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### **Improving Antibiotic Use in Chinese Livestock.**

Food is fuel, both at a fundamental biological level and as sustenance for societal innovation. It is the centerpiece of the human experience and one of the few common threads connecting generations and continents. Since the origins of human agriculture, creating more efficient means of production and developing an agricultural surplus to meet and exceed a growing demand has been the key to survival and progress. Each generation has been met with some variant of this fundamental problem, and with the world population bursting to a staggering 10 billion people by 2050, our generation is facing the same question on an unprecedented scale.

When considering more efficient measures of food production, oftentimes sustainability and safety are dismissed in favor of a higher yield. Typically, regulatory practices enforced in first world countries by programs such as the FDA ensure that a high agricultural outcome can be achieved while minimizing health risks. However, in rapidly developing nations with large populations, legislation regarding the sustainability of food production is often inadequate. One example of this problem is the overuse of antibiotics in meat production, specifically in China which leads the world in agricultural antibiotic use (Doucleff).

China led the world for centuries in agricultural and scientific development from their first cultivation of rice and millet to early production of gunpowder. However, China's early success was disturbed by centuries of famine, unrest, and war, and by the nineteenth century Europeans came to lead world technological development. After World War II, the communist regime wrested control of China and a strict socialist system was implemented. Leaders like Mao Zedong and Deng Xiaoping have transformed China from a fractured state to a global superpower, leading the world in size of population and coming in second for GDP and total land area (East. Web). However, China's rapid growth and industrialization has left the government with bursting agricultural production in order to provide for their staggering population of over 1 billion people, and weak regulatory practices which roughly resemble those of the US in the 1960's.

China is a massive country, encompassing 56 official ethnic groups and as many as 292 languages ("East"). The People's Republic of China instituted a one-child policy in 1979 which has since been modified to a two-child policy in 2015 ("East"). Correspondingly, the majority of families in China are composed of three to four people. China also has an ancient dedication to the social policy of filial piety, or ancestor worship, so older family members are typically cared for and often live with the younger generations. The Chinese diet is highly varied, reflecting the diversity of topography and cultural tradition throughout China. In general, culinary staples in the north and south are wheat-based noodles and rice, respectively. China is also among the world's leading producers of pork, poultry, and beef, all staples in the Chinese diet ("East").

Access and quality of education are highly dependent on location. Across China, education from the ages of six to fifteen is compulsory and free ("East"). However, educational spending in rural areas is significantly less than in urbanized areas, and access to senior secondary school (ages 16-18) and higher education is selective and can be extremely expensive, a financial burden many rural families are not prepared to meet. Chinese higher education when accessed, however, is among the best in the world ("East").

China's healthcare system is mostly privatized and high quality. 95% of China's population has basic health insurance, and diseases such as typhoid and scarlet fever which once were widespread are now well controlled (“East”). Even though cramped urban living has contributed to disease spreading and various epidemics, the Chinese healthcare system has handled these outbreaks efficiently. Among the biggest health concerns currently facing China is air pollution for carbon emissions, causing an estimated 1.2 million premature deaths to date (“East”). Additionally, widespread inappropriate usage of antibiotics has been an issue in China with nearly 40% being prescribed incorrectly (Minter).

Agriculturally, China has struggled with massive erosion of soil and large floods leaving millions of acres of potential farmland unsuitable for planting (“East”). However, in the meat industry, the biggest threat facing family farms in China is not natural disaster but, instead, the emergence of large factory farms to meet high demand for pork, chicken, and beef that has come as a result of improving standards of living and higher incomes. In 2001, 75% of pigs came from family farms, but in only nine years, this figure fell by half (Zhang). This large-scale agricultural revolution has resulted in the emergence of unsafe farming practices in order to maximize profits and production. Foremost among these methods is the feeding of heavy metals and antibiotics to animals intended for human consumption to increase yield, which presents a variety of threats including water contamination and the emergence of antibiotic-resistant pathogens that could be transferable to humans.

China's modernization and concurrent industrialization of the meat industry to meet the staggering demands of their population has eclipsed many family-run farms with large corporations which has forced these families to seek new livelihoods or work for these factory farms in oftentimes dangerous working conditions for smaller wages. However, the far-reaching effects of these large factory farms and resulting unregulated livestock management practices pose a far greater threat than most would expect.

