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Famine in Context: Possible long-term effects of exposure to starvation and malnutrition in early life and subsequent implications for the current crisis in South Sudan

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Famine in Context:

Possible long-term effects of exposure to starvation and malnutrition in early life and subsequent implications for the current crisis in South Sudan



Figure 1: Photojournalist Kevin Carter's Pulitzer Prize winning photo of a young Sudanese child collapsed en route to a feeding station, 1994.

Photograph: Photograph: Kevin Carter/Corbis Sygma

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Honors Senior Thesis

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Abstract

Central focus

The central focus of this thesis is to examine the historical and sociopolitical roots of famine. In examining the root causes of famine, we can more carefully analyze its effects on the human condition. More specifically, in analyzing the pathologies associated with food deprivation and malnutrition at an early age, we can examine the possible long-term consequences of malnutrition on human health. In doing so, we can apply this understanding to the current crisis in South Sudan, to consider the implications that the current political situation presents for future generations of South Sudanese people.

Thesis rationale

This thesis needs to be done because the country of South Sudan is currently on the verge of both genocide and famine. As a future physician and conscious global citizen, it is important that I be able to look at the possible consequences of sociopolitical disaster on a population's health and understand the implications that these circumstances create for future generations. This thesis is unique because it not only presents and examines scientific knowledge in order to draw conclusions regarding pathological effects of famine, but it also incorporates both historical and sociopolitical analyses to provide a full understanding of the issue.

Introduction

Purpose of exploration

South Sudan gained its independence in 2011, officially making it the world's youngest nation. However, although a new nation, South Sudan is no stranger to conflict and has a long history that is characterized by ethnic and religious tensions, political instability, violence and

famine. Since 2013, the young nation has been embroiled in a civil war which has led to the deaths of at least 10,000 people and the displacement of approximately 1.5 million. In addition, South Sudan is currently on the brink of famine, with the U.N. reporting that almost 4 million South Sudanese currently face starvation, without hope of sufficient relief (Green, 2014). With a current rating of 4 on the U.N.'s "Integrated Food Security Phase Classification" (IPC) scale, the crisis is officially considered an "emergency" and it is only a matter of time before the country obtains a rating 5 status of "famine" (Jeffrey, 2014). When the crisis in South Sudan is officially marked as famine, the country will have fallen into a catastrophe that, in combination with its current sociopolitical situation, will create severe and irrevocable consequences for future generations of South Sudanese people.

Historical and sociopolitical roots of famine

In order to fully understand the implications that famine status will have on the people of South Sudan, it is imperative that consideration first be given to the general historical and sociopolitical/economic roots of famine. In Western minds, the term famine most commonly draws up images of drought, blighted crops and mass starvation. This depiction and understanding of famine, however, is grossly oversimplified, largely inaccurate and wholly under acknowledges the complexity of this serious and impactful phenomenon. In fact, recent research has shown that during many recent instances of famine, "per capita food availability did not decrease significantly: what changed was the distribution of entitlements to food" (Watkins, 1985).

Famine itself results from the convergence of a diverse range of social, political, economic and natural factors. In its essence, famine is an issue which unifies both material rights and liberal human rights. One important factor influencing the propagation of famine is

government limitation of political and economic freedoms. By limiting political rights, such as access to information and rights to association and representation, the poor in society are unable to demand that their food needs be met when circumstances of deprivation or shortage arise. By limiting, or in some cases removing, economic freedoms, many people are forced into circumstances of abject impoverishment which only serve to worsen the effects of food shortages and hasten the approach of famine. Most important, however, is the influence that counterinsurgency operations and systematic violence play on the generation of famine. Oftentimes in counterinsurgency operations, the aim of the government is the intentional creation of famine, as a means to force submission upon its constituents (De Waal, 1991).

The physical shortage of food crops undoubtedly plays a factor in the generation of famine. However, it is incontrovertible that this is not the sole influence in the perpetuation of this phenomenon. Rather, it is a complex unification of political, economic, natural and social factors which serve to create instances of famine.

