions in a proper discipline to make the findings appropriate in our sense. I have sorted out many articles

which are enlisted in the reference section. I calculate the whole procedure that will make my goal comprehensible.

3.4.2 Article Selection

First of all, depending on the title key words search strings has been generated then for collecting appropriate article I did both manual and automated key search which reduced the biasness of selecting proper and accurate articles. I choose four renowned digital libraries to perform digital library search string. Lastly, to reduce any types of biasness, I made a cross check to the whole things just like a domain expert.

3.4.3 Explaining Methodology in Crystal

We explained our methodology of this paper very clearly. We would like to add one thing, on that methodology portion we followed qualitative method in considering case study research and content analysis.

CHAPTER 4

Results

After doing selection of articles with manner, our following phase is to illustrate the findings according to our study that has been discussed earlier.

Table 4.1: Basic information of the selected published articles that measured threat to achieving sustainable development goals regarding antibiotic resistance

Serial	Study References	Study Title	Authors	Year of Publication	Journal Name, volume, issue	Search Engine	Link of the Article
1	Aminov, R.I. (2010)	Brief History of the Antibiotic Era: Lessons Learned and Challenges for the Future	Rustam I. and Aminov	2010	Front Microbiol	Google	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3109405/
2	Llor, C., & Bjerrum, L. (2014)	Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem	Carl Llor and Lars Bjerrum	2014	Therapeutic Advances in Drug Safety, 5(6), 229-241	Google	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4232501/
3	H Goossens, M Ferech, R Vander Stichele, M Elseviers	Outpatient antibiotic use in Europe and association with resistance: a cross-national database study	Herman Goossens, Matus Ferech, Robert Vander Stichele, Monique Elseviers	2005	The Lancet, 365(9459)	Google	https://www.sciencedirect.com/science/article/abs/pii/S0140673605179070

4	Kamata, K., Tokuda, Y., Gu, Y., Ohmagari, N., & Yanagihara, K. (2018)	Public knowledge and perception about antimicrobials and antimicrobial resistance in Japan: A national questionnaire survey in 2017	Kamata, K., Tokuda, Y., Gu, Y., Ohmagari, N., & Yanagihara, K.	2018	PloS one, 13(11)	Google	https://doi.org/10.1371/journal.pone.0207017
5	Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J., Klugman, K., & Davies, S	Access to effective antimicrobials: a worldwide challenge	Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J., Klugman, K., & Davies, S	2016	The Lancet, 387(10014)	Google	https://www.sciencedirect.com/science/article/pii/S0140673615004742
6	C. Lee Ventola	The Antibiotic Resistance Crisis	C. Lee Ventola	2015	A peer-reviewed journal for formulary management	Google	https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4378521/
7	Francesca P., Patrizio P., Annalisa P.	Antimicrobial resistance: a global multifaceted phenomenon	Francesca Prestinaci, Patrizio Pezzotti, Annalisa Pantosti	2015	Pathogens and Global Health	Google	https://www.tandfonline.com/doi/abs/10.1179/2047773215Y.0000000030
8	Carl L. and Lars B.	Antimicrobial resistance: risk associated with antibiotic overuse and initiatives to reduce the problem	Carl Llor and Lars Bjerrum	2014	Therapeutic advances in drug safety	Google	https://journals.sagepub.com/doi/full/10.1177/2042098614554919
9	Jasovský, D., Littmann, J., Zorzet, A., & Cars, O	Antimicrobial resistance—a threat to the world's sustainable development	Dusan Jasovsky, Jasper Littmann, Anna Zorzet and Otto Cars	2016	Upsala journal of medical sciences	Google	https://www.tandfonline.com/doi/full/10.1080/03009734.2016.1195900
10	McDermott, E	The Threat of Antibiotic Resistance on Global Health	McDermott, Emma	2019	University of Prince Edward Island	Google	https://islandscholar.ca/islandora/object/ir%3A23089/datastream/PDF/view

Table 4.2: Background information and methodology of the selected published articles that measured threat to achieving sustainable development goals regarding antibiotic resistance

Serial No.	References	Study Place	Target Population	Study design	Sampling	Type of statistical analysis
1	Aminov, R.I. (2010)	UK	Ancient people	Randomized and history type	Simple random sampling	Incidence
2	Llor, C., & Bjerrum, L. (2014)	UK	Generalized	Quantitative analysis	Simple Random sampling	Inferential
3	H Goossens, M Ferech, R Vander Stichele, M Elseviers	EU	Regional	Randomized	Systematic sampling	Associational
4	Kamata, K., Tokuda, Y., Gu, Y., Ohmagari, N., & Yanagihara, K. (2018)	JAPAN	Regional	Randomized	Stratified	Inferential
5	Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J., Klugman, K., & Davies, S	75 countries	Generalized	Randomized and descriptive	Random sampling	Associational
6	C. Lee Ventola	USA	Regional	Descriptive	Systematic	Inferential
7	Francesca P., Patrizio P., Annalisa P.	Global	Generalized	Tabular formatted, quantitative	Systematic	Descriptive
8	Carl L. and Lars B.	Europe	Regional	Descriptive	Stratified	Inferential

9	Jasovský, D., Littmann, J., Zorzet, A., & Cars, O	Global	Generalized	Descriptive	Random sampling	Incidence
10	McDermott, E	Global	Generalized	Descriptive analysis	Systematic	Inferential

Simple random sampling: One of the best probability sampling techniques that helps in saving time and resources, is the Simple Random Sampling method. It is a reliable method of obtaining information where every single member of a population is chosen randomly, merely by chance. Each individual has the same probability of being chosen to be a part of a sample.
Cluster sampling: Cluster sampling is a method where the researchers divide the entire population into sections or clusters that represent a population. Clusters are identified and included in a sample based on demographic parameters like age, sex, location, etc. This makes it very simple for a survey creator to derive effective inference from the feedback.
Stratified random sampling: Stratified random sampling is a method in which the researcher divides the population into smaller groups that don't overlap but represent the entire population. While sampling, these groups can be organized and then draw a sample from each group separately.
Systematic sampling: Researchers use the systematic sampling method to choose the sample members of a population at regular intervals. It requires the selection of a starting point for the sample and sample size that can be repeated at regular intervals. This type of sampling method has a predefined range, and hence this sampling technique is the least time-consuming.