Food additives such as heavy metals and antibiotics have long been in use since the 1950's when US scientists discovered that the addition of antibiotics to animal feed increases growth rate (Tatlow). Since then, the practice has proliferated and become commonplace in most countries around the world that produce large amounts of meat products (with the exception of the EU which banned the practice in 2006 amid concerns of antibiotic resistance). In the past decade in particular, many groups have vocalized a growing concern for the impact of antibiotic use in animals and the accompanying increased emergence of antibiotic-resistant pathogens in humans. Governments have been receptive, and significant legislation has been passed in the US and abroad in an attempt to limit the amount of antibiotics being used in the livestock industry.

Currently, over 50% of the total antibiotics manufactured in China go to the livestock industry, the highest total amount in the world, totaling over 32,244,000 kilograms annually (Zhu). The sheer scale at which Chinese livestock farms are consuming these products is cause for great concern which is compounded by the lack of regulatory legislation being enforced by the Chinese government. As production booms, this issue becomes more and more extensive, not only impacting communities directly affected by it, but also the entire human population because of the extensive mobility of pathogens in our vastly interconnected world.

Supporters of the use of antibiotics in livestock production argue that there is a lack of specific scientific proof of a relationship between the emergence of antibiotic resistant pathogens and the use of antibiotics in livestock production. However, in a study published in the Proceedings of the National Academy of Sciences of the United States of America, a direct link was found between the concentrations of heavy metals and antibiotics and the prevalence of antibiotic resistant genetic material on various livestock farms throughout China (Zhu). The same study demonstrated the abundance and diversity of antibiotic resistant genes in bacteria, finding 149 unique antibiotic resistant genes in their samples, three times more than the control group (Zhu). This confirms the link between unsafe livestock practices and the

emergence of resistant pathogens and enforces the fear that this genetic material could create a pandemic which could have the potential to devastate the global meat supply resulting in food insecurity not only in China but all over the world. Additionally, there is great concern among the scientific community that antibiotic resistant genetic material could be easily horizontally transferred to human bacteria. As many as 2/3 of human illnesses have their origin in animals, a number which has risen significantly over the last 40 years in correlation with the increased use of antibiotics and heavy metals in livestock production (Ward). The heavy metals that are commonly used in meat production such as Cu, Hg, and Zn, are not only harmful to the environment and people if consumed in large enough quantities, but another study found that the presence of heavy metals greatly accelerates the emergence of antibiotic resistant genetic material in various pathogens (Ji).

The emergence of antibiotic-resistant pathogens is not the only factor when considering the danger of China's meat production. A study by Chinese scientists found that streams, wells, and field soils tested near livestock farms using antibiotics and heavy metals were contaminated (Zhou). This finding is particularly concerning as China has frequent floods that have the potential to carry heavy metals, antibiotics, and pathogens great distances, furthering the area of contamination. Groundwater contamination poses an additional threat to rural communities dependent on wells for fresh water, which if compromised could be very harmful to humans. Antibiotic resistant bacteria that emerge in livestock farms can also be spread by wind in dust, potentially for hundreds of miles (Zhu).

As China's population and thus demand for meat continues to grow, antibiotics and heavy metals are continually being used in the production of livestock with little intervention on behalf of the government. The insufficient legislation for regulating these products used in livestock production poses a significant global threat, especially as more and more cases of antibiotic resistance are emerging in both animals and humans. Scientists are working hard to collect data regarding this issue and studies detailing the extent of the damage unregulated livestock practices present are being published on a more frequent basis. In late 2015, Chinese researchers discovered bacteria resistant to Colistin, a last resort human antibiotic for serious infections, being harbored in the livestock in China (Ward). This discovery served as a strong wake-up call for policy makers in China, but antibiotic-resistant bacteria kills upwards of 700,000 million people per year, and the amount of attention this issue gets does not nearly reflect how serious it is (Ward).

