

*The Relationship Between Childhood Malnutrition & Infectious
Diseases: Case Studies of Four Countries*

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Introduction

Childhood health and nutrition is an important global health issue. Many countries have begun to prioritize the well being of children because they want to prevent mortality and morbidity at a young age. Mitigating childhood malnutrition, including wasting, stunting, and micronutrient deficiencies are important health goals for every country. In fact, the prevalence of malnutrition around the world today is extremely high, as there are about 161 million children who are chronically undernourished and about 51 million children who are acutely undernourished (UNICEF 8). If left untreated, childhood malnutrition, including undernutrition, can develop into serious health problems in adulthood. Specifically, malnutrition affects individuals by causing lower fat oxidation, lower energy expenditures, insulin resistance, increased risk for diabetes, and hypertension (Martins 1838). Given the health effects and the magnitude of this situation, it is no surprise that malnutrition has become a global health policy issue.

Besides childhood malnutrition, another health priority is the study of infectious diseases. The World Health Organization classifies infectious diseases as “pathogenic microorganisms, such as bacteria, viruses, parasites or fungi that can be spread, directly or indirectly, from one person to another” (“Infectious Diseases”). Examples of infectious diseases include influenza, malaria, tuberculosis, and dengue fever. Unfortunately, previous studies have confirmed that human actions have caused more infectious diseases to emerge (Lindahl 2). For instance, the loss of biodiversity from urbanization and climate change have proliferated the transmission and severity of these diseases (Bloom 6). As the global population increases, it is expected that infectious diseases will continue to impact human health.

While the negative health implications of childhood malnutrition and infectious diseases have been individually researched, the relationship between childhood malnutrition and infectious diseases is less clear. The current report utilizes four case studies in the United States, China, Philippines, and Nigeria to investigate how political and social policies can mitigate childhood malnutrition and infectious diseases. It is known that the purpose of the human immune system is to fight infections. However, with a weakened nutritional status (e.g. wasting or stunting), the immune system’s response may not be able to sufficiently fight off the infection. Given this information, there are certain policy suggestions that can be made to prevent the morbidity of both malnutrition and infectious disease.

Food insecurity in the United States disproportionately impacts infants and adolescents from low socioeconomic status. A lack of nutrients, including protein and calories, could further complicate influenza, which disproportionately affects young children. This situation means that government policies should prioritize infant health and maintain a high standard of primary and antenatal care. In addition, as seen in China, the dual burden of malnutrition and tuberculosis affects rural areas more than urban areas. This means that future health care and government

policies must be accessible and consistent for the entire population. Finally, the Philippines and Nigeria case studies demonstrate that there could be a direct association between undernutrition and the severity of Dengue/Malaria. To limit transmission and lower the risk factor for these diseases, governments are experimenting new treatments and ensuring citizens have access to mosquito nets. Although the current COVID-19 pandemic is different from these case studies, the global response should be similar. That is, governments should ensure individuals have access to healthy food services, prioritize the health of young children through preventative services, maximize health services to all locations, and collaborate on potential treatments.

Case Studies

United States

Introduction

This case study focuses on the United States. The current population of the United States is around 328 million, with 18.26% of the population between the ages of 0-14 years old, and an average life expectancy of 78.6 years (CDC “Life Expectancy”). This case will first explore malnutrition, specifically undernutrition in the United States, through under-five statistics, food insecurity, socioeconomic measurements, and various other studies. Secondly, we will explore infectious diseases, prominently influenza in the United States. After, we will look at the possible correlation between malnutrition and influenza and prevention efforts and policies as a method of combating both issues.

Undernutrition in the United States

As established above, malnutrition, “is the condition that develops when the body is deprived of vitamins, minerals, and other nutrients it needs to maintain healthy tissues and organ function” (Ongera, 2019). This term is further broken down into three broad groups of conditions which are undernutrition (including stunting or low height for age and underweight or low weight for age), overweight (including obesity and diet-related non-communicable diseases) and micronutrient (including micronutrient deficiencies or micronutrient excess) (Ongera, 2019). For this study, we will focus on undernutrition and micronutrient deficiencies.

The United States continues to experience a malnutrition burden among the under-five population. In 2016, the national prevalence of under-five stunting was 3.5%, compared to the global average of 21.9%, and under-five wasting prevalence of .4%, compared to the global average of 7.3% (“Global Nutrition Report; United States”). The United States is on course to meet the global targets, promoted by the World Health Organization, for under-five stunting and under-five wasting, but is not on course to meet targets for all other indicators analyzed in the Global Nutrition Report. Refer to Figure 1.A. below to see the other global nutrition targets.

Furthermore, in 2015 low birth weight prevalence was at 8%, which increased from 7.5% in 2000 (“Global Nutrition Report; United States”).

Figure 1.A.

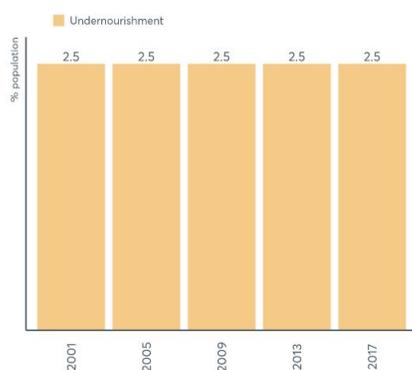
Progress against global nutrition targets 2019



The Nutrition Profile on the United States did not have data on the coexistence of wasting, stunting and overweight, low birthweight, or stunting at the subnational level, but did look at undernourishment and food supply at the national level (refer to Figure 1.B. below). We can see from the figure that from the years 2001 to 2017, the prevalence of undernourishment has remained constant, with no improvement, while the availability of fruit and vegetables have decreased over this time period.

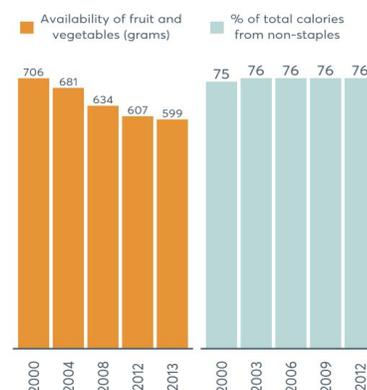
Figure 1.B.

Undernourishment



Source: FAOSTAT 2018.

Food supply



Source: FAOSTAT 2018.

Food insecurity also plays a major role in childhood malnutrition throughout the United States. In 2016, approximately 12 million children were measured as being food insecure, meaning they “are forced to skip meals or buy cheap non-nutritious food” (Ongera, 2019). Food insecurity is a social determinant of health, and although it has been found in all income groups,

low-income families, “can be especially vulnerable to poor nutrition and obesity, due to additional risk factors associated with inadequate household resources as well as under resourced communities” (Ongera, 2019). Furthermore, a “dual burden” is often present, defined as malnutrition coupled with obesity or a non-communicable disease. This burden “is prevalent in more than half of all malnourished households that reside in the United States. Many families do not have the resources to meet basic needs and these challenges increase a family’s risk of food insecurity (Ongera, 2019).