Historical instances of famine in Sudan and outcomes

South Sudan itself is no stranger to famine. Through its shared history with the larger nation of Sudan, it has been witness to several instances of famine, the most notable of which occurred during the years of 1984-85 and 1988. Because of the different circumstances under which these famines occurred, there were drastically different outcomes.

During the 1984-85 famine, there was much less food available to the Sudanese population than in 1988. However, it was during this instance of famine that almost all civilians survived and were able to return to self-sufficiency post-famine. The reason for this being that the Sudanese were able to develop coping strategies (such as eating wild foods, migrating in search of labor, selling animals and planting crops for future harvest) that enabled them to meet

survival their needs and therefore depart the famine largely unscathed. In fact, the famine itself ended in 1985 with a successful harvest and intact economic base for future livelihood (De Waal, 1991).

The 1988 famine, in contrast, existed under vastly different circumstances and had a much different outcome. Although there was much greater food availability during the 1988 famine, Sudan was embroiled in violent social and political turmoil which grossly affected the population's ability to cope under such strenuous circumstances. In fact, during the 1988 famine, the Sudanese government deliberately prevented the population from developing coping strategies and actively sought to destroy the livelihood and productive base of Sudan's agricultural peoples. By raiding and poisoning wells, killing and stealing animals, preventing the possibility of migration for food and labor and restricting access to food aid, the government perpetuated and worsened the famine, therefore ensuring the devastation of the Sudanese people (De Waal, 1991).

Starvation as a weapon of war in South Sudan

As shown by the example of the Sudanese famine in 1988, starvation is a very powerful weapon of war that only serves to propagate and encourage the progression of food shortage into famine. The current crisis in South Sudan is no exception to this. One of the primary modes by which the current civil war is being fought, is through the confiscation and destruction of civilian property. While this includes the meager amounts of sustenance that civilians already possess, it also extends to the minimal amount of relief aid that they are able to receive. Tens of thousands of displaced citizens, as well as those living in conflict-affected regions, rely almost entirely upon the relief aid, protection and shelter received from the United Nations and various non-governmental organizations (NGO's). As the conflict has worsened, not only have citizens

become victims of violence but aid workers have become targets, as well (Green, 2014). Rebel groups frequently target aid envoys and confiscate what little is able to be offered for suffering civilians. Unfortunately, it is the areas with the greatest need that are concurrently the most deeply affected by the current fighting. It is these areas which are most frequently have aid supplies looted, seeds stolen and livelihoods destroyed. As a result, these civilians who are already trying to cope with the annual food shortages are being forced toward the brink of famine.

Current political situation in South Sudan

The current crisis in South Sudan erupted in December of 2013, when President Salva Kiir accused former Vice President Riek Machar of plotting a coup against him. Although the former Vice President vehemently denied these accusations, he quickly assembled the Sudan People's Liberation Movement (SPLM) to combat the current President, therefore inciting the first of several clashes which have led to the displacement of 1.5 million people and the deaths of over 10,000 (Herlinger, 2014).

Although originating as a political dispute, the conflict quickly became characterized by the eruption of long-existing ethnic tensions between Salva Kiir's Dinka, the country's largest ethnic group and Riek Machar's Nuer, the country's second largest ethnic group. As the conflict has progressed, the country has been witness to horrific and frequent mutual ethnic massacring and a descent into complete and utter lawlessness that has encouraged further eruption of ethnic tensions and incited the involvement of even more minority ethnic groups in the current violence. While "negotiations" have been in progress since the early stages of the conflict, no solution has yet been found. The government and rebel groups have signed two cease-fire

agreements since the beginning of 2014, with both deals quickly disintegrating as the country descended once again into violence (Bariyo, 2014).

