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The Solution to Dangerous Antibiotic-resistant Bacteria

Ryan M. Marquardt

Cedarville University, rmarquardt@cedarville.edu

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“The Solution to Dangerous Antibiotic-resistant Bacteria” by Ryan Marquardt

Instructor’s Notes

The technical nature of Ryan Marquardt’s research paper could make it difficult for the average reader to understand, but Ryan not only makes his points clear and easily accessible to a general audience, but he also makes them interesting. How is he able to accomplish clarity? Accessibility? And interest? Is there any point in the essay where you find yourself wishing to know more?

Writers’ Biography

Ryan Marquardt is a junior Molecular and Cellular Biology major from Michigan. Ryan enjoys learning and discovering new things in the realm of biology and writing about them. His hobbies include reading the classics and essays on philosophy and religion, as well as playing guitar and working outdoors.

The Solution to Dangerous Antibiotic-resistant Bacteria

Infectious diseases have ravaged the human race unchecked in various places and times for millennia. When people think of widespread diseases and infections that have historically plagued humanity, often their minds go to the Middle Ages, a time when sanitation and living conditions had not caught up with the mass urbanization of Western society. Bacterial sicknesses like Bubonic Plague became major crises that killed multitudes of people in certain areas. In fact, Bubonic Plague killed as many as 40 million people (Bug1). Finally, during the 1940s when antibiotics such as penicillin became widely available, infectious disease death rates declined dramatically, and such diseases have since caused no significant trouble for the developed world (Interagency Task Force on Antimicrobial Resistance 3). However, microbial diseases are not simply a danger of the past; some infections, even in modern America, have antibiotic resistant strains. These strains hold the potential for devastating populations by overcoming modern medicine. In the

words of one source, “Multidrug-resistance organisms are one of the world’s top health problems” (Lilley et al 608). Currently, several types of Staph, Strep, Tuberculosis, Salmonella, E. coli, and many other infectious diseases strongly resist antibiotic treatment (CDC Office of Infectious Diseases 16-17). Antibiotic resistant bacteria present a major medical problem for modern humanity, and although many different solutions have potential, medical professionals must control bacterial resistance by cooperating with patients on a combination of strict hospital protocol and limited use of antibiotic medication.

While bacterial illness is a major problem that the medical world must address, bacteria do not cause every type of disease. A prerequisite for the study of antibiotic resistance is to know that humans also face the problem of viruses. The key difference between a bacterium and a virus is that a bacterium is a complete cell, capable of living on its own, whereas a virus must infect an already living cell. Antibiotics can only kill bacteria, not viruses, because they interfere in different ways with the life process of the bacterium cell as a whole. If researchers and doctors used this same strategy against viruses, they would kill normal body cells along with the viruses. Therefore, the issue of antibiotic resistance applies only to bacterial diseases.

Obviously, bacteria are the cause of bacterial diseases. In her article “Antibiotics and the Rise of Superbugs,” Georgina Casey, director of Continuing Professional Development for Nurses, explains that “bacteria are prokaryotes, which are single-cell organisms lacking a nucleus or other membrane-bound organelles,” and they can be harmful if they directly attack cells or produce toxins that damage cell processes (20). Although various types of harmful bacteria are everywhere, under normal circumstances epithelial tissue barriers such as skin and the walls of the digestive tract work with the immune system to keep these dangerous microbes in check. When the bacteria are able to reproduce quickly and overwhelm the immune system, however, the human body has problems. Like a swarm of locusts on desert vegetation, bacteria can quickly shut down the processes necessary to sustain life, kill the individual, and go on to reproduce and infect the next person. That is how deadly epidemics such as Bubonic Plague killed so many in the past.

The advent of antibiotic medication in the mid Twentieth

Century staggeringly improved human control over bacterial infection. Since bacteria differ from human body cells in structure and function, “antimicrobial drugs have been developed that can damage or kill the prokaryotic cell with minimal harm to the human host” (Casey 20). In essence, the drug impairs the bacteria’s ability to reproduce and spread. Depending on the specific case, an antibiotic will remove bacteria’s ability to either make its own food, synthesize structural elements, uncoil DNA for replication, or sustain life in other ways. Regardless of the mechanism, the ultimate purpose of an antibiotic is to reduce the bacteria population in the person enough that the body’s immune system can cope with the invasion (Casey 22). Without antibiotics, modern day surgical operations and other treatments would simply be unrealistic because of the risk of bacterial infection, according to Arias and Murray, both professors of medicine at Texas Medical School of Houston (439). Little would be the same in medicine without antibiotics.