Table 4.3: Major findings from the selected published articles that measured threat to achieving sustainable development goals regarding antibiotic resistance

Serial No.	References	Notable statistical findings	Major success of the antibiotic	Failure or limitation of the antibiotic	Identified confounding factors	Summary
1	Aminov, R.I. (2010)	Each year, about 25,000 patients in the EU die from an infection with the selected multidrug-resistant bacteria and more than 63,000 patients in the United States die every year from hospital-	Development of novel strategies in the search for new antimicrobials and designing more effective preventive measures.	The behavioral patterns, such as hygienic habits or compliance with antibiotic treatment regimens, may have consequences that are not limited only to individual health issues but, on a larger scale, contribute to the interaction with the resistors around us.	Antimicrobials, antibiotic resistance, and chemotherapy.	This article gives a very brief overview of the antibiotic era, beginning from the discovery of the first antibiotics until the present-day situation, which is marred by the emergence of hard-to-treat multiple antibiotic-

		acquired bacterial infections.				resistant infections
2	Llor, C., & Bjerrum, L. (2014)	According to the European Centre for Disease Prevention and Control, 25,000 people in Europe die each year as a direct result of resistant infection.	The benefits of antibiotic therapy for most respiratory tract infections are modest in the best-case scenario.	A recent survey including more than 1000 GPs carried out in the UK found that 55% felt under pressure, mainly from patients, to prescribe antibiotics, even if they were not sure that they were necessary, and 44% admitted that they had prescribed antibiotics to get a patient to leave the surgery.	Antibiotic resistance, rational use of antibiotics.	Antimicrobial resistance is a global public health challenge, which has been accelerated by the overuse of antibiotics worldwide. Increased antimicrobial resistance is the cause of severe infections, complications, longer hospital stays, and increased mortality. Overprescribing of antibiotics is associated with an increased risk of adverse effects, more frequent re-attendance, and increased medicalization of self-limiting conditions.
3	Herman Goossens, Matus Ferech, Robert Vander Stichele, Monique Elseviers	Prescription of antibiotics in primary care in Europe varied greatly; the highest rate was in France (32·2 DDD per 1000 inhabitants daily) and the lowest was in the Netherlands (10·0 DDD	We suggest that a low seasonal fluctuation of the early fluoroquinolones, such as ciprofloxacin, is a good marker of restrained use. Levofloxacin and moxifloxacin have better activities against pneumococci than do the early agents and their	Our study indicates a tendency to use new antibiotics, which fail to offer substantial improvements over other available drugs. We also show that the variation in resistance between different European countries can be explained by variation in selection pressure for resistance.	ESAC project, antibiotic prescribing	Resistance to antibiotics is a major public health problem and antibiotic use is being increasingly recognized as the main selective pressure driving this resistance. Our aim was to assess outpatient use of antibiotics and the

		per 1000 inhabitants daily).	introduction in Europe was generally very successful in countries with high antibiotic use and resistance rates.			association with resistance.
4	Kamata, K., Tokuda, Y., Gu, Y., Ohmagari, N., & Yanagihara, K. (2018)	Among a total of 3,390 participants, about half had taken antibiotics over the past 12 months, and the majority of them obtained the antimicrobials from healthcare institutions for the common cold. While 11.7% of the participants kept leftover antibiotics, 23.6% of them have adjusted doses by themselves. About 10% of the participants have requested antibiotics from their doctors, and nearly 30% of them preferred doctors who prescribed antibiotics	About 1 out of 10 participants (10.2%) asked for antibiotic prescriptions from their doctors at the medical visit, and 3 out of 10 participants (30.2%, 1023) believed that doctors who prescribed them for cold were good.	Only about 22% of participants in Japan know that antibiotics could not kill viruses. In the EU, 43% of the citizens knew that antibiotics do not kill viruses and thus twice the number of European people answered correctly. When asked if antibiotics are effective against cold and flu, only one-quarter of the participants (24.6%) provided the correct answer that they are not. Although 67.5% of the participants knew that antibiotics would not work in the future unless used properly, only about 20% of them knew what kind of diseases or pathogens they are effective for. Also, an understanding of the side effects of antibiotics was insufficient (Japan, 38.8%; EU, 66%).	cross-sectional survey, INTAGE Corporation	Antimicrobial resistance (AMR) is a threat to global health. To increase public awareness about AMR and encourage the prudent use of antimicrobials is one of the goals of the National Action Plan in Japan.

		when had a cold.				
5	Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J., Klugman, K., & Davies, S	It is estimated that universal coverage with a pneumococcal conjugate vaccine could avert up to 11·4 million days of antibiotics for pneumonia caused by Streptococcus pneumoniae in children younger than 5 years per year, a 47% reduction in days on antibiotics in the 75 countries included in our analysis.	Antimicrobials, particularly antibiotics, have been a mainstay of modern medicine for the last eight decades. Penicillin lowered mortality associated with pneumococcal pneumonia from 20–40% to 5%,1–3, and mortality from pneumococcal bacteremia from 50–80%4 to 18–20%.3,5,6 In the past few decades, antibiotics have been used to support modern medical care, including the ability to do surgeries and organ replacements and treat cancer.	Resistance to antibiotics threatens improvements made in child survival. Globally, an estimated 214 000 neonatal sepsis deaths (139 000 LHS minimum, 318 000 LHS maximum) are attributable to resistant pathogens each year.	Resistant organisms, surgeries, transplants, and cancer treatment	The importance of effective antimicrobials. We assess the disease burden caused by limited access to antimicrobials, attributable to resistance to antimicrobials, and the potential effect of vaccines in restricting the need for antibiotics.
6	C. Lee Ventola	Nearly two million Americans per year develop common (healthcare-associated infections) HAIs, resulting in 99,000 deaths, most due to antibacterial resistant pathogens. In 2006, two	Antibiotics have not only saved patients' lives, but they have also played a pivotal role in achieving major advances in medicine and surgery. They have successfully prevented or treated infections that can occur in patients who are receiving chemotherapy treatments; who	Incorrectly prescribed antibiotics also contribute to the promotion of resistant bacteria. Studies have shown that treatment indication, choice of agent, or duration of antibiotic therapy is incorrect in 30% to 50% of cases.5,18 One U.S. study reported that a pathogen was defined in only 7.6% of 17,435 patients hospitalized with	The Centers for Disease Control and Prevention (CDC), efficacy of antibiotics	The antibiotic resistance crisis has been attributed to the overuse and misuse of these medications, as well as a lack of new drug development by the pharmaceutical industry due to reduced economic incentives and challenging