The American Academy of Pediatrics, in 2018, issued a policy statement highlighting the importance and irreversibility of the 1000 day window (Schwarzenberg, 2018). The report focuses on maternal prenatal nutrition and the child’s nutrition in the first 1000 days (~2 years) of life and the child’s neurodevelopment and mental health. Child and adult health risks, including obesity, hypertension and diabetes, may be determined by nutritional status during this period. “Calories are essential for growth of both fetus and child but are not sufficient for normal brain development...Failure to provide key nutrients during this critical period of brain development may result in lifelong deficits in brain function despite subsequent nutrient repletion” (Schwarzenberg, 2018). Key nutrients that support neurodevelopment include protein, zinc, choline, folate, iodine, vitamins A, D, B6, and B12.

Influenza in the United States

The infectious disease we will focus on in the United States is influenza, or more commonly known as the flu. “The flu is a contagious respiratory illness caused by influenza viruses that infect the nose, throat, and sometimes the lungs. It can cause mild to severe illness, and at times can lead to death” (“CDC Flu”). People who have the flu often have all or some of the symptoms of fever or feeling feverish/chills, cough, sore throat, runny or stuffy nose, muscle or body aches, headaches, fatigue; and some people may have vomiting and diarrhea, though this is more common in children than adults (“CDC Flu”). The flu is spread through human interaction, oftentimes through droplets made when people infected with the flu cough, sneeze or talk.

In 2018 the CDC published a study determining the incidence of influenza in the United States. The study “suggested that on average, about 8% of the U.S. population get sick from the flu each season, with a range between 3% and 11%” (“Seasonal Incidence of Symptomatic influenza In the United States”, 2018). The same study found that children are the most likely to get sick from the flu and that adults 65 years or older are the least likely to get sick from the flu. “Median incidence values (or attack rate) by age group were 9.3% for children 0-17 years, 8.8% for adults 18-64 years, and 3.9% for adults 65 years or older. **This means that children younger than 18 are more than twice as likely to develop a symptomatic flu infection than adults 65 years and older**” (“CDC Flu”). The period of contagiousness ranges, with the most contagious period being in the first 3-4 days after the illness begins (“CDC Flu”). **“Some people, especially young children and people with weakened immune systems, might be able to infect others**

for an even longer time” (“CDC Flu”). Complications of the flu can include bacterial pneumonia, ear infections and worsening chronic medical conditions (“CDC Flu”). Anyone can get the flu, but children under 5 years old, adults 65 years and older and people with certain chronic medical conditions are at a higher risk of developing flu-related complications if they get sick (“CDC Flu”).

The most important way to prevent getting and spreading the flu is to get a flu vaccine each year. “Flu vaccine has been shown to reduce flu related illnesses and the risk of serious flu complications that can result in hospitalization or even death” (“CDC Flu”). The CDC also recommends everyday preventive actions, like “staying away from people who are sick, covering coughs and sneezes and frequent handwashing, to help slow the spread of germs that cause respiratory illnesses” (“CDC Preventing Flu”). When diagnosing, it can be difficult to distinguish between other viral or bacterial respiratory illnesses based on a patient’s symptoms alone, but there are tests to diagnose the flu.

Childhood Malnutrition and Influenza in the United States

Although the most effective way to prevent becoming infected with and spreading influenza is by getting an annual flu vaccine, there is a relationship between childhood malnutrition and influenza. As seen above, children under five are more high-risk of getting infected with the flu and experiencing flu related complications once infected. Social determinants and low-income households have repeatedly been shown to have lower health outcomes compared to other middle and high-income households. As established above, in 2016 approximately 12 million children were measured as being food insecure (Ongera, 2019) and approximately 13.2 million children, or 18% of children in the United States, lived in poverty (“Food Research Action Center”). “A considerable amount of research demonstrates that people living in or near poverty have disproportionately worse health outcomes and less access to health care than those who do not” (“Food Research Action Center”). Specifically, “childhood poverty and socioeconomic inequalities have health implications that carry through into adulthood- for example lower childhood socioeconomic status is associated with chronic disease, poor mental health, and unfavorable health behaviors in adulthood” (“Food Research Action Center”). **“After multiple risk factors are considered, children who live in households that are food insecure, even at the lowest levels, are likely to be sick more often, recover from illness more slowly, and be hospitalized more frequently”** (Schwarzenberg, 2018). In 2016, under-five stunting was still measured at 3.5% and under-five wasting measured at .4% (“Global Nutrition Report, United States”). This evidence, as well as the 2018 policy statement by The American Academy of Pediatrics establishes the importance and irreversibility of the first two years of a child’s life and highlights the need for continued and improved action by the United States to combat childhood malnutrition and infectious diseases such as influenza.

There have been studies on the relationship between childhood malnutrition and susceptibility to influenza infection. A study published in The Journal of Infectious Diseases

found that protein energy malnutrition (PEM), which is a condition that arises from the lack of dietary protein or calories and is a common cause of immunodeficiency in children, “is associated with an increased risk of infections” (Taylor, 2012). The researchers investigated the influence of PEM on susceptibility to, and immune response following, “influenza virus infection using isocaloric diets providing either adequate protein (AP; 18%) or very low protein (VLP; 2%) in a mouse model” (Taylor, 2012). The study found that mice on the VLP diet, when compared to mice on the AP diet, showed more severe disease following influenza infection, including “virus persistence, trafficking of inflammatory cell types to the lung tissue, and virus-induced mortality” (Taylor, 2012). Furthermore the study found mice on the VLP diet, “showed significantly lower virus-specific antibody responses” (Taylor, 2012). Arguably the most important finding was when switching mice on the very low protein diet to the adequate protein diet, the mice showed improved virus clearance and protective immunity to viral challenge (Taylor, 2012). **This proves that by improving overall diet, specifically through increased consumption of protein and calories, we are able to decrease susceptibility to influenza infection.** The study acknowledges that few studies have addressed the relevance of PEM as a risk factor of influenza, highlighting the need for further extensive research; although the conclusion from this study proves that through improving diets of children, the United States would not only be able to decrease the prevalence of malnutrition, but also decrease susceptibility to influenza infection.

