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## An Era of Resistance

by Alexa Bowers

(English 1102)

Just as in life, for every problem there is almost always a solution. In the medical field, for every disease there is almost always a cure. The Golden Age of Microbiology took place from 1875-1918. During this time, most pathogenic bacteria had been discovered, and scientists began working to create antibiotics to kill them. Paul Ehrlich was one of the many scientists; he searched for a “magic bullet” that would kill a microbial pathogen without harming the host (J. Malik, personal communication, October 20, 2016).<sup>1</sup> Ernst Chain and Howard Florey used the work of Alexander Fleming<sup>2</sup> to treat a police officer who had been dying from a life-threatening Staph infection (J. Malik, personal communication, October 20, 2016). Eventually, their short supply ran out before they could cure him, and he died (J. Malik, personal communication, October 20, 2016). This failure led to one of the greatest discoveries of all time: Penicillin G, the first antibiotic capable of curing bacterial infections. From this moment on, more antibiotics have been discovered, and today individuals are being vaccinated to prevent these diseases from ever occurring. For those who are unfortunate and do get infected with a bacterial disease, antibiotics are readily available to treat these patients.

Following the eras of pathogenic discovery and antibiotic discovery came a new era, the “postantibiotic era” of microbial resistance (Alqallaf & Winit-Watjana, 2015, p. 24). With the creation of antibiotics came individuals who abused them. By improperly using antibiotics, multiple species of bacteria began to form a resistance to them. Once bacteria become resistant, they gain an ability to “survive and resist exposure” to one or multiple antibiotics (Kandelaki, Lundborg, & Marrone, 2015, p. 2). To better understand antimicrobial resistance, picture evolution. In species of bacteria there are variations within their genetic makeup just as any other species. While most species can be killed with an antibiotic, variations within a few may make them resistant to the drug and develop an immunity towards it. The surviving bacteria can then reproduce future bacteria with the same immunity as their own. This is how resistance grows. The more people who improperly take antibiotics, the more likely a resistance is to form, and if it currently exists, spread. The lesser knowledge of antibiotics found in underdeveloped countries directly correlates to the expansion of microbial resistance and can be prevented by proper education of said antibiotics.

In many underdeveloped countries, it is common to see antibiotics being sold over the counter within pharmacies. The reason for this is that many medical costs are paid out of pocket by the public. To make healthcare more affordable, the government makes drugs available at pharmacies without a prescription. That means the public has easy access to these drugs, and can purchase them at any time. In the Republic of Georgia, all drugs besides “psychotropic medication” can be sold at a pharmacy without an individual needing to go to their doctor to have them prescribed (Kandelaki et al., 2015, p. 2). A study including 250 individuals was done in the Republic of Georgia by Kandelaki et al. (2015). Ketevan Kandelaki is the Secretary-General for the United Nations Educational, Scientific and Cultural Organization (UNESCO) in Tbilisi, Georgia. Cecilia Stålsby Lundborg works for the Department of Public Health Sciences for Karolinska Institutet in Sweden with Gaetano Marrone, who is a statistician. There, almost 95% of the population avoids seeing their doctor, and instead chooses to self-medicate without any knowledge of antibiotics (Kandelaki et al., 2015, p. 2). This poses a threat to people within countries that have no regulation on prescription drugs because they lack knowledge on the drugs themselves, but can still access them without any trouble.

While the Georgia government intends to lower healthcare costs by allowing the public to purchase antibiotics in pharmacies, they are increasing the rate at which antimicrobial resistance forms. In a cross-sectional study done by Kandelaki et al., (2015) over residents in Tbilisi, Republic of Georgia, they found that over 50% had no proper knowledge on what antibiotics were used to treat. This goes to show that too much responsibility regarding the purpose of antibiotics is given to the population by allowing them to purchase these drugs without consulting a physician first.

Although in underdeveloped countries it is easy to purchase antibiotics for treatment, this isn't the case for everyone. Some people cannot even afford to buy these prescription drugs so they resort to using drugs already purchased by friends, family and neighbors. Improper self-medication, which will be discussed later on in this paper, can result in having leftover antibiotics. The owners of these leftovers will either give them away to help someone else, or sell them for money. This can be a huge issue in increasing the already existing microbial resistance within underdeveloped countries.