		HAIs (sepsis and pneumonia) were found to be responsible for the deaths of nearly 50,000 Americans and cost the U.S. health care system more than $8 billion.	have chronic diseases such as diabetes, end-stage renal disease, or rheumatoid arthritis; or who have had complex surgeries such as organ transplants, joint replacements, or cardiac surgery.	community-acquired pneumonia (CAP). In comparison, investigators at the Karolinska Institute in Sweden were able to identify the probable pathogen in 89% of patients with CAP through use of molecular diagnostic techniques (polymerase chain reaction [PCR] and semiquantitative PCR). In addition, 30% to 60% of the antibiotics prescribed in intensive care units (ICUs) have been found to be unnecessary, inappropriate, or suboptimal.		regulatory requirements. The Centers for Disease Control and Prevention (CDC) has classified a number of bacteria as presenting urgent, serious, and concerning threats, many of which are already responsible for placing a substantial clinical and financial burden on the U.S. health care system, patients, and their families.
7	Francesca P., Patrizio P., Annalisa P.	In the US, more than two million people every year are affected with antibiotic-resistant infections, with at least 23 000 dying as a result of the infection. In the US, the CDC estimated the cost of AMR as $55 billion per year overall: $20 billion in excess for direct healthcare costs, with additional society costs for lost	Several fields of modern medicine depend on the availability of effective antibiotic drugs; chemotherapy for cancer treatment, organ transplantation, hip replacement surgery, intensive care for pre-term newborns and many other activities could not be performed without effective antibiotics. In fact, infections caused by multidrug-resistant bacterial strains are among the main factors influencing morbidity and	In the hospital setting, the intensive and prolonged use of antimicrobial drugs is probably the main contributor to the emergence and spread of highly antibiotic-resistant nosocomial infections; but other factors can play an important role: presence of highly susceptible immunosuppressed patients (e.g. AIDS patients, cancer patients, or transplant recipients) and fragile elderly patients, invasive surgical procedures and intensity of clinical therapy, lengthy of stay in hospital,10 failure to control infections spread	Global surveillance, Veterinary medicine, MRSA, Klebsiella pneumoniae, Non-typhoidal Salmonella, Mycobaterium tuberculosis	It will be focused on antibacterial resistance (ABR), which represents at the moment the major problem, both for the high rates of resistance observed in bacteria that cause common infections and for the complexity of the consequences of ABR. It will be described the health and economic impact of ABR, the principal risk factors for its emergence, and, in particular, will be illustrated the highlights of four antibiotic-resistant

		productivity as high as $35 billion a year.	mortality in patients undergoing these procedures.	from patient to patient.		pathogens of global concern – Staphylococcus aureus, Klebsiella pneumonia, non-typhoidal Salmonella, and Mycobacterium tuberculosis.
8	Carl L. and Lars B.	According to the European Centre for Disease Prevention and Control, 25,000 people in Europe die each year as a direct result of resistant infection. Antibiotic resistance leads to an increased amount of healthcare costs. It is estimated that complications associated with antibiotic resistance cost €9 billion annually in Europe. A recent review demonstrated that the additional cost of resistance could be of £20,000 per patient episode in hospital.	Most of the antibiotics used in medicine are prescribed by general practitioners (GP). In fact, primary care accounts for 80–90% of all antibiotic prescriptions in Europe and most antibiotics are prescribed for respiratory tract infections. Utilization of antibiotics is also very important in other sectors; for instance, approximately 80% of antibiotics in the United States are consumed in agriculture, farming and aquaculture.	Infection with antibiotic-resistant bacteria may cause severe illness, increased mortality rates, and an increased risk of complications and admission to hospital. Consumption of antibiotics puts patients at risk of adverse effects. Antibiotics account for approximately 20% of all drug-related emergency department visits in the United States. Although nearly 80% of these visits are attributable to allergic reactions, certain commonly prescribed antibiotics contribute to conditions that range from gastrointestinal to neurologic and psychiatric disorders.	Antibiotic resistance, primary care, point-of-care tests, rational use of antibiotics, strategies	Antibiotic overprescribing is a particular problem in primary care, where viruses cause most infections. About 90% of all antibiotic prescriptions are issued by general practitioners, and respiratory tract infections are the leading reason for prescribing. Multifaceted interventions to reduce the overuse of antibiotics have been found to be effective and better than single initiatives.
9	Jasovský, D., Littmann, J.,	Resistance to antimicrobial drugs already	Communicable diseases. Alarmingly,	The impact of AMR is not limited to infectious diseases. It	Antibiotic resistance; antimicrobial	This commentary examines how specific

