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Zombies: The American Response to a Disease Outbreak

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**Zombies:**  
**The American Response to a Disease Outbreak**

A thesis submitted to the Faculty of Barry University  
in partial fulfillment of the requirements  
for the completion of the Honors Program

by

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Zombies have invaded our lives, first through popular culture in the form of movies and video games and now they've lurched their way into academics as well. Zombies have become a way to explain many academic fields such as the human body and politics. In regards to this, it can be used to effectively educate people about neuroscience, virology, epidemiology, political science, and even philosophy.

Aside from the fact that zombies are an engaging way to learn educational material, zombies are also a pressing concern to all of humanity. I will argue that the zombie disease can be created. Also, the disease would be devastating to the human population as explained in the mathematical section. Plus, the government is notorious for poorly handling disasters so it would be reflective of how they would handle a zombie outbreak. Zombies also create an interesting thought problem in ethics.

## ACKNOWLEDGEMENTS

I have never spent so much time on a project in my life unless you include master prestige in Call of Duty but that's more of a hobby. This project took two years. It even took over a summer break and a Christmas break. However, I couldn't have done it alone.

First off, I want to thank the Zombie Research Society. The organization led me to some amazing research and ideas to think about. I couldn't have done this without their previous research.

I want to thank the thesis committee. I'm happy that I could find fellow academics to approve and enjoy this project. To Dr. Smith, thank you for the help with grammar and historical additions. To Dr. Hengartner, thank you for the help with the scientific portion of the thesis. My only regret is that we didn't meet sooner. I would have loved to have sat down and discuss science fiction with you more before if I would have known you found the topic to be interesting. To Dr. Foreman, thank you for not only your assistance in reviewing the information about the U.S. government but also all of the classes I have had with you. Plus, I can't forget the experiences I had as part of the Model United Nations. Most importantly, thank you for the educational and life-saving extra credit opportunities. My GPA will forever hold you in its heart. Finally, to Dr. Sirimangkala: Thank you for the mentorship in the honors program and HPSAB. It has been a wonderful experience working with you and the other students. Also, thank you for approving this thesis idea. I know many people were skeptical at first but it looks like the project came out well.

Now don't think I forgot about you Dr. Ruth Tallman. I may need 50 more pages to get through your acknowledgments. In my first semester, I didn't care about philosophy or know anything about it, but that Intro to Philosophy course changed my life. I will never forget staying up late to finish the readings like a good student and falling asleep in the front row of class the next morning only to arise from that comatose state to keep the philosophical debate going. I don't even know if I can count all of the classes I have had with you on one hand. Anytime I had to take a philosophy class, I always checked to see if you were teaching it because I loved your teaching style and interactive classroom discussions. More importantly, who else would put up with my academic sarcasm and humor? Plus, the giant 20-sided die you use for tests will always make me laugh. Ethics bowl was also an amazing experience. The practices were always fun because we would discuss the ethical standpoints on controversial cases while incorporating unethical dark humor for an occasional chuckle. Plus, the death stare you gave me after the regional competition, when you had found out that that was my fourth night without sleep that week and that I was running on four energy drinks, was absolutely priceless. You even kept count of my energy drinks to make sure I didn't have a heart attack at the national competition. I couldn't have asked for a better thesis advisor. You always replied with comments to my drafts quickly and you kept me on track. On top of that, you helped me to battle a devastating enemy: senioritis. I don't know how I would have gotten this thesis done without you kicking me into gear with your surprisingly intimidating emails. Also, thank you for the endless amount of recommendations where you probably highlighted my "wonderful penmanship." From the bottom of my heart thank you for all you have done for me Ruth.

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## **Statement of Purpose**

Communities have faced many perilous issues from hunger to war but none more dangerous and mysterious than disease. Diseases have killed humans since the dawn of existence without medical professionals of the time understanding what had happened. From bubonic plague to leprosy, diseases have devastated societies and baffled doctors. Along with this fact, government has a state interest in protecting its citizens. Government is supposed to protect its citizens but this could lead to limiting individual rights. If government is required to protect its populous from something as dangerous as an epidemic, the residents of that country should know what actions to expect from their government.