Implications of current political situation on famine status

The conflict that has enveloped the nation of South Sudan has ensured that it has remained one of the least-developed nations in world. The current violence has not only destroyed the livelihoods of the South Sudanese people, disrupted farming and harvests, killed thousands and displaced millions, but it has also isolated and prevented civilians from receiving the life-sustaining aid that they require. With no basic infrastructure, aid is unable to reach the South Sudanese. In the rare cases where they can be reached, current violence has ensured that citizens are most often unable to receive the aid provided (Bariyo, 2014).

If the situation continues to progress unchanged, UNICEF has projected that upwards of 50,000 children will be dead by the end of 2014, as a result of malnutrition (“South Sudan Food Crisis”, 2014). This is not taking into account the number of children that have already died as a result of disease, nor does it take into account the fate of the remaining 3,950,000 South Sudanese that currently face starvation. However, while current violence continues to ravage this young nation and humanitarian efforts struggle to obtain sufficient funding, one thing is abundantly certain: if nothing is done to address the current crisis in South Sudan, a country that is already on the verge of genocide will also descend into a famine of massive proportions, leaving not only an incomprehensible amount of death in its path, but also producing long-term consequences for a young nation that is severely underequipped to address them.

Health Implications of Famine

Disease as a primary mode of mortality

While starvation and malnutrition are undoubtedly the most recognized aspects of this phenomenon, they are by no means the most immediate threat during famine. Interestingly enough, it is in fact disease which is the primary killer during famine. As food resources dwindle and living conditions deteriorate, so does the human immune system. An inability to maintain good health increases vulnerability to disease and thus leads to the short-term increases in incidence of mortality. Those who are not claimed by disease, usually succumb to death by starvation.

As a result of the appalling conditions in which the internally displaced Sudanese live, they have become increasingly more vulnerable to the threat of disease. No group has been affected more so than the pediatric population, due to the fact that malnourished children have weak bodies which more readily succumb to illness and disease (Migiro, 2014). Of the conditions which affect famine-exposed South Sudanese, it is malaria, acute respiratory infections and acute watery diarrhea that account for the majority of the disease burden. In addition, there has been an increase in occurrence of cholera, Kala-azar disease and hemorrhagic fever as the situation in South Sudan has worsened (Kala-azar cases, 2014). By April 2014, approximately 20 children under the age of five were dying per week as a result of illness and malnutrition (Beukes, 2014).

Examination of past and current literature

Past literature has most frequently examined the effects of pre-natal exposure to starvation and malnutrition, when examining long-term pathological implications of famine. A majority of these studies terminate their research post-birth or within the first 1000 days of life, which are considered the most crucial for development. The long-term consequences of exposure during childhood and adolescence are often overlooked. However, there are various literature

sources which have begun to examine post-natal effects of exposure to famine, emphasizing the periods of infancy, childhood and adolescence.

Previous research has also lacked strong analysis of the mechanisms by which famine-associated pathologies occur. These mechanisms can be varied, as are the pathologies associated with exposure. However, recent literature has revealed links between famine exposure and transgenerational inheritance or transmission of famine-induced traits to consequent generations of offspring.

What is starvation?

Starvation implies weight-loss, via an extreme reduction in the intake of energy. There are two classes of starvation, with very different effects: long-term and short-term starvation.

Short-term starvation is also termed extended fasting. This state consists of dietary and nutrient deprivation for a period of several days (McCance, 2002). In instances of famine, we are examining instances of pathological long-term starvation. This state commences after several days of nutritional and dietary deprivation. The eventual outcome of this state is death.

Existence in a state of long-term starvation results in marasmus or protein energy malnutrition. A major characteristic of long-term starvation or nutrient deprivation, is a decreased dependency on gluconeogenesis (Mahan et al., 2000; Stipanuk MH, 2000). It also results in an increased utilization of ketone bodies as a cellular energy. These ketone bodies are a product of lipid and pyruvate metabolism. In a state of long-term starvation, insulin levels are extremely depressed, while glucagon, cortisone, epinephrine and growth hormones levels are greatly increased. This state promotes lipolysis in adipose tissue, therefore promoting ketone body oxidation (McCance, 2002). However, as adipose tissue is depleted, the body commences

the breakdown of muscle and visceral protein. As loss of renal, pulmonary and cardiac function occur in conjunction with severe alterations in electrolyte balance, mortality becomes likely.