	Zorzet, A., & Cars, O	causes an estimated 700,000 deaths annually and without effective action is predicted to cause 10 million deaths annually and cost up to US$100 trillion by 2050.	214,000 neonatal sepsis deaths annually are directly attributable to drug-resistant pathogens. This severely impacts plans to reduce neonatal mortality to less than 12 per 1,000 live births under SDG target 3.2. In the last 15 years, child mortality has declined by 47%, which is largely due to reductions in deaths from pneumonia, a leading cause of child mortality globally. If drug resistance continues to rise, and if access to effective antibiotics is not guaranteed, these health gains could be reversed.	also has potentially disastrous consequences for the treatment of many non-communicable diseases (NCDs). A clear example is a threat that AMR poses to the safety and effectiveness of procedures such as surgical interventions, cancer treatment, and organ transplants. For example, up to 50% of pathogens causing surgical site infections are resistant to standard prophylactic antibiotics in the US. Similarly, every fourth patient on cancer treatment suffered from infections caused by pathogens that were resistant to commonly used antibiotics. Immunocompromised patients who have undergone transplantations or chemotherapy or who have AIDS are more vulnerable to infections.	resistance; sustainable development; sustainable development goals	sustainable development goals (SDGs) are affected by antimicrobial resistance and suggests how the issue can be better integrated into international policy processes. The paper stresses the need for greater international collaboration and accountability distribution and suggests steps towards a broader engagement of countries and United Nations agencies to foster global intersectoral action on antimicrobial resistance.
10	McDermott, E	The Organization for Economic Co-operation and Development (OECD) predicts that by 2050 an estimated 2.4 million deaths, in North America,	Since the discovery of antibiotics, the leading cause of death in the United States has switched from communicable diseases to non-communicable diseases, such as cardiovascular diseases or cancer, and the	When routinely used antibiotics, often called first-line antibiotics, become less effective against their respective bacteria infections, healthcare providers are forced to use more potent second-and third-line options. As shown in Figure 4, the prescription of second-line	The Organization for Economic Co-operation and Development, health risk, social, economic, and political factors, and current global preventative actions/programs.	This mini-thesis project is a part of UPEI's Master in Global Affairs program in partnership with the Universidad Rey Juan Carlos in Spain. It will use a multi-disciplinary approach to examine the threat antibiotic

		Australia, and Europe alone, will be due to drug-resistant infections.	average life expectancy has increased by slightly more than thirty years. The discovery of antibiotics was a world-altering moment in history, but increased rates of antibiotic resistance are threatening to send us back to a 'pre-antibiotic era', where what we currently consider to be minor infections could easily become life-threatening.	antibiotics is already becoming more prominent, especially in the countries that have higher overall prescription rates.		resistance poses to global health. Topics considered will include the causes of antibiotic resistance, the effects of widespread antibiotic resistance on social, economic, and political factors, and current global preventative actions/programs.

4.1 Summary & Critical Appraisal of the Selected Published Articles

a. Paper 1(Aminov, R.I. (2010))

This article provides a high-level overview of the antibiotic period, from the discovery of the first antibiotics to the current situation, which is characterized by the rise of difficult-to-treat multidrug-resistant illnesses. The development of novel strategies in the search for new antimicrobials, the design of more effective preventive measures, and, most importantly, a better understanding of the ecology of antibiotics and antibiotic resistance are discussed as possible responses to the antibiotic resistance challenges. It is also examined how current advancements in the fields of antimicrobials, antibiotic resistance, and chemotherapy have expanded conceptual frameworks. Despite the fact that the post covers a highly scary issue at this ideal study environment, adding some more layers of details and analysis would improve the content for the researchers.

b. Paper 2(Llor, C., & Bjerrum, L. (2014))

Antimicrobial resistance is a global public health issue that has been exacerbated by antibiotic misuse across the world. Severe infections, complications, longer hospital admissions, and higher mortality are all linked to growing antibiotic resistance. Antibiotic overuse is linked to an increased risk of side effects, more frequent re-visits, and increasing medicalization of self-limiting diseases. Antibiotic overuse is a significant issue in basic care, because viruses are the most common cause of illness. General practitioners write around 90% of all antibiotic prescriptions, with respiratory tract infections being the most common cause for doing so. Multiple approaches have been demonstrated to be more successful and better than single initiatives in reducing antibiotic misuse. The use of antimicrobial stewardship programs, the active participation of clinicians in audits, the use of valid rapid point-of-care tests, the promotion of delayed antibiotic prescribing strategies, the enhancement of communication skills with patients using information brochures, and the performance of more pragmatic studies in primary care should all be part of the interventions.

c. Paper 3(H Goossens, M Ferech, R Vander Stichele, M Elseviers)

Antibiotic resistance is a serious public-health concern, and antibiotic usage is rapidly being recognized as the primary selection factor generating resistance. Our goal was to look at antibiotic use in outpatient settings and see if there was a link to resistance. Between January 1, 1997, and December 31, 2002, we calculated the number of defined daily doses (DDD) per 1000 inhabitants per day in 26 European countries that provided internationally comparable distribution or reimbursement data, using WHO anatomic therapeutic chemical classification and DDD measurement methodology. Using Spearman's correlation coefficients, we evaluated the ecological relationship between antibiotic usage and antibiotic resistance rates. The greatest rate of antibiotic prescription in primary care in Europe was in France (322 DDD per 1000 people daily), while the lowest rate was in the Netherlands (100 DDD per 1000 inhabitants daily). A transition from traditional narrow-spectrum antibiotics to new broad-spectrum antibiotics was seen. We also found significant seasonal variations, with winter peaks in nations with high annual antibiotic use. Antibiotic resistance was shown to be greater in high-consumption nations, which is likely due to the fact that southern and eastern Europe use more antibiotics than northern Europe. These findings might be valuable in evaluating public-health programs aimed at reducing antibiotic usage and resistance.

d. Paper 4(Kamata, K., Tokuda, Y., Gu, Y., Ohmagari, N., & Yanagihara, K. (2018))

The threat of antimicrobial resistance (AMR) to global health is real. One of the aims of Japan's National Action Plan is to raise public awareness about antimicrobial resistance and urge the wise use of antimicrobials.

Based on the Antimicrobial Resistance Eurobarometer Survey, a countrywide online cross-sectional survey was undertaken to assess current knowledge and perceptions of AMR in Japan.

Participants were Japanese people between the ages of 20 and 69 who were not medical practitioners.

About half of the 3,390 participants had taken antibiotics in the previous 12 months, and the majority of them got the antibiotics from healthcare facilities for the common cold. While 11.7 percent of those who took part in the study retained leftover antibiotics, 23.6 percent modified their dosages on their own. Approximately 10% of the individuals asked their doctors for medicines, and almost 30% favored doctors who recommended antibiotics when they had a cold. The most popular sources of information were television news and newspapers, and more than 40% of the participants said they had received some information in the previous year. However, about 80% of the participants were unaware that antibiotics do not kill viruses and are useless against the common cold and flu.