Prevention Efforts in the United States

Continued efforts by the United States are needed to combat malnutrition and the spread of infectious diseases. Today, “we can tackle malnutrition by prioritizing public policies that ensure the provision of adequate nutrients and healthy eating during the crucial 1,000 days that would ensure that all children have an early foundation for optimal neurodevelopment” (Ongera, 2019). Prioritizing public policies, “that ensure the provision of adequate nutrients and healthy eating during this crucial time would ensure that all children have an early foundation for optimal neurodevelopment, a key factor in long-term health” (Schwarzenberg, 2018). In order to effectively implement such public policies, we must first understand the complexity of nutrition and the roles of micro and macronutrients, and how they combat all forms of malnutrition and optimize nutrient-dense meals for developing children (Schwarzenberg, Georgieff, Pediatrics). **“Currently, agencies commonly measure success by quantifying the people or meals served. Addressing the dual burden of malnutrition requires a shift from thinking from the quantity of people to the quality of food served and the impact on individuals”** (Ongera, 2019). Such public policy efforts can be made through federal nutrition programs such as the Child Nutrition Programs and the Supplemental Nutrition Assistance Program or SNAP (Ongera, 2019). “Research demonstrates that these programs can reduce food insecurity, alleviate poverty, support economic stability, improve dietary intake and health, protect against obesity and boost learning and development” (Ongera, 2019). The Global Nutrition Report examined whether the

United States currently has a national policy in place relating to the issues of malnutrition and micronutrient deficiencies, and whether there are further targets in place. The United States does not currently have national policies on mandatory legislation for salt iodisation of a sugar-sweetened beverage tax. Furthermore, there are no targets included in the national (nutrition or other) plan related to stunting or wasting. As food insecure children have proven to have less favorable health outcomes and the prevalence of protein energy malnutrition increases susceptibility to influenza infection, mitigating these problems is crucial to lowering the dual burden of malnutrition while simultaneously combating the spread of infectious diseases due to improved overall health and well-being of children.

China

Introduction

As the world's most populous country residing in East Asia, China covers approximately 9.6 million square kilometers and is one of the largest countries by area. Governed by the Communist Party of China, the state looks over 22 provinces, five autonomous regions, four municipalities as well as special administrative regions. Rapid and substantial economic transformations in the People's Republic of China over the past 35 years have translated into remarkable advances in poverty reduction and social development. By lifting millions out of hunger through policy, the country met its Millennium Development Goal of halving the number of hungry people by 2015 and cutting the global hunger rate by two-thirds (Zhu). However, there are still large pockets of poverty, especially in remote, mountainous areas, and there are huge income disparities and nutritional status gaps between rural and urban areas (Suri). About 150.8 million are undernourished (Suri). Given the size of China's population, rates of 9.4% for child stunting, 19.6% for anemia and 25% for overweight are significant global burdens (Suri). The current population of China is 1.393 billion people.

Undernutrition in China

Halving malnutrition in less than five years has been one goal that the Chinese Government achieved by 2000 (UNICEF). The current state of childhood malnutrition continues to improve. According to the 1992 Child Survey conducted by the State Statistical Bureau (SSB) in 26 provinces and autonomous regions and 3 municipalities, the prevalence of under-five malnutrition was 17.9 percent, 34.7 percent and 4.7 percent respectively: mild and serious underweight, stunting and waste. But significant disparities exist between urban and rural children and between provinces (Suri). Typically the highest prevalence rate occurred in the children's second year of life, and this may be the product of insufficient weaning food given to babies. Compared with data collected by SSB in nine provinces and autonomous regions in 1987, there has been a significant underweight improvement within these five years (UNICEF). The prevalence declined by 20.5 percent on average, specifically for children living in urban areas (UNICEF). Due to increased healthcare infrastructure and food allocation policy, China's urban

populations improved undernutrition issues related to micronutrient deficiencies. However, this trend was not seen in rural areas, as the underweight prevalence increased 5.9 percent (Suri). The prevalence for underweight urban children was low to waste and remained at the same level whilst there were some that increased in rural areas. The goal of reducing malnutrition by half in terms of underweight could be reached by the year 2000 with constant economic development and careful consideration to at-risk areas and groups (CDC). In 2020, China is still off course to meet targets for preventing stunting and wasting, as recorded by the CDC.

Figure 2.A

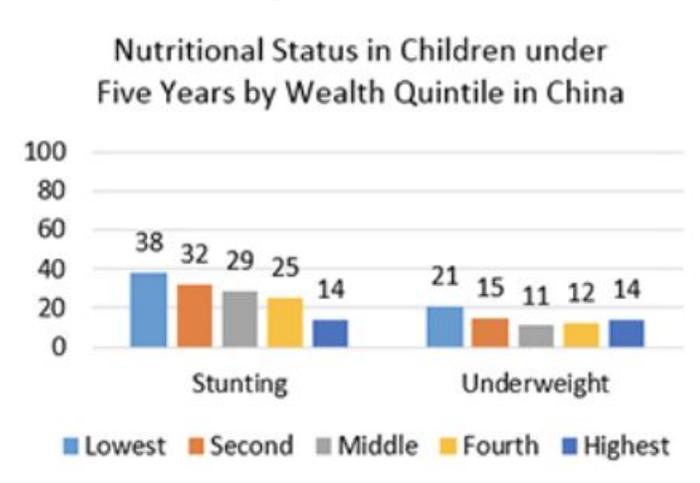
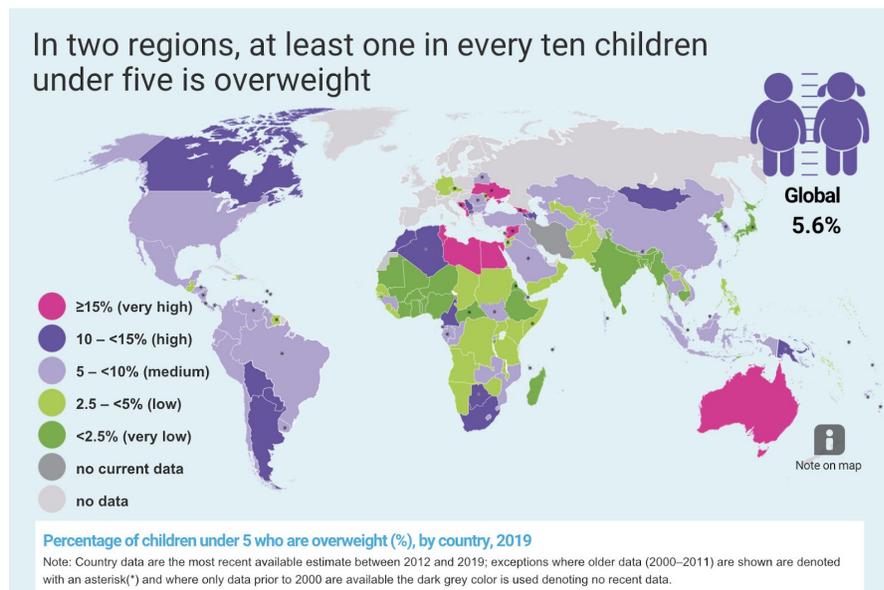


Figure 2.B



A twenty year study by Chinese researchers aimed to find the relationship between child malnutrition and social determinants among children under the age of 5 in China, as well as provide evidence and valuable information to assist policy-makers in designing social policies to improve child nutrition. Information from the longitudinal survey data of 2,434 children aged 0-5 in the China Health and Nutrition Survey (CHNS) was collected for study from 1991 to 2011 (Suri). Using World Health Organization Child Growth Standards for weight-for-age, height-for-age, and weight-for-height, children were defined underweight, child stunting, and child waste (Suri).