In breaking down the body's tissues for required sustenance, there are innumerable additional effects on the body and pathological implications abound. Especially during infancy and throughout development in early-life, these pathological changes in physiology produce irreparable results that most frequently manifest themselves throughout adulthood.

Long-term pathological implications

Hypertension

A previous study (Khoroshinina, 2004) obtained data on males and females who had been exposed to and survived the siege of Leningrad (1941-1944). The results of this study indicated that prolonged starvation in children and teenagers significantly affected the onset, progression and severity of various diseases in later life. Of these diseases, severe arterial hypertension was found to be much more frequent in those who had been exposed to and survived the siege. However, it is important to note that there were demonstrations of both age and sex-related difference throughout the results.

A separate study (Huang et al., 2010) collected data on 35,025 women, from the China-U.S. Collaborative Project for Neural Tube Defect Prevention. The referenced women born two years prior to the Chinese famine of 1959-1961, as well as the two years following. One of the aims of this secondary cross-sectional cohort study was to assess the impact of famine exposure on hypertension. The 1958 cohort demonstrated an association between exposure and a 3-fold increase in the odds for emergence of hypertension, therefore providing evidence to suggest that an increase in hypertension was linked with exposure between mid-infancy and 4 years of age.

Obesity

The results of this Chinese famine study also indicated that an increase in hypertension and BMI may be associated with famine exposure within the first 3 years of life. More specifically, the 1957 cohort, who experienced exposure between 1.5 and 4.5 years, saw a BMI increase of 0.92 units, in comparison to the unexposed cohorts. Contrary to these findings however, was the association between a decrease in BMI for the cohorts whose exposure was confined to gestation and infancy. For the 1960-1961 cohorts, a BMI decrease of 0.3 units was observed, when compared to non-exposed cohorts.

The findings relating fetal and infant exposure to decreased BMI, were contradicted by a secondary cross-sectional cohort study which utilized data from a 2002 Nationwide Nutrition and Health Survey (Yang et al., 2008). This data examined rural residents who were born between 1959 and 1961 and were compared with an unexposed cohort, born in 1964. This study produced results to indicate that females who experienced undernutrition in early life were at significantly increased risk for becoming overweight or obese. An important note to make is that this study also suggested that there are no significant long-term BMI implications associated with male exposure to famine in early-life.

Diabetes Mellitus (DM)

A 2011 study (Portrait et al., 2011) utilized data from the Longitudinal Aging Study Amsterdam to collect data on a cohort of 3107 Dutch individuals, who lived in famine exposed cities during the Dutch Hunger Winter of 1944-1945. This study produced findings that indicated a significant between the presence of DM in females aged 60-76 and adolescent famine-exposure. This study proposed that a possible reason for increased emergence of DM in exposed

populations is that pancreatic beta cells become more resistant to insulin with undernutrition, as pancreatic islet development extends throughout adolescence.

Similar to the previous study on the Chinese famine of 1959-1961 (Yang et al., 2008), this study found a significant association between DM and exposure of females. However, there was no association found between male exposure and development of DM.

Cognitive Ability

Studies have also suggested possible associations between famine exposure in early-life and detriments to cognitive development. A 2001-2004 cross-section cohort survey of 1,906 men and 1,826 women produced findings that indicated an association between early-life famine exposure and poorer cognitive function, as measured by mean MMSE (Woo et al., 2010). However, this study also found that poorer cognitive function was insignificantly associated with exposure to famine in late childhood.