Many Japanese people lack proper knowledge regarding antimicrobials and AMR, and many have misused antimicrobials. To raise public awareness and create effective remedies against AMR in Japan, more educational activities are required.

e. Paper 5(Laxminarayan, R., Matsoso, P., Pant, S., Brower, C., Røttingen, J., Klugman, K., & Davies, S)

Life expectancy and access to antimicrobials have improved dramatically in recent years, particularly in low- and lower-middle-income countries, but rising bacterial resistance to antimicrobials threatens to reverse this progress. Resistant organisms in health-care and community settings jeopardize patient survival from major infections, such as newborn sepsis and health-care-associated infections, and restrict the health benefits of operations, transplants, and cancer therapy. The challenge of expanding appropriate antimicrobial access while restricting inappropriate access, particularly to expensive, newer generation antimicrobials, is unique in global health, and it necessitates new approaches to financing and delivering health care, as well as a one-health perspective on pathogen transmission in animals and humans. We discuss the necessity of effective antimicrobials in this article. We analyze the illness burden caused by limited antimicrobial availability due to antimicrobial resistance, as well as the potential impact of vaccinations in reducing the need for antibiotics.

f. Paper 6(C. Lee Ventola)

This paper has covered a lot of things such as history of Antibiotics, benefits of Antibiotics, Causes of the antibiotic resistance crisis (overuse, inappropriate prescribing, extensive agricultural use etc.). It helps to get idea regarding the topic but there was not any kind of applied research like simulation or data analysis. That’s why there was no out come from this paper but it generates a

lot of knowledge which could not find other paper. The main purpose of this paper is to demonstrate the facts which is also important to enhance the knowledge for doing research.

g. Paper 7(Francesca P., Patrizio P., Annalisa P.)

Antimicrobial resistance (AMR) is one of the century's most important worldwide public health issues. The first World Health Organization (WHO) Global report on AMR surveillance, published in April 2014, gathered data from national and international surveillance networks for the first time, revealing the extent of this phenomenon in many parts of the world as well as large gaps in existing surveillance. In this study, we focus on antibacterial resistance (ABR), which is now the most serious issue, both because of the high rates of resistance found in bacteria that cause frequent diseases and because of the complexities of ABR's effects. We describe the health and economic consequences of ABR, as well as the main risk factors for its emergence. We highlight four antibiotic-resistant pathogens of global concern – Staphylococcus aureus, Klebsiella pneumoniae, non-typhoidal Salmonella, and Mycobacterium tuberculosis – for which we provide global resistance data. The authors provide strategies for preventing the formation and spread of ABR.

h. Paper 8(Carl L. and Lars B.)

Antimicrobial resistance is a global public health issue that has been exacerbated by antibiotic misuse across the world. Severe infections, complications, longer hospital admissions, and higher mortality are all linked to growing antibiotic resistance. Antibiotic overuse is linked to an increased risk of side effects, more frequent re-visits, and increasing medicalization of self-limiting diseases. Antibiotic overuse is a significant issue in basic care, because viruses are the most common cause of illness. General practitioners write around 90% of all antibiotic prescriptions, with respiratory tract infections being the most common cause for doing so. Multiple approaches have been demonstrated to be more successful and better than single initiatives in reducing antibiotic misuse. The use of antimicrobial stewardship programs, the active participation of clinicians in audits, the use of valid rapid point-of-care tests, the promotion of delayed antibiotic prescribing strategies, the enhancement of patient communication skills with the aid of information brochures, and the performance of more pragmatic studies in primary care should all be part of the interventions.

i. Paper 9(Jasovský, D., Littmann, J., Zorzet, A., & Cars, O)

This opinion looks at how antimicrobial resistance affects certain Sustainable Development Goals (SDGs) and offers suggestions for how the problem might be better integrated into international policy processes. We explore how antimicrobial resistance affects environmental, social, and economic aims in the SDG framework, in addition to the need of effective antibiotics for the treatment of acute infections and health care in general. The study emphasizes the importance of

increased international collaboration and responsibility, as well as moves toward a deeper participation of governments and UN agencies to create global antimicrobial resistance intersectoral action.

j. Paper 10(McDermott, E)

One of the largest public health risks currently facing the world is antibiotic resistance. Antibiotic resistance is when bacteria develop a resistance against antibiotics that could previously have been used to treat them. The Organization for Economic Co-operation and Development (OECD) predicts that by 2050 an estimated 2.4 million deaths, in North America, Australia, and Europe alone, will be due to drug-resistant infections. Humans have become increasingly dependent on the success of antibiotics at treating bacterial infections, and therefore the looming threat of resistance is a critical global threat. This mini-thesis project is a part of UPEI's Master in Global Affairs program in partnership with the Universidad Rey Juan Carlos in Spain. It will use a multi-disciplinary approach to examine the threat antibiotic resistance poses on global health. Topics considered will include the causes of antibiotic resistance, the effects of widespread antibiotic resistance on social, economic, and political factors, and current global preventative actions/programs. Antibiotic resistance is a major emerging health risk, and the extent of its impact is underappreciated in the global community.

CHAPTER 5

Discussions

5.1 Global Response

Dr. Tedros Adhanom Ghebreyesus stated that "strong, sustained action across all sectors is vital if we are to turn back the tide of antimicrobial resistance and keep the world safe" (World Health Organization, 2017d, para. 4), and the global community is slowly beginning to recognize the looming threat of antimicrobial resistance. In December 2014, 30 nations gathered at a high-level conference to examine concerns about rising global antimicrobial resistance (World Health Organization, 2014), and in 2016, antimicrobial resistance became the UN General Assembly's fourth-ever health issue (World Health Organization, 2016).