A change that everyday citizens could make which would greatly impact this issue is reducing the amount of pork they consume. According to another study published by the Proceedings of the National Academy of Sciences, pork farmers use four times as many antibiotics than beef farmers (Van Boeckel). By reducing demand for pork, supply would in turn be reduced and the use of antibiotics in pork production would be decreased. Of course, public pressure alone will not eliminate the use of growth influencing antibiotics in meat production, strict legislation dictating specific regulation on antibiotics is necessary.

One of the biggest challenges facing scientists and politicians interested in passing regulatory legislation for the use of antibiotics and heavy metals in livestock production is a lack of understanding about the significance of the threat and a focus on making profits at the expense of quality. Helping people to grasp the science behind these claims and where their food is coming from could potentially create public pressure on legislators to change the regulations.

In order for protocols to be sufficient, they need to include the entire livestock production system on both factory and family farms. Additionally, these regulations need to be accompanied with significant penalties to encourage compliance, regular government monitoring of the farms, and education for the farmers so they understand why these regulations are necessary. The more the public is educated, the more invested they will be in ensuring their food is coming from a sustainable farm. An issue this widespread will take significant pressure from consumers and community members to solve. If China

were to create stronger legislation to address this issue, it would still likely be difficult or even impossible logistically to enforce rules across such a vast and varied nation. However, this challenge may not be as arduous to address as one would think, as demonstrated by China's reduction of human consumption of antibiotics.

The government in China has been very concerned with the over prescription of antibiotics directly to humans as currently their rate of antibiotic resistant infection is the highest in the world (Zhang). In response to this danger, public educational ad campaigns were run in China and strict regulations were enforced in hospitals to educate patients about the proper usage of these powerful drugs. As a result, the percentage of outpatients who received antibiotics dropped from 22% to 14%. Even more impressive, the percentage of surgical procedures which employed the antibiotic prophylaxis dropped from a staggering 95% to 44.6% (Xiao). The actions of the government and health care professionals in China regarding human consumption of antibiotics proves that even in a nation as massive and varied as China, strong legislation and proper enforcement can have a significant impact on important issues.

Even with the feasibility of limiting the use of antibiotics and heavy metals on China's farms, it would be impossible to totally eliminate their use in livestock care. Moderate use of antibiotics is essential to animal health and welfare and preventing epidemics that can spread to an entire herd. To completely withhold these powerful drugs, production of meat would take a major hit and the conditions of sick animals would become inhumane. However, certain protocols and safeguards can ensure that farmers use their antibiotics in a healthy, sustainable way.

After antibiotics have been administered to an animal, a period of time needs to be allotted from the last dosage to the time of slaughter to ensure that none of the antibiotics remain in the system of the animal. Additionally, manure management is essential to prevent groundwater contamination (Zhu). Livestock manure is an extremely valuable fertilizer, but it is also filled with the metals and antibiotics the livestock are fed. Simple dilution is not enough to return the manure to a normal range of contamination, and manure composting yields mixed results when tested (Zhu). With the technology currently available, more studies need to be performed to determine the ideal composting time and technique for livestock manure before it is released to the environment. Geographical and environmental features need to be identified as well so they can be used or avoided to limit groundwater runoff from the farms, which means water and soil near livestock farms need to be consistently monitored for contamination. Ideally, more technologies such as low-cost containment sensors and filtration systems will be developed to help limit environmental damage and the proliferation of antibiotic resistant genes.

Currently, the most important entity equipped to handle this crisis in China is the Chinese government. It has significant resources it could mobilize in educational campaigns and enforcement of regulations regarding antibiotic use. However, this issue is not strictly isolated to China. Nations, even ones with existing regulations, are contributing to this issue. In fact, the US is the second lead consumer of antibiotics, using 10% of the total world production (Doucleff). Considering how serious the threat of antibiotic resistance is, it does not get the attention it deserves on a global scale. In order for this problem to be addressed, people need to be aware of it. The World Health Organization has been working to raise awareness for the overuse of antibiotics, but a stronger multinational effort needs to be made to spread this information and make effective laws which will help combat the frivolous use of these powerful drugs. Our world is too interconnected, and we have too many collective resources to let countries tackle these issues on their own, and ultimately the health and future of humankind rests on how well this crisis is addressed.

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