These findings corresponded with another study, which examined the cognitive consequences of early-life famine exposure in Ghana (Ampaabeng et al., 2013). This study concluded that famine exposure resulted in significant and negative impacts on cognitive development in children that were exposed within 2 years after birth.

Severity of famine exposure also had implications for the severity of cognitive setbacks. For the particular cohort in the Ghana that experienced exposure within the first 2 years of life, a standard deviation increase in intensity of exposure resulted in a 6% decrease in IQ. These findings, however, did not apply to children exposed in later childhood.

Mental Health

Perhaps the mostly thoroughly explored association in the literature is that between mental illness and early-life exposure to famine. One study which explored this association collected data from a 2001-2005 mental health epidemiology survey. This survey provided data on 4972 Chinese, born between 1956 and 1963 (Huang et al., 2013). This survey assessed mental illness risk with 8 other risk factors, in addition to the 12-item General Health Questionnaire. Findings indicated that higher GHQ scores and increased risk for mental illness was associated with females born during the Chinese famine (1959-1961).

With the 1959 cohort having a GHQ score of 1.52 points higher, it is suggested that detrimental pathologies of famine-exposure are intensified by severity and length of exposure. The data from this study indicated no significant associations between early-life famine exposure and risk of mental illness in males born during the famine.

A second study (Xu et al., 2009) examined data from the Liuzhou prefecture of Guangxi in China, to compare psychological health in those born before, during and after the Great Leap Forward famine. The study's results found a 2-fold increase for schizophrenia in those who faced gestational exposure at the height of the famine. This study also found a relationship between the risk of developing schizophrenia and severity of exposure.

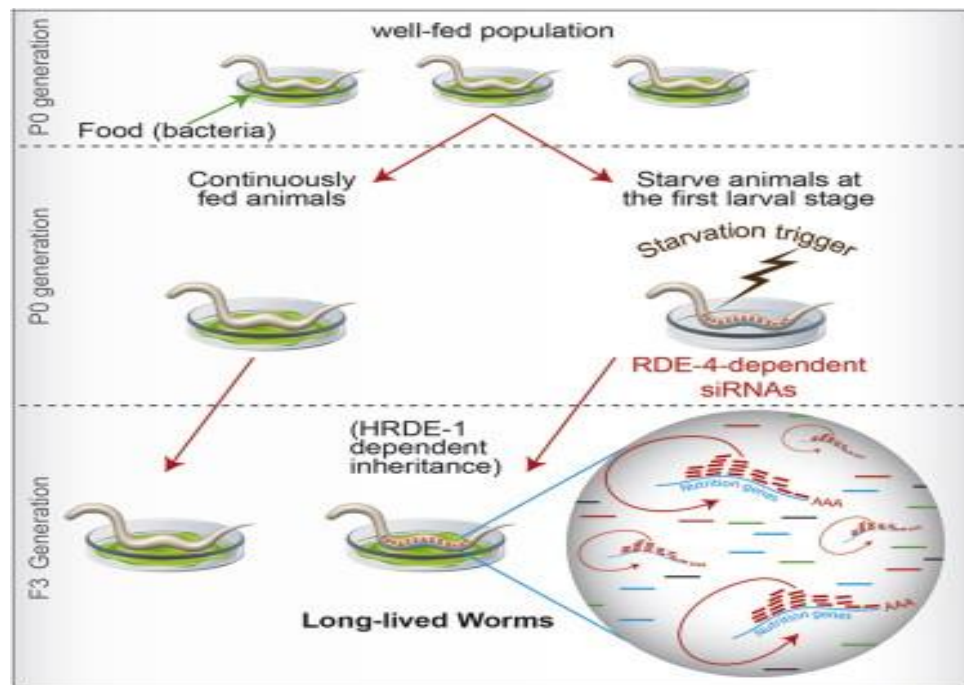
Transgenerational epigenetic inheritance/implications

While the associations between early-life famine exposure and the emergence of various pathologies in adulthood is alarming, even more alarming is the potential of transgenerational transmittance of these adverse effects.