An experiment was conducted by Oh, Hassali, Al-Haddad, Sulaiman, Shafie, and Awaisu, (2011) in Penang, Malaysia on 408 respondents. The authors are all clinical pharmacists that have previous educations at the school of pharmaceutical studies at the Universiti Sains Malaysia. There, researchers found that 67.7% of their respondents agreed that they would give their medication away to a sick family member if they were ill (Oh et al., 2011, p. 340). This is a behavior seen in a lot of underdeveloped countries due to lack of funds, but globally as well.

Individuals without insurance or money will use anyone close to them to gain access to antibiotics if it can't be done so legally. Also, a lack of time, common in what many call "first-world countries," will result in individuals getting antibiotics from people they know. This form of medication increases the microbial resistance; by not seeing a doctor, one will never know what they're infected with and whether an antibiotic will treat them. Taking the wrong antibiotics, or taking them when they are not needed, is one of the many causes for microbial resistance. Just going off symptoms is not enough to properly diagnose oneself.

The misconceptions regarding antibiotics make self-medication very dangerous for anyone. Self-medication can be defined as "antibiotic use without prescription," despite whether they're obtained legally or illegally (Kandelaki et al., 2015, p. 2). One of the most common misconceptions individuals have is that antibiotics can be used to treat a wide range of infections. This is completely false. Antibiotics can be used *only* to treat a bacterial infection, but many people don't know this. An experiment was done by Alqallaf and Winit-Watjana (2015) involving patients from health centers and community pharmacies in Bahraini. Alqallaf is a graduate of Cardiff University, who currently works as a coordinator for the pharmacy program at the University of Bahrain. He has contributed to seventeen research papers, most focusing on his areas of expertise: diabetes and pharmacology. Winit-Watjana has a Ph.D. in Pharmacy Practice, and has made contributions to fourteen research articles. His area of expertise is in geriatrics and pharmacology. What their results found was that 82% knew antibiotics could be used to treat bacterial infections, but in addition, 69.3% believed they treated viruses, 37.9% believed they treated fungi, and 21.6% believed they treated insects (Alqallaf & Winit-Watjana, 2015, p. 27). Only 19.9% knew that antibiotics could *only* cure a bacterial infection (Alqallaf & Winit-Watjana, 2015, p. 27). Referring to the experiment done in Tbilisi, Republic of Georgia, similar results appeared. From the group of 250 respondents, 55% believed that antibiotics sped up the recovery of a cold, and the same percentage believed they could be used against viruses (Kandelaki et al., 2015, p. 5). This is why it is bad to take antibiotics when they are not necessary: the antibiotic attacks the normal flora in the body, bacteria that are beneficial to the body and live there naturally. The antibiotic doesn't kill the cold or virus like individuals believe. Antibiotic resistance occurs in the normal flora, then can spread to foreign bacteria whenever they enter the body.

Two additional misconceptions that go hand in hand are that antibiotic treatment can be stopped early, and that leftovers can be saved for future use. The problem with ending an antibiotic

course early is that it doesn't ensure that all the foreign bacteria in the body have been killed. What happens next is any surviving bacteria will then be able to mutate and become resistant to the antibiotic, infecting the individual once again and becoming immune to the previously used antibiotic. In the Penang, Malaysia cross-sectional study, 37% said they discontinued their antibiotics once they began feeling better (Oh et al., 2011, p. 344). In the study conducted in Bahraini, 35.6% would stop taking an antibiotic as soon as they began feeling better (Alqallaf & Winit-Watjana, 2015, p. 28). This is over a third of individuals who have the misconception that it is acceptable to discontinue antibiotic treatment once they begin feeling better. *One third* of individuals who are contributing to microbial resistance.

When using leftover antibiotics, resistance becomes a risk because the individual skips seeing a doctor, so they don't truly know if they have a bacterial infection. If the individual does indeed have a bacterial infection, they don't have a full course of antibiotics needed to kill the bacteria. In the experiment done by Oh et al. (2011), 72.5% kept a stock of leftovers at home for emergencies, and in the experiment conducted by Alqallaf and Winit-Watjana (2015), 33.7% believed they can be saved and used again in the future. These are just two examples of populations in undeveloped countries believing there is no harm in saving their antibiotics; a consequence of lack of knowledge.