Weight-for-age values, height-for-age values or weight-for-height values below 2 standard deviations were viewed as underweight, stunting and waste. The 'igrowup' app was used by the World Health Organization to measure the prevalence of underweight, child stunting, and food waste. The logistic regression model was used to analyze the relation between malnutrition of children and social determinants such as income, education, housing, and region. The prevalence of underweight children and child stunting decreased by 64.8% and 67.8% respectively from 1991 to 2011, although the prevalence of child wasting remained at a comparatively low level (CDC). In China, the problem of underweight and stunting children had been resolved significantly (UNICEF Data). Female children had better outcomes on improving nutritional status than their male counterparts. Of all the non-socio-economic determinants of child malnutrition, both risk factors for malnutrition were children with a low-height mother and children who had inadequate protein intake. The social determinants that are significantly associated with child malnutrition included: living in western regions and central regions, living in communities with low urbanization levels, low household incomes and low educational levels (Zhu). Western and central regions have been seen as predominantly rural with less arable land, giving many populations a lack of food and preventative resources such as multivitamins and cheap nutritious food.

More attention should be paid to the social determinants behind childhood malnutrition in order to further decrease the prevalence of childhood malnutrition and alleviate child health inequities. Furthermore, social policies that are conducive to the promotion of child nutrition must be taken urgently. Significant social policies suggested by the researchers included an emphasis on maternal and child dietary intake, improving the economic situation of households, improving the level of maternal education, and balancing economic development and the distribution of resources among different regions of China. As of 2020, the progress being taken by China is only considered on course for under-five stunting, wasting, and birthweight (Borgen Project). However, China's reform of rural development and per-capita income in these developing areas needs to be improved. Nearly half of China's 1.3 billion people live in rural areas, 70 million of them living on less than a dollar a day (Borgen Project).

Tuberculosis in China

Research will focus specifically on tuberculosis and its steady increase in China. According to the CDC, “China has the second highest tuberculosis (TB) burden after India” (CDC China). Around 900,000 people were diagnosed with TB in 2017. Tuberculosis (TB) is a disease caused by the *Mycobacterium tuberculosis* bacteria. The bacteria normally attacks the lungs but other parts of the body may also be affected. TB is prevalent in largely populated areas, given that it can be spread through air and bodily fluids (Zhu). Established in 1981, the National Tuberculosis Program in China controlled efforts to report and treat TB across the country. However, due to a lack of funding, the TB epidemic in China spread and hampered the program’s capacity. After various international efforts launched by the World Health Organization in the late twentieth century, the project aimed to save 100,000 deaths a year.

Today, it is found that Tuberculosis in China was able to cure 85% of identified patients, creating a separate insurance service that allowed to pay for the TB treatment nationwide. However, it’s also been found that China’s modern TB treatment was only available for permanent residents, excluding urban migrants numbering over 150 million over the past ten years (Borgen project). Despite the efforts made locally, nationally, and globally, China still has the highest rate of TB, with 1.3 million affected and 150,000 dead annually.

Childhood Malnutrition and Tuberculosis in China

Malnutrition and tuberculosis (TB) tend to work together. TB may lead to deficiencies in nutrition, which in turn weakens immune functions. Proper nutritional support during TB can promote recovery. One study aimed at assessing the effectiveness of nutritional support in promoting the recovery of adult pulmonary TB patients with anti-TB drugs. In the continued Global Burden of Disease study, it is found that malnutrition is generally an unseen factor of strengthening the TB transmission apart from smoking, alcohol use, and ambient air pollution (Zhu). Malnutrition is an increasingly dangerous micro and macro-deficiency that has affected various populations in China, including females under 5 years of age. Like malnutrition, rural areas which account for half of China’s population are the most vulnerable populations, hurting them three times higher than in economically developed and urban parts of China.

Malnutrition does not only mean being underfed, but it also indicates hidden hunger through a lack of micronutrients, leaving children at a disadvantage when these resources are not available. In a recent article by the World Health Organization, researchers and politicians alike have found that implementing nutrition plans within health services could save millions of vulnerable populations from malnutrition (Zhu). In China, various clinics that aim to treat TB have been considered free to all permanent residents by the government. However, national programs to combat malnutrition and hidden hunger have been more vague, leaving many residents unfed and affected by a lack of nutritious food. Through UNICEF, food programs to help the most vulnerable populations in China have gained ground in nourishment yet significant difficulties exist. Although there has been a worldwide decrease in malnutrition (low stature

for-age proportion): somewhere in the range of 1990 and 2018, the pervasiveness of hindering in kids matured under 5 years declined from 39.2% to 21.9%, or from 252.5 million to 149.0 million children, progress has been much slower in China (UNICEF). UNICEF researchers believe that the largely dense populations and affecting diseases such as TB are factors that heavily affect child mortality rate in the Western and Central regions of China.

Prevention Efforts in China

To address this public health problem of global significance, CDC and local partners have been working to, “improve TB surveillance, strengthen infection control practices at health care facilities, increase treatment completion rates among TB patients, and address multi-drug resistant TB (CDC).” The Centers for Disease and Control also provides strategies in order to combat emerging epidemics. Examples include supporting international quality control measures, implementing worker safety across the Chinese region, and assurance practices such as SLMTA, the Strengthening Laboratory, Management Toward Accreditation (CDC). Although China’s efforts have been heavily funded through international organizations such as the World Health Organization, Tuberculosis has been left as a consistent epidemic plaguing China since 1990.

Malnutrition’s relation with TB has left many immunocompromised, with increased out-of-pocket hospital expenses, or even dead. Regardless if the study focuses on malnutrition or TB, both are always mentioned as an influencing factor. Malnutrition directly contributes to TB, and TB is very high-risk for child mortality. If China wants to decrease the impacts of Malnutrition and TB, efforts towards reforming clinical infrastructure and healthcare allocation to rural areas must be done. If not, the current efforts will prolong the TB epidemic. As for malnutrition, country policies such as income reform and maternal education are systemic barriers that require more than donations and a single policy change to fix (Borgen Project).