A 2011 study investigated transgenerational inheritance of viRNAs in *C. elegans*. (Rechavi et al., 2011). These viRNAs are a small, acquired RNA-based viral silencing agent that

was found to be transmitted in a non-Mendelian fashion throughout several generations of progeny. This therefore provided evidence for the possibility of transgenerational transmittance of acquired traits, induced by physiological challenges.

This study was followed-up by an investigation into the possible transgenerational effects of starvation (Rechavi et al., 2014). The prompting of starvation-induced developmental arrest in *C. elegans* indicated the production of small RNAs that were inherited by at least 3 consecutive generations of *C. elegans* progeny.



Source: Rechavi, Oded, Lea Hourli-Ze'ev, Sarit Anava, Wee Siong Shoh, Sze Yen Kerk, Gregory Hannon, and Oliver Hobert. "Starvation-Induced Transgenerational Inheritance of Small RNAs in *C. Elegans*." *Cell* 158.2 (2014): 277-87. PubMed. Web. 27 Sept. 2014.

As humans and worms are specialized in different regulatory epigenetic processes, it can be difficult to apply findings from worm studies to human beings. However, it is still worthwhile and important to investigate the role that noncoding RNAs may play in human starvation, as the implications could greatly impact our understanding of the transgenerational impact of famine exposure. Additionally, while it is unwise to assume that mammalian epigenetic mechanisms are

similar to those of worms, there are human studies which have suggested a tri-generational span of famine-related effects (Victora et al., 2008).

Future research into pathological implications

It is extremely vital that further research be done to examine the negative effects of post-natal exposure to famine-related circumstances. Studies have indicated associations between long-term pathological implications and exposure to famine during not only infancy, but childhood and adolescence. While some literature has investigated exposure throughout early-life, the majority of literature focuses on the consequences of pre-natal exposure.

It is also crucial that further research be done on the mechanisms by which these pathologies arise. The literature has consistently demonstrated associations between exposure and the emergence of long-term pathologies. However, it has become consistently clear that there is limited understanding of or research into the mechanisms by which these long-term complications arise. Understanding these mechanisms may give a more clear understanding of the long-term implications of exposure to famine and may assist in combatting the effects of exposure, before these long-term consequences emerge.

Review/conclusions regarding emergence of long-term pathologies

Examination of the literature has shown clear associations between exposure to famine-like circumstances and greater vulnerability to hypertension, diabetes mellitus, delayed cognitive development, obesity and mental health disease. Most literature tends to focus on pre-natal exposure or exposure during the first 1000 days of life. However, it has been indicated that childhood and adolescent exposure can lead to the emergence of complications in later life. The

literature has also indicated association between severity of exposure and intensity of long-term health complications.

This information has great significance for the nation of South Sudan, which currently rests on the brink of famine. Understanding the long-term implications of famine-exposure is of special importance, as this high-risk population lacks the basic infrastructure and healthcare resources required to combat and treat long-term health outcomes of early-life exposure to famine.

Conclusion

Re-examination of the roots of the current issues in South Sudan

The current crisis in South Sudan is both complex and severe. As a nation in the early stages of post-independence, South Sudan is faced with common issues of development and stability. However, the violent circumstances under which the new nation achieved independence and the current civil war only further contribute to the severity and complexity of the situation. As the country's food crisis verges on the edge of famine, the emergency of the situation is only further compounded and exacerbated by the political and social instability that is wracking the nation.

Actions taken (Early Warning Systems)

In response to severe famines that occurred in Sudan and Ethiopia during 1984-85, the international community created various forms of Early Warning Systems (EWS), in order to detect the signs of famine and prevent this type of crisis before it could occur. While these systems have the potential to be useful tools in the prevention of famine, they are only effective if they trigger an early and rapid response from the international community. In a majority of

famine cases, the EWS give ample warning throughout the development of a food crisis. However, it is most often only when a crisis level has been attained that a humanitarian response is elicited. By the time an alarm is sounded, children and other vulnerable populations are already experiencing disease outbreaks and acute malnutrition. When and if the international community finally takes action, it is often too late for much more than meager damage control (Kim, 2012).