Education is the number one solution in underdeveloped countries to prevent further microbial resistance. Unexpectedly, education doesn't just begin with the consumers, but with the doctors. It is common to see that due to misconceptions, many patients believe that antibiotics are needed whenever a fever is present, or for a common cold. Those who do go see a doctor, demand antibiotics to treat these, and doctors give in. In Penang, Malaysia, 38% of individuals would receive antibiotics from their doctor to treat a cold (Oh et al., 2011, p. 345). Another common mistake doctors make is the frequent prescribing of antibiotics for viral respiratory infections that go away on their own (Oh et al., 2011, p. 345). This brings back the issue of trying to treat viral infections with antibiotics which are only effective on bacteria.

In undeveloped countries, missing a day of work can be devastating, so many demand an instant recovery. A survey was conducted on teachers in New Delhi, India, by Kotwani, Wattal, Joshi, and Holloway (2016). Anita Kotwani is a professor at the Department of Pharmacology, V.P. Chest Institute in New Delhi. Chand Wattal is a microbiologist who works for the Sir Ganga Ram Hospital in New Delhi. P.C. Joshi works for the Department of Anthropology at the University of Delhi, and Kathleen Holloway is a regional advisor for WHO and works at the Department of Essential Drugs and other Medicines in New Delhi. They found that the teachers would ask their doctors for strong antibiotics to cure them instantly, and doctors would obey (Kotwani et al., 2016, p. 368). The problem here isn't the fact that these doctors don't have the right knowledge, but instead, that they need to be stricter with not giving into the demands of their patients.

Researchers Kotwani et al. (2016) suggested that the most "malleable user group" within underdeveloped communities was students because they spend 7-9 hours a day in school. This can be used to an advantage to teach them amongst their peers and educators about microbial resistance, being "both current and future users of antibiotics" and "influential advisors to parents" (Kotwani et al., 2016, p. 365-366). By adding lessons regarding proper usage of antibiotics and about antimicrobial resistance into current curriculums, high school students could be used as a middleman between generations. Not only can they further educate their parents, grandparents, and any other relative, but they can one day pass down their knowledge to their own kids.

A final source for education in underdeveloped countries is the pharmacists themselves educating the public on the antibiotics they purchase. Alqallaf and Winit-Watjana (2015) believe that pharmacies should play a "vital role in patient counseling" to help inform them of the antibiotics they're taking. Kandelaki et al. (2015) suggest that the government should change the laws on certain prescription medicines and put pharmacists in charge of teaching consumers about proper antibiotic

use and the growing resistance. This would allow pharmacies to continue to sell antibiotics, but also give them the important task of educating the public.

Antibiotics have become a blessing and a curse, especially for the public in underdeveloped countries. What was once intended to cure people has now become a threat itself. As governments legalize their sale at local pharmacies, their easy accessibility puts the public at risk for increasing the spread of microbial resistance due to misconceptions they carry. Only urgent education within doctors' offices, schools, and pharmacies to name a few, can help to stop this era of resistance from growing anymore. Although the damage cannot be reversed, the war against bacterial resistance can be stopped. With the proper education, the knowledge of antibiotics can be taught to underdeveloped countries who otherwise lack antibiotic lore, thus preventing any further expansion of microbial resistance.

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### Notes

1. Paul Ehrlich was a German physician who focused mainly on developing a cure for syphilis. It wasn't until the beginning of the 1900s when he developed Salvarsan, the first documented example of a chemical used as an antimicrobial. This drug was used as a treatment for individuals with syphilis.
2. Alexander Fleming's work consisted of incubating cultures of the bacteria, *Staphylococcus Aureus*. While doing so, he observed that bacteria growing around contaminated mold appeared to be dissolving (J. Malik, personal communication, October 20, 2016). He identified the mold as a species of *Penicillium* and discovered it was producing a substance that was killing the bacteria. He was unsuccessful in purifying that substance (J. Malik, personal communication, October 20, 2016).

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