The purpose of my paper is to predict what the United States would do if a devastating disease outbreak, specifically zombies, were to take place within its borders. This inductive thesis is based on analyzing anatomy, physiology, and neuroscience to determine the physical ailments necessary to create zombie like symptoms; zombie symptoms in accordance with this paper include: a craving for human flesh, excessive aggression, and contamination through the exchange of bodily fluids especially through biting. I will also identify possible pathogens that could cause the zombie disease. I will apply mathematical formulas found in epidemiology to predict how fast the disease would spread. I will also analyze government policies and military protocols to determine what the government, military, and the Center for Disease Control (CDC) response would be. Finally, I will address concerns of morality in regards to killing zombies and proposed quarantine procedures.

I chose zombies as the disease for my thesis because science fiction is an excellent tool for understanding our world and our future. Science fiction has shown that it is not uncommon for it to come true. For example, many of the Jetson's ideas have come to fruition. Flat screen



televisions, video calls, a Roomba vacuum, and many other inventions have been created that were originally imagined in a simple cartoon. Something as devastating as a zombie epidemic needs a plan of action for when science catches up to fiction.

The other reason for choosing zombies is that they can be treated as an encompassing disease with applications to other diseases. If we can understand how zombies work and how the disease spreads, we can better understand how the human body works and how other diseases spread based on the exchange of bodily fluids.

Zombies have grown in popular culture to the point that the average person can find this paper accessible and understandable without an academic background. Of course, the modern zombies are fictional and originate from George Romero's 1968 film *Night of the Living Dead*. They began as walking zombies with a fear of light because Romero got the idea from the book *I Am Legend*. The Hollywood zombie was modified into zombies craving brains as portrayed by *Return of the Living Dead* 1985. The outbreak has also been caused by different factors in the movies that have ranged from radiation, fungus, virus, and even magic. All of these different ideas were inspired by George Romero's original film, but I will discuss the evolved zombie that Romero inspired, the living zombie.

## **Literature Review**

Alemi, A. A., Bierbaum, M., Myers, C. R., & Sethna, J. P. (2015). You can run, you can hide:

The epidemiology and statistical mechanics of zombies. *Physical Review E*, 92(5).

doi:10.1103/physreve.92.052801

This scholarly mathematical journal article takes the SIR<sup>1</sup> (susceptible, infected, recovered) model and changes it to the SZR (susceptible, zombie, removed) model to specifically apply it to the epidemiological study of zombies. The mathematical formulas take into account that the zombie virus is not an airborne agent, it spreads through fluid exchange. It applies a bite-to-kill ratio in regards to uninfected humans bitten and zombies killed. From this article, an interactive zombie spread map has been developed to display the spread of zombies.

Drezner, D. W. (2015). *Theories of international politics and zombies*. Princeton (N.J.): Princeton University Press.

The book applies the premise that the zombie apocalypse has occurred. Assuming that, the author goes into detail applying various theories of international politics to understand how countries would respond and how they would interact with each other. It also analyzes the international interactions through the scope of war because the countries would be at war with the zombies. A zombie outbreak could travel to other countries causing an international devastation due to an unknowing infected individual taking an international flight.

Mogk, M. (2011). *Everything you ever wanted to know about zombies*. New York, NY: Gallery Books.

The book really is just about anything anybody would want to know about zombies. The book encompasses nearly everything from zombie science to government response and many more. The book outlines the history of zombies and proposes an

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<sup>1</sup> The SIR model is a mathematical model for mapping how fast a disease would spread in epidemiology

appropriate definition of the modern zombie we are thinking of. It analyzes past government responses to disasters and a few physiological explanations of zombies. I primarily use it to look at past government response and various proposals of zombie science.

Smith? R.<sup>2</sup> (2011). *Braaaaaiinnss!* *From Academics to Zombies*. Ottawa: University of Ottawa Press.

The book is made up of multiple scholarly authors applying zombies to various parts of life. A few examples are analyzing a zombie outbreak or apocalypse from the perspective of virology and police strategic planning. I primarily use the source for its analysis of the police system and virology. The virology section analyzes different zombies movies and uses the different zombies as specimens for determining what kind of infectious agent has been acquired and treatment options. The other section that I use is the analysis of police strategic planning as the police would be the first responders to any sort of community disturbances, zombies included.