The only truly effective way to prevent the long-term emergence of famine-related health consequences is to prevent these instances of famine from ever occurring. While this is both a difficult and lofty goal, it is a possibility. However, it is essential that EWS be successfully implemented and utilized. Not only must the international community take note of the warnings the EWS provide, but they must also provide a rapid and early response. By delaying an effective response, a crisis is allowed to develop into a catastrophe and countless individuals are further put at risk for the development of both acute and long-term health issues.

Humanitarian response

The first calls for humanitarian aid to South Sudan occurred early in 2014. It has been projected that 1.8 billion dollars would be needed in order to implement the Crisis Response Plan (CRP) that was developed by the UN to address the current crisis. In particular, it is the nutrition and protection programs that are vital to assisting affected children, who have the greatest need of aid. As of recently, only half the required amount has been raised to assist these programs and ensure the implementation of the CRP (Rwakaringi, 2014). Without an intense surge in humanitarian interest, it is unlikely that sufficient funds will be raised to aid the 7 million South Sudanese currently at risk of hunger and disease ("South Sudan: UN Relief ", 2014).

Current status of the political/health system in South Sudan

The status of the political system in South Sudan is dismal, at best. While fragile to begin with, the system continues to experience further collapse under the pressure of both social and political instability and violence. This continued instability has only served to worsen the status of the nation's underdeveloped and grossly underfunded healthcare system.

Due to the fragility of the government, it has fallen largely upon the leadership, funding and services of the World Health Organization and other humanitarian organizations to provide healthcare to the people of South Sudan (WHO, 2014). The country is currently facing a severe shortage of all types of health professionals and therefore relies largely upon low-skilled and undertrained health workers, the majority of whom are staffed directly from various NGO's.

Based upon current statistics, it is estimated that there is only 1 physician per 65,574 people (WHO, 2014). There is also a severe shortage of medicines, clean water, sanitation and healthcare facilities in the nation. Any healthcare facilities available are of poor quality and are understaffed, in addition to lacking proper supplies and equipment to sufficiently address even basic health concerns ("Hemorrhagic Fever", 2014). With a healthcare system that is unable to actively and successfully treat even simple health issues, the country is left vulnerable to instances of disease and malnutrition, as well as the long-term health complications that emerge as a result of exposure to famine.

Long-term consequences of the recurrence of famine

As is visible from the research presented, there are a wide range of both acute and long-term consequences that arise from the occurrence and recurrence of famine. While violence, disease and starvation present immediate threats to the lives and well-being of South Sudanese

citizens, it is the emergence of long-term issues that lends greater emergency to the prevention and treatment of famine. It is extremely important to note that, although citizens of all ages are affected by the scourge of famine, none are affected more so than the pediatric population.

Not only has it been shown that exposure to famine in early-life may lead to the emergence of pathophysiological complications in later life but it has also been shown that these complications may be transmitted to future generations. As a nation with very little political stability and a virtually non-existent healthcare system, South Sudan has neither the ability nor the means to treat acute famine-associated complications, let alone multi-generational long-term complications. As the political and social stability of the country continues to crumble, so does the likelihood of the country developing a healthcare system that can sufficiently meet the needs of the South Sudanese people.

The health crisis in South Sudan was categorized as a “Grade 3” by the World Health Organization in February of 2014. This grade categorization is the highest classification of humanitarian emergency possible, putting the crisis on par with the Ebola outbreak in West Africa (WHO, 2014). If the current situation continues to progress untreated, the consequences will be severe and widespread in impact. While there is much debate as to how the situation should be addressed, it is both apparent and universally acknowledged that immediate action must be taken.

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