A worldwide action plan on antimicrobial resistance was formed in 2015 at the World Health Assembly to "guarantee the prevention and treatment of infectious illnesses using safe and effective treatments" (World Health Organization, 2018a, para. 19). Increasing knowledge and understanding, boosting surveillance and supporting research, optimizing usage, lowering the overall frequency of infections, and promising long-term investment in the fight against antimicrobial resistance were among the five key aims outlined in this strategy (World Health Organization, 2018a). The World Health Organization has also established a Global Task Force to help nations cooperate, collaborate, and build their own specific action plans targeted at lowering antibiotic resistance rates (World Health Organization, 2013).

The World Health Organization (WHO) is leading the campaign against antibiotic resistance, but it is not alone. The worldwide community is beginning to notice antibiotic resistance. The United Nations Secretary-General, co-chaired by the Director-General of the World Health Organization, has established an Interagency Coordination Group on Antimicrobial Resistance, which brings together various UN agencies, international organizations, and experts in order to improve coordination and take more effective action against this growing threat (World Health Organization, 2018a). Regional agreements are also forming, such as the Transatlantic Taskforce on Antimicrobial Resistance, which was established in 2009 by an agreement involving Canada,

the European Union, Norway, and the United States (Centers for Disease Control and Prevention, 2018b).

The European Union has begun to take measures as well. Antibiotics were banned in agriculture for growth promotion in 2006, and the European Union created the One Health Action Plan against Antimicrobial Resistance in June 2017, with the three key objectives of "making the EU a best practice region, boosting research, development, and innovation, and shaping the global agenda" (European Commission, n.d-b, para. 3). Furthermore, the Organization for Economic Cooperation and Development (OECD), the G7, and the G20 have all joined the battle against antibiotic resistance (OECD, n.d.), and other nations are following suit. The global community is finally starting to help in the urgent fight against increasing rates of antimicrobial resistance, from creating national policies to antimicrobial stewardship programs (Bordier, 2018; Canadian Food Inspection Agency, 2017; Centers for Disease Control and Prevention, 2018a; Government of Canada, 2018b; National Collaborating Centre for Infectious Diseases, 2017; Public Health Ontario, 2018).

Unfortunately, this is still insufficient. Antimicrobial resistance prevention and control programs are found in fewer than 40% of the world's countries, and only a quarter have enacted national policies on the subject (European Commission, n.d.-a). The US produced a Worldwide Threat Assessment at the start of 2019, identifying dangers to national security, yet it only discusses drug resistance when discussing the threat of Malaria, and it fails to address antibiotic resistance in its totality (Coats, 2019). It would have been simple to include a section on drug resistance to handle malaria and other drug-resistant illnesses, but the US decided to ignore the threat of antibiotic resistance to society by excluding it from the evaluation. "Improved global cooperation and partnership is needed to identify and promote incentives needed to develop effective business models for the development of new therapeutics, diagnostics, and antibiotics, including ways to control the distribution, use, and misuse of antibiotics," according to the World Health Organization (World Health Organization, 2013, para. 6). Only a multi-sectoral international reaction can help prevent antibiotic resistance from spreading further, or at the very least allow us time to identify other options.

5.2 Increasing Awareness Through Educational Campaigns

Educating health professionals and the general public on the causes and effects of antibiotic resistance is one method to help lower the rising risk of resistance. World Antibiotic Awareness Week is the only week-long campaign conducted by the World Health Organization, and it is one of eight recognized global health initiatives (World Health Organization, n.d.-a). Since 2015, awareness of antibiotic resistance and encouraging best practices among the general public, health workers, and policymakers to prevent the establishment and spread of antibiotic resistance." (WHO, n.d.-b, paragraph 1)

Do Bugs Need Drugs? (Alberta Health Services and the British Columbia Centre for Disease Control, 2013) is one example of a local and national campaign, but individuals are also taking action. After learning about the dangers of antibiotic resistance, three Syrian pharmacists were concerned about how pharmaceutical practices in Syria may be contributing to the problem. Antibiotics are sold without a physician's prescription in many pharmacies in Syria, resulting in antibiotic misuse and overuse. Hanaya Raad, Sarah Safadi, and Nour Allahham collaborated with the Syrian Pharmacists' Association to address their concerns and design "an awareness campaign targeting pharmacists' antibiotic prescribing behaviors and public antibiotic abuse." (World Health Organization, 2017a, para. 5). The three were able to reach nearly 400 pharmacies in Damascus' capital city, as well as members of the general public and pharmacy students, with their educational campaign. They intend to expand their campaign to other parts of the country (World Health Organization, 2017a). More people are becoming aware of the hazards of antibiotic resistance and what they can do to help combat it as a result of these initiatives.

Despite these campaigns' best efforts, a huge portion of the worldwide public remains unaware of the impending threat of antibiotic resistance. According to one poll, 44 percent of 1,500 Canadian adults believe antibiotic resistance is "more of a worry for underdeveloped nations" than in their own country (Ubelacker, 2018, para. 12). While 92 percent of Americans questioned agreed that overuse of antibiotics contributes to antibiotic resistance, more than 40% still thought antibiotics were a reasonable therapy for common viral diseases like a runny nose or sore throat (Carter et al., 2016). Worse, just 30% of respondents agreed that antibiotic resistance was a concern (Carter et al., 2016). Another research in Japan showed similarly frightening outcomes. According to Kamata et al., 80% of the 3,390 participants were unaware that antibiotics would not work against viral colds or flus, and 23.6 percent acknowledged to stopping or adjusting the dose prematurely (2018). Mason et al. (2018) showed that educational efforts did not raise public understanding regarding antibiotic resistance and that "exposure to an antibiotic campaign had no meaningful influence on knowledge about concordance/adherence" in London (Mason et al., 2018, para. 3). These findings indicate that more education is required to fully teach the general people about the hazards of antibiotic resistance, as well as how they may help avoid it.