Unfortunately, antibiotic medication is no longer a “magic pill” that holds the answer to all cases of bacterial infection. Because of their rapid rates of reproduction, bacteria commonly develop genetic mutations in their DNA, and these changes can occasionally cause a benefit to the microbe in its defense against antibiotics (Casey 23). Before the invention of antibiotics, this would not have mattered because the non-mutated bacterium reproduced uncontrollably anyway. However, once antibiotics came into common usage, these mutated bacteria began to outlive the original type and continue reproduction. Over time, the mutated strain would make up the majority of the population, and the antibiotic that had previously been effective would no longer help. Since multiple types of antibiotics can be useful, this may not cause a dangerous situation in the short term. Simply administering a different antibiotic that the bacteria had no resistance to would succeed in controlling it, though perhaps not as effectively. The real problem is that bacteria constantly mutate, and the strain that survives and reproduces more will become the dominant group. This means that if a bacterium mutates again and obtains some sort of mechanism to resist the new drug, the new strain will survive exposure to both antibiotics. Over time, a species of bacteria may build resistance to all relevant antibiotics in this manner and leave an infected patient untreatable. Although this phenomenon of resistance sounds dangerous on a

scientific level, the practical peril is even more frightening. The CDC Office of Infectious Diseases (OID) reports that each year between bacterial and fungal infections that have a resistance to the antibiotic designed to treat them, over 20 million illnesses and 23,000 deaths occur (13). For a culture that tends to believe modern medicine has infections and bacterial diseases completely under control, that is a devastating amount of illness and death. Humans can pick up microbes in many different ways such as *E. coli* in tainted water or meat or MRSA entering through the open wound of a surgical site in a hospital. Because of the incredible variety in bacteria, finding a single solution is completely unrealistic, and this makes fixing the problem even harder. Even if medicine brings one microbe under control, one that harms in a different way or spreads differently may spring up in its place. The practical danger is obvious.

Antibiotic resistant bacteria present such a real problem because of their unpredictable ability to change, making appropriate antibiotics useless. Theoretically, any harmful bacteria could develop dangerous resistance to several drugs and become an epidemic. Since this is such a relevant threat, many microbiologists and medical professionals are exploring different options to defeat microbes. Some would say that researchers must simply continue to stay ahead of bacteria by formulating new antibiotics to treat a disease before the old ones become ineffective. Arias and Murray explain that “a concerted effort on the part of academic researchers and their institutions, industry, and government is crucial” to formulate new antibiotics that can successfully exterminate resistant bacteria before they become resistant to all currently available antibiotics (443). Ideally for humans, it would work out this way and a new antibiotic would simply wipe out a bacteria. However, since the original antibiotic did not exterminate the bacteria before it developed resistance, assuming that a new antibiotic would wipe it out is unrealistic, and it also presumes upon the fact that researchers will actually invent new antibiotics for all dangerous bacterial infections. While new research is important, and this solution is theoretically possible, humans cannot count on it in the short term to prevent a major outbreak of an antibiotic resistant disease that could kill many. In addition, society cannot view simply inventing new antibiotics to keep bacteria that have developed resistance to other medications in check as a long term solution because at some

point researchers will run out of options in ways to kill bacteria with antibiotics. Other types of solutions are necessary now and most likely also necessary for long term control of bacteria.

One novel solution researchers are currently developing is the use of nanosilver to combat antibiotic resistant *E. coli* and other microbes (Dugal and Chakraborty 498). In this treatment, silver particles disrupt the respiration of the bacteria which cuts off their ability to use energy and kills them (Dugal and Chakraborty 498). The benefits of this treatment include the fact that “silver has a far lower propensity to induce microbial resistance than antibiotics,” and “has been known to be nontoxic to humans in low concentrations” (Dugal and Chakraborty 498). Although this is a fairly new treatment, and more research is necessary before doctors can widely implement it, it has significant potential in the future. The problem right now is that no one fully knows all the potential side effects, and even if it works perfectly, it is expensive and only fights against *E. coli* and *Pseudomonas*, not other antibiotic resistant bacteria (Dugal and Chakraborty 500). Again, this solution is one that vulnerable humans cannot fully count on at this point to solve the problem of even one or two types of bacteria, let alone all types of bacteria.

A slightly more hopeful solution under current research is furthering the use of vaccinations rather than antibiotics. Dr. Charles Knirsch, a senior administrator for a major medical research company, said in an interview, “I think the future, though, will be individual manipulation of the immune system, not just as immune suppressives but as immune adjuvants...I do think that vaccines will be used on individual patients both preventively but also therapeutically.” Although he admits he does not know the specifics of how this would work, Knirsch sees immune system manipulation as a hopeful future solution once someone develops it with further research. Solutions like this would dramatically impact the fight against antibiotic resistance, but again, an effective invention is not inevitable. Since this treatment is not currently available, standing by waiting for researchers to formulate it will not help the problem now.