Philippines

Introduction

The Philippines is an archipelagic country consisting of over 7,000 islands located in South Asia. It has a total population of 106.7 million, a child population of 36.3 million and the average life expectancy is 70.95 years. Although the country is generally considered to be a developing country, the Philippines has a rapidly expanding economy due to a strong labor market and an increase in urbanization. According to the World Bank, poverty in the Philippines has declined from 23.3% in 2015 to 16.6% in 2018. Despite the improvements in the economy during the past several decades, the Philippines still has a variety of challenges to face including high malnutrition rates and a wide variety of infectious diseases.

Undernutrition in the Philippines

Undernutrition, specifically stunting, is still extremely prevalent in the Philippines today. According to data collected by UNICEF, every day 95 Filipino children die from malnutrition and one third of Filipino children are stunted, around 12.1 million children. As mentioned earlier, stunting is when children are small or short for their age usually due to undernutrition related causes. Stunting can have irreversible life-long consequences including making the children more susceptible to illness and disease throughout their life. It can also cause damage to their overall mental and physical development. Around half of all reported deaths among infants and children up to the age of 4 is due to undernutrition (Ravenholt, 1982).

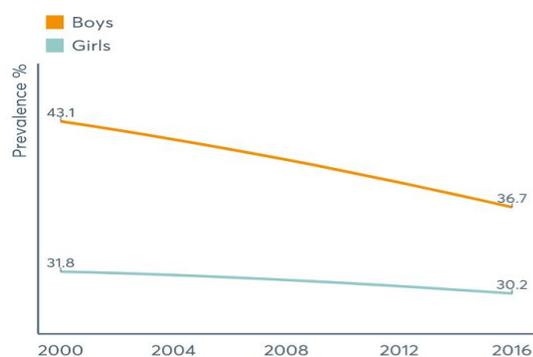
Malnutrition in the Philippines is further exacerbated by intestinal parasites and gastrointestinal diseases which are relatively common in children. These diseases rob children of around 5-10% of their nutrition intake leading to lifelong side effects if untreated (Ravenholt, 1982). In rural villages, Kamayan, the cultural practice of consuming food using one's hands, contributes to the spread of such illnesses.

In response to the large prevalence of undernutrition among Filipino children, the Philippines government has established malnutrition as a case of immediate concern. The government has created the Philippine Plan of Action on Nutrition (PPAN) 2017-2022 to combat malnutrition. "PPAN features 8 nutrition-specific programs devised to address the immediate causes of malnutrition: inadequate food and nutrient intake, poor care-giving and parenting practices, and infectious diseases. Programs under the PPAN 2017-2022 aim to reach 90 percent of the target population and the "ambitious" target is to reduce stunting from the current 33.4% to 21%" ("A Turning Point for the next Generation of Filipinos with the Launch of a New Nutrition Action Plan"). **Despite the government's efforts, malnutrition rates have still not improved significantly. According to UNICEF's, *The State of the World's Children 2019*, one in three Filipino children under five years old are still stunted in 2019.** According to the global nutrition report, while the percentage of underweight children has decreased over the past two decades, a large percentage of children are still underweight.

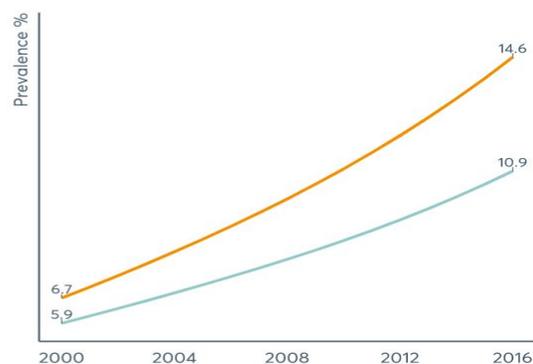
Figure 3.A.

Child and adolescent (aged 5-19) nutrition status

Underweight by sex



Overweight by sex



Sources: NCD Risk Factor Collaboration.

Figure 3.B.

Progress against global nutrition targets 2019



Sources: UNICEF global databases Infant and Young Child Feeding, UNICEF/WHO/World Bank Group: Joint child malnutrition estimates, NCD Risk Factor Collaboration, WHO Global Health Observatory and Global Burden of Disease, the Institute for Health Metrics and Evaluation.

Dengue in the Philippines

Dengue is a viral infection transmitted through mosquitoes and is most prevalent in tropical/subtropical areas. It is the most common mosquito borne viral disease in the world (Elling, 2013). Dengue can be caused by four different viruses, DENV-1, DENV-2, DENV-3, DENV-4, that all belong to the *Flaviviridae* family of viruses. The majority of Dengue patients are children, however, the age distribution of Dengue is rapidly increasing and now includes patients of all ages (Tantawichien, 2012). Those infected may experience flu like symptoms but may also be asymptomatic, which leads to consistently under reported rates of dengue infections. Dengue may progress to Dengue Hemorrhagic Fever/Severe Dengue (DHF) in certain cases which have more severe symptoms and can be fatal. DHF often leads to many health complications including severe bleeding, organ impairment, and plasma leakage (World Health Organization). Another dangerous side effect of dengue infection is Dengue Shock Syndrome (DSS). DSS occurs when a dengue patient is infected with a secondary virus strain. DSS patients have a high chance of developing organ failure and eventually, death (Rajapakse, 2011). Dengue infection, DHF, and DSS currently have no antiviral treatment. A vaccine for Dengue was created in 2017 called Dengvaxia. This vaccine was used in the Philippines and after vaccinating

1 million Filipino children, it was discovered that this vaccine actually increased the chances of children developing DHF after they were infected with Dengue. Use of the vaccine in the Philippines was suspended and there is yet to be a reliable placement vaccine (Cohen, 2019).

Models estimate that the global number of Dengue infections per year range from 284-528 million people. However, 70% of the global infections are in Asia (World Health Organization). One of the most impacted countries by Dengue is the Philippines with the first infection reported in the early 1900's. Throughout the 1900's and early 2000's, the infection rates of Dengue have steadily increased with several epidemics occurring around every other decade. The latest epidemic in the Philippines was declared in 2019 when the number of cases spiked to over 400,000. The epidemic that began in 2019 is currently still ongoing in 2020, however, the cases have decreased throughout the start of 2020. In reaction to the 2019-2020 Dengue epidemic, the Philippines health department has doubled down on efforts to destroy mosquito breeding sites and ensure that hospitals have adequate supplies to treat patients. The severity of a Dengue outbreak is often linked to changes in weather patterns as a longer rainy season creates an increase in mosquito breeding sites. As there is currently no reliable vaccine for Dengue, it is crucial to combat mosquitos as a way to decrease the spread of Dengue.