Smith? R. (2014). *Mathematical Modelling of Zombies*. Ottawa: University of Ottawa Press.

Robert Smith? applies the epidemiological math formula known as the SIR model to zombies. SIR stands for “susceptible, infected, and recovered.” It is a set of differential equations used to determine the spread of a disease and whether it will die out. He compares the spread of zombies to bubonic plague and Spanish flu. He applies the formula using numbers imagined in the movie “28 Days Later” (2002) and determines zombies to be extremely dangerous. I utilize his application of the formula for zombies

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<sup>2</sup> His real name is Robert Smith?. It isn't a typo. The question mark is part of his name.

and critique it. However, I leave out his example of the formula in regards to “28 Days Later” (2002) because it is using fabricated numbers. He proposes an interesting application of the SIR model, but I will go into more detail on my criticisms of it later.

Verstynen, T., & Voytek, B. (2016). *Do zombies dream of undead sheep?: A neuroscientific view of the zombie brain*. Princeton: Princeton University Press.

The book analyzes the human brain and various genetic diseases. Our knowledge of the human brain has often come from war. When a person was facing some sort of physical or cognitive issues directly caused by brain damage from combat injuries, then it could be logically assumed that that part of the brain controls those physical or cognitive functions. For example, if someone struggles to speak language or understand language because of brain damage then they likely have damage to their Broca’s area or Wernicke’s area of their brains. This conclusion could be made because many patients would demonstrate the same symptoms and doctors would notice that they had damage to the same part of the brain. Therefore, damage to that part of the brain must control those bodily functions because damage to that part of the brain hinders those bodily functions. In regards to zombies, we can understand zombie symptoms as a culmination of various brain damage called Consciousness Deficit Hypoactivity Disorder (CDHD) in the book. Therefore, a zombie is simply someone with serious brain damage to select portions of the brain.

J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from

<https://www.scribd.com/doc/223872345/CONPLAN-8888>

This document is the current policy the American government has specifically for zombies. It was created as an effective training tool for the military. At the moment, that is its current purpose. Should a serious zombie outbreak take place, it would likely be implemented. There is currently no other plan of counterattack against zombies and it accurately portrays common military strategy for dealing with a persistent threat. I use the document to understand the American military strategy for addressing zombies. It explains an effective response to zombies while still considering international policies and the civilians.

## **Research Questions**

The primary research questions in my thesis is “how can zombies come into existence?” and “how would the United States respond?” Within these two primary questions, they can be further subdivided into five more specific questions:

1. What ailments share similar symptoms to zombies when the ailments are combined together?
2. What kind of pathogen, parasite, or combination could create the zombie disease?
3. How fast would a zombie outbreak spread in the United States of America?
4. How would the government, military, and CDC respond to a zombie outbreak?
5. What moral conundrums would people face

## **Methodology**

This paper presents an inductive argument as to how a zombie outbreak could happen and what would happen. In regards to research methods, surveys and questionnaires wouldn't have been practical. I had to research books, articles, history, and government documents. First, I

decided to research the history of zombies and learn where they came from. Afterwards, I tackled the scientific portion of research. I analyzed the human body to understand the biological processes and neural functions to explain the onset of zombie symptoms. Along with that, I researched virology, parasites, and other pathogens that could cause those symptoms that zombies display.

Once I completed the scientific portion I went onto the mathematical portion. If a disease outbreak takes place in a country, I need to know how fast it would spread. I found mathematicians that used the SIR model, an epidemiological mathematical model, to explain the spread of the zombie disease. I even found a number of mathematicians who created the SZR model which is a variant of the SIR model but for the specific purpose of mapping out zombies.

After understanding the rate of spread, I researched government policies, CDC powers, and military protocols related to the subject at hand. I analyzed the military chain of command to understand the initial likely response of the American military. I also utilized history to show what these entities have done in the past and will likely do in the future.

Finally, I applied philosophical reasoning to determine the morality of killing a zombie and quarantine procedures. I primarily compared these arguments to euthanasia and the harm principle to make my point. I also applied the idea of self-defense and the common good argument. Finally, I determined what to morally do with conscious zombies. A conscious zombie would be someone infected with the disease, but retains their higher levels of thought and needs human flesh for sustenance.