Aiming at immediate solutions, Toby Butler, a Quality Improvement Specialist for the Oklahoma Foundation for Medical Quality, presents a very practical, tangible strategy. He asserts that

medical professionals should treat the multi-drug resistant (MDR) bacteria problem like a pest infestation by systematically seeking and destroying sources of the bacteria before they spread (13). Better hospital sanitation protocol and policies are his proposed solution, and he has good reason. Recent statistics show that “health care-associated infections develop in approximately 10% of hospitalized patients, and the cost of treating these infections amounts to \$4 to \$11 billion annually,” and they are usually acquired from various medical instruments (Lilley et al 586). Lilley et al also goes on to report that at least 70% of hospital related infections are avoidable (586). Since so many antibiotic resistant infections spread in a hospital setting, eliminating bacteria’s ability to transfer from patient to patient would choke off an infection’s growth and solve a majority of the problem. While this approach does not help patients who have already contracted an infection, it does prevent future problems. If professionals perfectly execute this plan, it could even eliminate much of the need for antibiotics in the first place. This solution would require some practical research on how infections spread in the hospital in order to find out where the focus needs to be on preventing transfer of microbes. One example of this already happening is a study done by Usha, Kumar, and Gopal in which they discovered MDR bacteria in hospital sewage (45). This raises the need for better sterilization of sewage before it is released from the hospital. Besides creating new protocol, this preventative solution could also require more training for medical professionals and potentially necessitate more personnel to oversee implementation of stricter policies. All of these steps would cost money and possibly inconvenience hospital staff, but together they are a very practical and simple solution to limit the spread of any type of bacteria and reduce the need for antibiotics, which would ultimately save lives and money.

Another potential solution to resistant bacteria that is very practical and would save lives is to avoid overprescribing antibiotics and only use them when absolutely necessary. Ever since antibiotic medication became available, many doctors have gotten into the habit of playing it safe and prescribing antibiotics to any patient whose illness they thought might possibly be rooted in bacteria. Although this practice does help many patients recover more quickly, it greatly increases the amount of antibiotics in use

and aids bacteria's ability to develop resistance. Physicians must act on the knowledge that the fewer antibiotics they utilize, the less the bacteria will develop resistance to the antibiotics for when they are absolutely needed (Thomas et al 2065). Similar to improving sanitation protocol, this takes discernment and discipline on the part of medical professionals. If doctors are willing to wait longer to prescribe antibiotics until they are sure they are necessary, it will cut down on antibiotic resistance. Unfortunately, this may cause more patient discomfort or even death since immediately treatable patients have to wait a few days to receive it until the doctor is sure they do, in fact, need the medication. On the other hand, this method is not expensive like many of the other proposed solutions but rather will save money, and it will help reduce the resistance of every type of infection which will ultimately save lives.

A similar simple, practical, and inexpensive solution is patient education. Patients who misuse their antibiotics by overusing them or taking them at the wrong times or improperly using them in other ways contribute to antibiotic resistance because they are essentially wasting them and causing more antibiotic use than necessary. The obvious drawbacks to this solution are that doctors cannot actually follow patients around everywhere to make sure they follow instructions, and the overall effect of even perfect use by patients will probably be fairly small. However, this is a solution that is easy and inexpensive to implement and could aid in the fight to limit antibiotic resistance.

In reality, the best solution to antibiotic resistance is a combination of several proposed solutions. While research is important, and new cures are very helpful, they are not inevitable. For now, focusing on the practical, controllable aspects of limiting antibiotic resistance is the most helpful. Hospital staff must put extra effort into proper hospital sanitation around the world even if it is difficult and inconvenient. The best way to snuff out a disease is to cut it off from spreading. Doctors also must be willing to make tough choices in administering antibiotics instead of just prescribing them in the hope that they help a patient. First, he or she must be certain antibiotics will eradicate the infection from the patient, and then he or she may prescribe them. In addition, medical professionals must put more effort into public awareness of the danger of antibiotic resistant bacteria. Proper education will give patients motivation

to use antibiotics properly and assist in proper sanitation efforts. If doctors, nurses, pharmacists, and patients do all they can at the practical level in hospitals, antibiotics will stay useful when they are truly necessary, and MDR bacterial superbugs will not run rampant. Although many in modern American society are ignorant to the modern danger of bacterial infection and disease, experts agree that it is a serious problem. Human health is fast approaching the edge of a cliff. As more bacterial infections mutate and become invincible to current antibiotics, modern medicine must answer the call and provide workable solutions for them. If humans do not want to experience another plague reminiscent of the Middle Ages, experts say something must change. While researchers continue their important search for new cures which may or may not exist, medical professionals and patients must understand the real danger of antibiotic resistance and work together to stop it by cutting off transmission in the hospital setting and by properly using the antibiotics that are currently available. A concerted effort on everyone's part, doctor, patient, and researcher alike, is necessary if humanity is to outlive pathogenic bacteria.

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