5.3 Implementation of Surveillance Systems

The Global Antibiotic Resistance Surveillance System, or GLASS, was designed by the World Health Organization to assist monitor antimicrobial resistance rates and regulate actions throughout the world. "Some of the world's most prevalent – and possibly most fatal – illnesses are becoming drug-resistant," says Dr. Marc Sprenger, head of the World Health Organization's Antimicrobial Resistance Secretariat. Worst of all, viruses have little regard for national boundaries. As a result, WHO is urging all nations to establish up effective drug resistance surveillance systems that can feed data into this global system" (World Health Organization, 2018b, para. 6). The GLASS system collects, analyzes, and shares data to inform decision makers

and support action at the local, national, and international levels (World Health Organization, 2018a), and is expected to help "estimate disease burden, plan diagnostic and treatment services, monitor the effectiveness of control interventions, and design effective treatment regimens to address and prevent future resistance" based on the design of previous systems (World Health Organization, 2018a) (World Health Organization, 2018b, para. 11).

Antibiotic resistance is still forming, and it will take years for it to become entrenched, which is one of the primary constraints of our existing surveillance techniques. The GLASS initiative has 52 nations joined as of January 2018, and the World Health Organization was actively assisting more countries in developing their own monitoring systems so that they could contribute to GLASS (World Health Organization 2018b). This is an encouraging start, but the fact that over half of the participating nations are classified high-income and only seven are labeled low-income raises questions about the data's veracity. GLASS' typical rates and values will be based mostly on one income class, and hence may not accurately reflect universal world values (World Health Organization, 2018b). Furthermore, the World Health Organization acknowledges that antibiotic resistance surveillance is still evolving, and that the first GLASS report varies "widely in quality and completeness" (World Health Organization, 2018b, para. 9), because the program relies on each country's own surveillance systems, which are all evolving at different rates, if they exist at all. They do, however, emphasize the significance of improving surveillance so that we may "predict and combat one of the most serious dangers to global public health" (World Health Organization, 2018b, para. 8). While the World Health Organization has established drug-resistance surveillance systems for tuberculosis, HIV, and malaria, all of which produce reliable and meaningful data (World Health Organization, 2018b), they all took personnel, funds, infrastructure, and, most importantly, time to establish. Antibiotic resistance isn't going away any time soon.

Another potential flaw in monitoring methods is that they may overestimate existing levels of antibiotic resistance, underestimating the efficacy of the few drugs we still have. The real rates of antibiotic resistance in community-acquired uncomplicated urinary tract infections (UTIs) were much lower than the rates reported in the Antimicrobial Resistance Surveillance System (ARS) data, according to a research by Klingeberg et al. This was most likely owing to the fact that urine culture testing is usually only done in complex or recurring cases, and hence only reported in ARS. Overestimation of antibiotic resistance rates in surveillance data may lead to healthcare practitioners dispensing reserved medicines more frequently, rather than saving them for when we need them most, because the data suggests there are less viable alternatives (Klingeberg et al. 2018).

5.4 Technology and Antibiotic Resistance

Antibiotic resistance is being aided by technological advancements. A new MALDI-TOF equipment has been installed at the Queen Elizabeth Hospital (QEH) in Charlottetown, Prince

Edward Island. The MALDI-TOF equipment, which stands for'matrix-assisted laser desorption ionization time-of-flight' mass spectrometry, allows doctors to perform quick on-site testing to detect infections in the heart, blood, lungs, urinary tract, and other serious organs. Patients used to have to wait 24 hours for their findings, but now they may get them in seconds. The new BD Phoenix antimicrobial susceptibility machine may then be used to find the optimum antibiotic to treat the individual ailment. The QEH Provincial Laboratory conducts 1.7 million tests every year, thus these devices will help cut down on operating expenses. While initially expensive, due to the reduction in time and labor necessary to execute them, a test that formerly cost more than $5 per test now costs less than 50 percents. Dr. Greg German, a QEH medical microbiology and infectious disease expert, also discusses how this machine improves patient care by reducing test wait times, which allows patients to receive treatment and begin to heal sooner (QEH Foundation, 2019; Russell, 2019). Investing in the development of new fast point-of-care testing and technologies will assist clinicians confirm diagnoses and determine whether antibiotics are the best treatment option (Llor and Bjerrum, 2014). Technological advancements are making it simpler to diagnose infections, decide the optimal treatment strategy, and assess if antibiotics are needed to treat the illness, all while preserving medication efficacy.

While technology may help to solve the problem of antibiotic resistance, it may also contribute to its spread. Telemedicine is a new technology that allows people to have audio-video conferences with doctors via their mobile devices. In comparison to urgent care clinics or doctor's offices, children were far more likely to receive antibiotics during telemedicine sessions, according to recent research. Only 59 percent of telemedicine appointments followed clinical guidelines for antibiotic prescriptions, compared to only 32 percent in doctors' offices, and "a higher proportion of those prescriptions disregarded medical guidelines" (The Associated Press, 2019, para. 2), with over half of telemedicine appointments receiving antibiotic prescriptions. Researchers found that telemedicine consultations may lead to cover prescription since doctors are unable to physically check patients or conduct tests over the platform, making it more difficult to distinguish between bacterial and viral diseases (National Institutes of Health, 2019; Ray et al., 2019). Telemedicine in healthcare may improve the ease and accessibility of visiting a doctor, but it may also jeopardize antibiotic efficacy in the future.

5.5 Balancing Preservation and Research

Antibiotic resistance is on the rise, therefore it's critical that we retain the efficiency of the medications we still have. The World Health Organization has developed an antibiotic section on the Essential Medicines Lists, which was formed in 1977 to assist address public health requirements, and now contains a section suggesting "which antibiotics to use for common diseases and which to save for the most urgent situations" (World Health Organization, 2017e, para. 1). The World Health Organization divides antibiotics into three categories based on when they should be used: ACCESS, which they recommend should be widely available to treat common

infections, WATCH, which are antibiotics that can be used as first or second line treatments but should be reserved for specific infections, and RESERVE, which are last-resort options that should only be used in life-threatening situations when no other options are available. "The overarching goal is to encourage sensible usage in order to decrease antimicrobial resistance and retain the effectiveness of medicine's most important antibiotics." This goal is included in the recommendations for antibiotic use in agriculture in today's guidelines" (World Health Organization, 2017d, para. 13). This list gives reason to hope for the survival of the most vital antibiotics for human health.