Undernutrition and Dengue in the Philippines

Like other infectious diseases, scientists have researched the connection between undernutrition and Dengue. Previous research has been conducted on how malnutrition affects dengue infections, particularly in children. However, the research done includes many conflicting results. Some studies suggest a negative correlation between malnutrition and dengue infections/DHF while others suggest a positive correlation. One study that was conducted in Bangkok assessed children infected with either dengue or DHF. The study assessed the nutritional status of 100 children who had been diagnosed with DHF by measuring the weight, height, and circumference of the left arm of each child. The study found that only 13% of the patients were undernourished. This is much lower than malnutrition rates found in children infected with other infectious diseases(Thisyakorn, 1993) However, this study is purely an assessment of infected children and their nutritional status and is only correlational. **There is still little non correlational research done on how malnutrition exactly affects dengue patients, particularly children.** A different study that was also conducted in Bangkok observed the exact opposite conclusions as the previous study. This study observed over 4,000 patients that were admitted to a children's hospital in Bangkok between 1995-1999. Out of all the patients, 9.3% were classified as malnourished and 24.2% as obese. The study concluded that malnourished patients had a 37.8% chance of developing DHF (as compared to 29.9% chance in patients of a healthy weight)(Kalayanaroj, 2005). Similar to the last study though, this study is also purely correlational.

A systematic review and meta-analysis of the association of malnutrition and Dengue was performed in 2016 by researchers who analyzed previous studies done on malnutrition and

Dengue. While the meta-analysis “indicated a statistically significant negative correlation between malnourished children with dengue virus infection and healthy children”, the researchers warn that “the findings should be interpreted cautiously because all significant associations were lost after removing the largest study” (Trang, “Association Between Nutritional Status and Dengue Infection: A Systematic Review and Meta-Analysis”). More research still needs to be done on the exact effect of malnutrition on Dengue patients. Besides the conflicting correlational data, little is known about malnutrition and Dengue.

Prevention Efforts in the Philippines

Since there is not yet a clear relationship between undernutrition and Dengue, combating undernutrition may not be a useful tactic to combat Dengue. However, the Philippines government has addressed the severity of Dengue epidemics and taken steps to try to lessen the burden of Dengue on the Philippines. Due to the frequency of Dengue outbreaks, the Philippines Department of Health has created the Dengue Prevention and Control Program. The program’s objectives are to “to reduce dengue morbidity by at least 25% by 2022”, “to reduce dengue mortality by at least 50% by 2022”, and “to maintain Case Fatality Rate (CFR) to < 1% every year”. The program is broken into six components: surveillance, case management and diagnosis, integrated vector management, outbreak response, health promotion and advocacy, and research. These six components all play a different role ranging from community work to training doctors. Although it is still too soon to see the outcomes of this government program and its effectiveness in combating Dengue, it will be interesting to see the overall results of this program. If this program proves useful in combating Dengue, it could be a helpful model for other countries in combating similar infectious diseases to Dengue. Other non profit organizations such as Break Dengue and the World Mosquito Program are also attempting to fight the high rates of Dengue infections. Break Dengue is currently using big data to build a more comprehensive Dengue tracking system on a global scale. This tracking system can eventually help predict Dengue outbreaks and also more accurately determine the number of global infections. The World Mosquito Program is attempting to use a type of bacteria called *Wolbachia* to fight transmission of mosquito borne viral diseases. While there has been action taken against fighting Dengue epidemics, there are still many unknowns on combating Dengue. There is still no reliable vaccine and a lack of research connecting undernutrition and Dengue. There must be more research done and more initiatives on preventing the spread of Dengue in the Philippines and in the world.

Nigeria

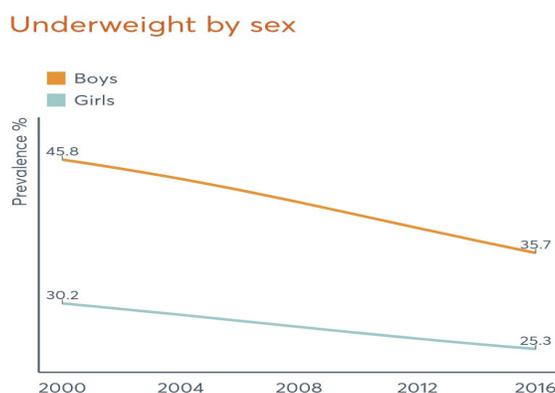
Introduction

Nigeria is located in Western Africa and borders along the Gulf of Guinea, Benin, and Cameroon. Compared to other countries in the region, Nigeria is the most populated, with about 200 million people living there. Approximately 43.87 percent of the population is 0-14 years old, 53.39 percent of the population is between 15-64 years old, and only 2.75 percent of the population is 65 and older (“Age Demographics in Nigeria”). One important indicator of Nigeria’s overall health is life expectancy. According to the World Bank, the overall life expectancy is 54.33 years old (“Life Expectancy at Birth”). Given Nigeria’s age demographics and current health status, a majority of public policies and health policies should prioritize the health and well-being of children, adolescents, and young adults. This means that in terms of malnutrition and infectious diseases, the Nigerian government and officials should make an effort to prevent mortality and morbidity to the young population, especially children and adolescents.

Undernutrition in Nigeria

While addressing childhood malnutrition is important in every country, Nigeria has the “second highest burden of stunted children in the world, with a national prevalence rate of 32 percent of children under five” (“Malnutrition in Nigeria”). This affects approximately 2 million children in the country, yet only 2/10 children receive the proper treatment for childhood malnutrition due to a lack of resources, infrastructure, and access to health care. Furthermore, in Nigeria, the biggest form of malnutrition for children is stunting, which greatly impairs growth. Stunting can lead to an increased risk of death, poor cognitive development, lower educational performance, and lower productivity in adulthood. Based on Figure 4.A, the prevalence of undernutrition has decreased over time (Figure 4.A), but many Nigerian children still suffer from malnutrition and future policies should still be aimed at improving this issue (“Nigeria Nutrition Profile”).

Figure 4.A.



Previous research studies have examined the patterns of childhood malnutrition in Nigeria. One study found that there are inequalities in the distribution of stunting. In fact, the “South-east and south-west regions [of Nigeria] had low average levels of childhood malnutrition, but the inequalities between the poor and the better-off were very large. By contrast, North-east and North-west had fairly small gaps between the poor and the better-off on childhood malnutrition, but the average value of childhood malnutrition was extremely high” (Uthman 5). The inequalities in rates suggest that other factors, such as socioeconomic status may affect malnutrition rates. **These conclusions are consistent with previous findings that “individual [e.g. socioeconomic status] and community [e.g. government policies and healthcare system] contribute to the variation in chronic childhood malnutrition”** (Uthman 112).

Malaria in Nigeria

Another public health problem in Nigeria is malaria. According to the World Health Organization, malaria is also known as the protozoan parasite, *Plasmodium*. In general, the transmission of malaria occurs through the bites of the female *Anopheles* mosquitoes. Once the parasite enters the human body, there is an incubation period of about seven days and then the illness develops. Symptoms of malaria include fever, chills, headache, muscle aches, weakness, vomiting, cough, diarrhea, and abdominal pain. In certain cases, the illness can be fatal if left untreated. Individuals who are at highest risk are young children, pregnant women, immunosuppressed, and the elderly (“Malaria”). Since young children constitute a significant portion of Nigeria’s population, it is imperative that health officials pay close attention to this age demographic and their health.

Even though there have been significant scientific and technological improvements in terms of treatments, the incidence of malaria is still high. In 2018, there were about 228 million estimated cases of malaria (“Malaria Key Facts”). Specifically, there were about 84 million cases in the Democratic Republic of the Congo and Nigeria. Furthermore, in all malaria cases, it was reported that children under five years old account for about 67 percent or about 272,000 of all deaths. Given the high incidence of malaria cases in Nigeria and in children, more research should be conducted to determine why this is the case.

One primary reason why malaria is so common in Nigeria and Africa is because of the vector of the disease. According to the Center for Disease Control and Prevention, the specific mosquito, *Anopheles gambiae*, has a relatively long life cycle and so they are able to spread malaria through their bites. In addition, the weather conditions in Africa are the perfect environment for the mosquitos to thrive. Given this information, it is difficult for public health officials to completely eradicate malaria.

Undernutrition and Malaria in Nigeria

While both childhood malnutrition and malaria are pressing public health issues, it is possible that these two issues are closely related. One study assessed the malaria infection and nutritional factors of more than 4,000 children in northern Ghana. They concluded that “malnutrition is a fundamental factor contributing to malaria-associated morbidity and anemia, even if [malaria] exhibits multifactorial patterns” (Ehrhardt 108). These findings are qualified by another study by the Worldwide Antimalarial Resistance Network. They stated that, “chronic malnutrition was relatively consistently associated with severity of malaria such as high-density parasitemia and anaemia” (Das 11). It appears that there is a closer relationship between malaria and malnutrition than previously thought, and this is especially problematic with children and/or adults with chronic undernutrition.

It is understood that nutrition plays a vital role in a child’s development and overall health. Children and young adolescents are encouraged to have a sufficient caloric intake and adequate nutrients and supplements. The vitamins, minerals, and calories are used to build a proper immune system and sustain enough energy to fight infections. **In fact, one study explains that improved “nutritional status lessens the severity of malaria episodes and results in fewer deaths due to malaria”** (Caulfield 55). However, it is important to note that one potential limitation of these research studies is accounting for confounding variables. Oftentimes, external factors such as income may affect malnutrition and treatment for malaria. Nevertheless, recent studies highlight that there is a positive relationship between childhood malnutrition and malaria.

Prevention Efforts in Nigeria

Since there is a positive association between the two issues, by combating either childhood malnutrition or malaria, the government will be decreasing the negative health impacts and co-morbidities. In order to decrease the incidence of malaria, the Nigerian government should continue the partnership between international organizations (e.g. UNICEF) to further develop maternal and child health services, including antenatal care and immunizations (“Malaria Key Facts and Figures”). Organizations can also decrease the vectors of malaria by providing mosquito nets to families in local communities. By limiting the transmissions of the disease, the population will be healthier and malaria should be controlled (“Bed Nets Prevent Malaria”). Since nutrition plays an important role in disease prevention, the Nigerian government must also address childhood malnutrition. The government should continue to prioritize the design of the primary health care system and expand current medical professionals, including physician assistants and nutritionists. Local communities can maintain their own medical team that works directly with families and children. Finally, the government in collaboration with UNICEF must establish the necessary funds and materials to ensure that the population is provided with enough vitamin and mineral supplements to complement their diet. By focusing on these policies, the prevalence of childhood malnutrition and malaria may decrease.

Synthesis of Case Studies

We have now examined malnutrition, specifically undernutrition, infectious diseases and their relationship in four countries: the United States, China, the Philippines, and Nigeria. We also examined various prevention efforts throughout the countries and current policies or lack thereof that are in place.

In the United States, socioeconomic determinants as well as large food insecurity has resulted in skipped meals or non-nutritious food being consumed. Low-income families in the United States have been shown to be especially vulnerable to poor nutrition and lower health outcomes throughout their lives (Ongera, 2019). The American Academy of Pediatrics published a policy statement in 2018 highlighting the importance and irreversibility of the first 1,000 days of a child's life, including their neurodevelopment and mental health. Children who live in households that are food insecure, are more likely to be sick more often, recover slowly, and be hospitalized more frequently (American Academy of Pediatrics, 2018). The statement proves that although calories are important, they are not sufficient for adequate development (Schwarzenberg, Georgieff, Pediatrics). Key nutrients including proteins, minerals, and vitamins are all necessary components of any healthy diet. Furthermore, a study published by The Journal of Infectious Diseases found that protein energy malnutrition decreases immunity and increases susceptibility to influenza infection in mice. Importantly, the study found that through increased protein and calorie consumption, immunity increased and susceptibility to infection decreased. (Taylor, 2012). The United States needs continued and improved policy that focuses not only on the quantity but the quality of food being produced.

The case of China showed that although the country's prevalence of poverty has decreased substantially over the last 35 years, there are still large populations of people living in poverty, specifically in remote and mountainous areas. Roughly 150.8 million people are undernourished, and there is a prevalence of 9.4% stunting (Suri). The different health outcomes of children in rural vs. urban areas highlights an important need for improved efforts throughout rural communities and governments to obtain quality and nutritious diets for children, especially in their first two years of life. Furthermore, families in the lower wealth quintile in China have lower nutritional status than children under five in higher wealth quintiles. With the continued prevalence of tuberculosis, China may effectively target reducing the spread of this disease while also decreasing the burden of malnutrition throughout the country through improved and targeted policies. However, further policy regarding the improved infrastructure and mobilization of resources should be introduced.

The Philippines has also experienced a rapid decrease in overall levels of poverty from 23.3% in 2015 to 16.6% in 2018, but continues to face challenges of high malnutrition rates as well as a variety of infectious diseases (World Bank). It is estimated that everyday 95 Filipino children die from malnutrition and 1/3 of all Filipino children are stunted (UNICEF). Furthermore, around half of all reported deaths among infants and children are due to undernutrition (Ravenhold, 1982). Contrary to the United States and China, the Philippines government has

established malnutrition as a case of immediate concern and the Philippine Plan of Action on Nutrition was created in 2017 to combat malnutrition. But despite these efforts, there has been little improvement throughout the country, highlighting the need for revised and/or improved policy and implementation. With infectious diseases such as Dengue, in which children are at high risk of being infected, it is important to further study the relationship between malnutrition in children and the spread of infectious diseases. Existing research between Dengue and malnutrition has produced conflicting results, ranging from a negative to positive correlation, so more research is needed to reach a solid conclusion and make accurate and effective policy stances in the Philippines.