While preservation is crucial, we must be careful not to overly restrict antibiotic usage. In low- and middle-income nations, more children die each year due to a lack of antibiotic availability than from drug-resistant diseases (Laxminarayan et al., 2016). While resistance may jeopardize antibiotics' long-term effectiveness, short-term solutions must involve increasing their accessibility in these nations (Laxminarayan et al., 2016; Nadimpalli et al., 2018). Antibiotics will become more difficult to get if regulations on their usage are tightened. As a result, it's understandable that the World Health Organization devised many categories in order to strike a compromise between accessibility and preservation.

Unfortunately, it is unlikely that new antibiotics will be developed. "The difficulty is that the pharmaceutical industry is no longer investing time or money looking for new antibiotics," says Gerry Wright, director of McMaster University's Institute for Infectious Disease Research (Ubelacker, 2018, para. 7) because finding new antibiotics is not only difficult but also expensive. "Drug manufacturers aren't prepared to commit the average $1-billion outlay to develop an antibiotic that can cure an infection in five to ten days, when they can put their resources into medications for conditions like high cholesterol or blood pressure, which are typically taken for life," said Gerry Wright, director of the antimicrobial stewardship program at the Sinai Health System and University Health Network in Toronto. Add in the fact that a new antibiotic's shelf life may be limited due to the possibility of resistance among the bacteria it's supposed to treat, and there's little reason" (Ubelacker, 2018, para. 9). Furthermore, the World Health Organization warns that, while some researchers are focusing on creating new medicines, they are unlikely to be successful against antibiotic-resistant bacteria (World Heath Organization, 2018a). "Change Can't Wait" was one of the key slogans for the most recent World Antibiotic Awareness Week, and for good cause. "Our Time with Antibiotics is Running Out" (World Health Organization, n.d.-b), and we can't just wait for new antibiotics to replace the ones that have already lost their efficacy.

A solution may be to focus on fresh research and development, such as prolonging the lives of our present antibiotics. The Global Antibiotic Research and Development Partnership was formed by the World Health Organization and the Drugs for Neglected Diseases program. This initiative fosters research and development through public-private collaborations, with the goal of "developing and delivering up to four new medicines, through enhancement of current antibiotics and acceleration of the entrance of new antibiotic medications" by 2023. (World Health Organization, 2018a, para. 25). Many innovative antibiotic therapies in the past were essentially

improvements on existing antibiotics. Amoxicillin, for example, is a -lactam antibiotic to which bacteria finally evolved resistance. These antibiotic-resistant bacteria can produce -lactamase, an enzyme that breaks down amoxicillin and renders it useless. The bacteria were able to survive despite being treated with amoxicillin because of this ability. Researchers produced a medication that combined amoxicillin with clavulanic acid in order to restore amoxicillin's efficacy. Clavulanic acid is a strong -lactamase inhibitor, which means it can make the bacteria's -lactamase enzymes inactive. This permits the amoxicillin to continue to target the bacteria without being disrupted, extending the antibiotic's efficacy (Todd and Benfield, 1990). New improvements don't necessarily have to involve waiting for an accidental discovery of a novel antibiotic; they might alternatively include restoring the potency of existing antibiotics.

5.6 Sustainable Development Goals as a Solution

Achieving the Sustainable Development Goals of the United Nations may also aid in the reduction of antibiotic resistance. The Sustainable Development Goals, or SDGs, were established in 2015 with the goal of "providing a common blueprint for peace and prosperity for people and the planet, now and in the future" (United Nations, n.d., para. 1). Many of the specific goals outlined in these SDGs, such as increasing vaccine availability, improving access to healthy food and clean water sources, and reducing communicable disease rates, aim to comprehensively address the many global challenges we face, from climate change to poverty and inequality. Antibiotic resistance requires a multilateral, multisectoral approach, and many of the SDGs' targets are aimed at addressing the causes of antibiotic resistance. As a result, meeting these objectives will help to slow the spread of antibiotic resistance.

Number 3: Good Health and Well-Being is the most evident aim that would help to reduce the spread of antibiotic resistance. Antibiotic resistance would be reduced if everyone had access to affordable, universal healthcare. "One of the major reasons parents stated for diverting antibiotics was that they wished to save the expenditures associated with a second trip to the doctor," according to the study on prescription diversion (American Academy of Pediatrics, 2018, para. 10). Antibiotic resistance can also be reduced by vaccinations. If you're protected against vaccine-preventable infections, you won't require antibiotics to treat them, which means you won't add to antibiotic resistance.

Progress on SDG 6: Clean Water and Sanitation, on the other hand, would increase infection management and prevention, limiting the spread of all illnesses, including those caused by antibiotic-resistant bacteria. Nadimpalli et al. (2018) describe a One Health strategy that focuses on ensuring that polluted waste is treated and that access to clean water and sanitation is improved, as well as strengthening food supply chains and regulating antibiotic usage in both humans and agriculture (Nadimpalli et al., 2018). Both higher vaccine usage and enhanced cleanliness, according to the World Health Organization, might help reduce the rising rates of antibiotic resistance (World Health Organization, 2017d). While working toward the SDGs might help

combat antibiotic resistance, widespread antibiotic resistance could prevent the SDGs from being met.

CHAPTER 6

Conclusion

Antibiotic resistance is a serious global health problem that has yet to be sufficiently addressed by the international community. Despite existing measures at the local, national, and international levels, many people are still uninformed of the threat, and more action is required to ensure the long-term preservation of antibiotics. Antibiotic resistance is closely linked to human behaviors, and although the discovery of antibiotics has transformed medicine, doctors must highlight the necessity of correct use and disposal of these prescriptions to ensure that they remain an effective tool against infectious illnesses. We must learn to target infections more precisely and to reduce the indiscriminate use of antimicrobials and other activities that hasten the establishment of emerging resistance mechanisms. Investigating the microbiological world around us for probable causes of antibiotic resistance and spread might aid in the development of early warning and preventative methods to ensure antibacterial effectiveness.

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