Lastly, the case of Nigeria highlights the need for public and health policies to prioritize the health and well being of children, especially given the large percentage of the population falling into this age bracket in Nigeria. Nigeria is measured as having the second highest burden of stunted children in the world, with a prevalence of 32% of children under five (“Malnutrition in Nigeria”). This means that 2 million children are being affected, and yet only 2 out of every 10 children affected receive proper treatment for malnutrition. This highlights an urgent need for improved action by the Nigerian government and officials to ensure the health and well being of their children and adolescents. Like the other countries studied, socioeconomic determinants and food insecurity play major roles in the children that are most affected by malnutrition and prove that “individual [e.g. socioeconomic status] and community [e.g. government policies and healthcare system] contribute to the variation in chronic childhood malnutrition” (Uthman 112). Important in the case study of Nigeria is the relationship between malnutrition and malaria. One study found that malnutrition was a fundamental factor contributing to malaria-associated morbidity and anemia (Ehrhardt, 108). This problematic relationship between malaria and undernutrition in children further the need for improved policy as a method of combating both issues through the positive correlation between them.

Childhood health and nutrition are important global health issues and many countries have placed priority on improving the health and well being of children, but there may be a lack of connectivity between the issues of combating malnutrition and the spread of infectious diseases. From the studies above, we have seen the important and irreversible role that the first 1,000 days has on the development of children and the continued impact into adulthood. Although childhood health has been a priority in many countries, there are still 161 million children around the world who are chronically undernourished and 51 million children who are acutely undernourished (UNICEF 8). If the goal is to combat the spread of infectious diseases through improved health of children, our case studies highlight a need for better quality intervention that guarantee nutritious diet regardless of socioeconomic status or location. Such prevention efforts and policy suggestions are further examined in the following section.

Conclusion and Potential COVID-19 Implications

From the four case studies, it is clear that governments have a responsibility to continue addressing the burden of malnutrition and infectious diseases. However, in countries with well established health care systems and access to accurate information,, individuals also have a personal responsibility to seek care and follow government guidelines and regulations when needed. In the midst of COVID-19, we recommend that healthy individuals continue to seek primary health care and preventative services through telehealth, if possible. Research thus far has shown that several infectious diseases may be exacerbated with poor diet and malnutrition. Individuals, especially children, should have access to seek advice from physicians and establish a healthy and sustainable diet, full of key nutrients including protein, minerals, and vitamins. Although many infectious diseases, including COVID-19 may be unpredictable, individuals in good health commonly have stronger immune systems and quicker recovery and responses to diseases. However, still today many individuals do not have the resources to seek primary care or maintain a healthy diet/lifestyle. After closely examining the relationship between undernutrition and a variety of infectious diseases and examining several policies and tactics used by different governments and organizations, there are several standout suggestions for lowering the burden of malnutrition and tackling future infectious diseases.

First, we recommend that governments place a special emphasis on infants, especially the first 1,000 days of a child's life. During the first several years of one's life, irreversible damage such as undernutrition can have lifelong consequences for a child's life. Research done by the American Academy of Pediatrics proved the importance and irreversibility of the first two years of a child's life, highlighting the need for the United States as well as all other countries to place a special emphasis on the overall health and well-being of infants. By focusing on infant health care, it "ensures that all children have an early foundation for optimal neurodevelopment, a key factor in long term health"(Schwarzenberg, Georgieff, Pediatrics). Similarly, policies put into place in Nigeria include a large emphasis on preventative medicine for children. By developing and providing primary care services, antenatal care, and immunizations, Nigeria emphasizes the importance of child health which in turn prioritizes the long term health of individuals. Policies and NGO work in Nigeria also attempts to expand the prevalence of physician assistants and nutritionists in villages as well as ensuring that each community has their own unique medical team to create a personal patient-physician relationship.

In addition to preventative care, we recommend that officials focus on preventing the burden of childhood malnutrition and poverty because this can help combat infectious diseases. In the United States, social determinants and low-income households have repeatedly been shown to have lower health outcomes compared to middle and high-income households (Ongera, focus for health). Similarly, according to research by the Food Research Action Center, "childhood poverty and socioeconomic inequalities have health implications that carry through

into adulthood- for example lower childhood socioeconomic status is associated with chronic disease, poor mental health, and unfavorable health behaviors in adulthood”. In the Philippines, where a large portion of children suffer from undernutrition, the government has created the Philippine Plan of Action on Nutrition (PPAN) 2017-2022. While it is still too soon to tell the results of this plan, the message it sends is clear. We must focus on combating undernutrition for children as malnutrition can lead to irreversible life long consequences. In Nigeria, vitamin and nutritional supplements are given to civilians to combat undernutrition. Compared to China, efforts towards combating malnutrition efforts have been located towards more densely populated urban areas where vitamin deficiency is mainly prevalent in rural regions. While there are many policies and plans put into place towards tackling the large prevalence of malnourished children in our world today, there is still a lot of progress we have to make towards lessening the burden of childhood malnutrition and in turn, lower transmission rates of infectious diseases.

Finally, for viruses that are transmitted through mosquitoes such as Dengue and Malaria, an obvious suggestion is to prevent the spread of the virus by lowering transmission rates from mosquitoes. This can manifest in a variety of tactics including distributing mosquito nets to civilians or simply killing the mosquitos. However, recently, a variety of new tactics to combat mosquito borne viral diseases are being developed and researched. The World Mosquito Program is attempting to use a type of bacteria called *Wolbachia* to fight transmission of mosquito borne viral diseases. When a certain type of mosquito carries the *Wolbachia* bacteria, the mosquito is less likely to transmit certain diseases. Thus, the World Mosquito Program breeds *Wolbachia* carrying mosquitos to lower the risk of mosquito borne viral diseases. The Harvard T.H. Chan School of Public Health recently developed a new approach to fighting malaria by directly targeting the parasite that is responsible for the disease. The researchers are using an antimalarial compound, atovaquone, which blocks mosquitoes from being infected by the parasite that causes malaria. These new breakthroughs in research greatly aid in the fight against mosquito borne viral diseases and can be used to lower the overall transmission and infection rate of many infectious diseases.

Ultimately, malnutrition, specifically undernutrition plays a crucial role in exacerbating the spread of infectious diseases. Undernutrition lowers an individual’s immunity which in turn increases their risk of disease. If the individual is then infected, their body needs an increase of energy and nutrients to fight off the disease. Since the body is now using more nutrients, the individual becomes further malnourished and the cycle repeats. To lower morbidity and mortality rates of infectious diseases, governments must address this vicious cycle of malnutrition and infectious diseases. More research needs to be done on the role malnutrition plays in each specific infectious disease. Governments must continue to implement or create new policies that specifically address malnutrition in their country as a way to not only combat infectious diseases but also to improve the overall long term health of individuals.

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