## **Zombies: The American Response to a Disease Outbreak**

### **Introduction**

Science and technology are constantly advancing. Humanity is always on the verge of a new breakthrough in medicine. However, it doesn't always improve lives. The advancement of antibiotics has saved countless lives but has also mutated and increased the strength and resilience of the same bacteria that they protect against. The atomic bomb was thought of as a weapon to end all wars, but instead it appeared as a weapon to end all life. It's only a matter of time before humanity creates its own self destruction.

The U.S. government is charged with protecting the residents of the country. Not only is it supposed to establish national security and wellbeing but it also must protect its people from dangerous diseases and epidemics. The CDC was established to prevent epidemics and protect people from disease. It was originally founded as the Malaria Control in War Areas (MCWA) in 1946 to control malaria spread around U.S. military bases.<sup>3</sup> However, most people don't know what powers the entities have to maintain security. It begs the question, "How will the United States go about protecting its people from a devastating disease outbreak?"

Zombies may have originated from fiction, but with modern science, zombies can become a real danger to society. As time goes on, science fiction becomes science. The Jetsons and Star Trek no longer portray a magical world of wonder and imagination. Instead, it begins to act as a prophecy to the future. Scientists will experiment and ask the question "can it be done" instead of "should it be done." In regards to this, the dangerous curiosity of humanity can bring about its own downfall.

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<sup>3</sup> "Our History - Our Story." Centers for Disease Control and Prevention. July 22, 2015. Accessed April 17, 2017. <https://www.cdc.gov/about/history/ourstory.htm>.

Studying zombies acts as an appealing avenue for a person to study epidemiology, the human body, and to tackle disaster preparedness. It engages audiences in subjects that would otherwise not be of interest. For example, if a professor advertised that he is going to host a discussion on the physiology of the human body's gastrointestinal tract, the average person would be disgusted and uninterested. However, if the professor advertised that he is going to host a discussion on what happens after a zombie eats a person, the average person would find it more appealing to attend. They would still learn the principle material but the zombie aspect would act as an innovative way of enticing the audience to otherwise dull subject matter. Not only am I bringing to light a very dangerous disease that could arise in the near future, but I am also using zombies as a way to interest people in subjects such as physical science, political science, math, history, and philosophy.

### **Defining a Zombie**

Zombies have had different names over the years: undead, walkers, and infected to name a few. Along with the varying names, the general idea of a zombie has stretched far and wide. Do they crave brains alone or any form of flesh? Are they walking corpses or are they still alive? Do they walk or run? A zombie has a very vague definition so I must define what kind of entity I am referring to before continuing.

The zombies typically seen in movies today are what I'm referencing. They resemble humans that display aggressive tendencies, a lack of higher thought/mental consciousness due to a biological agent (such as a virus, bacteria, fungus), and insatiable primal hunger (even cannibalistic). There are of course notable differences between the zombies seen in movies and zombies that could come into existence, but that will be discussed in a later section. There are also living zombies and undead zombies, but I will be referring to them as runners and walkers



based on their movement capabilities because zombies would not be dead, they would be organisms infected with a disease and still living. There are many Hollywood zombies that are physically dead but I am only discussing the living ones because that is the only scientifically achievable kind.

There are two types of zombies: runners and walkers. Walkers are the zombies that have severely damaged motor skills. They walk slowly and are unable to move in a quick or coordinated fashion. The runners possess most of their higher motor function. They are able to run and even sprint to reach their prey.

A few academics have attempted to define the zombie affliction with scientific means. Two such people are Timothy Verstynen and Bradley Voytek. Verstynen is an assistant professor in the Department of Psychology and the Center for the Neural Basis of Cognition at Carnegie Mellon University. He is also the director of Cognitive Axon Lab. Voytek is an assistant professor of computational cognitive science and neuroscience at the University of California, San Diego. He is also in charge of Voytek Lab which is a lab for cognitive and computational neuroscience. They have mapped out what the zombie brain would look like in their book<sup>4</sup> and observed the disease as a psychological disorder due to damage to various parts of the brain. They watched zombie movies and highlighted common symptoms found in zombies such as aggression, lack of facial recognition, and difficulties with language. By understanding what causes each of those symptoms in the human brain, they successfully explained how zombies would be a product of damage to various parts of the brain if zombies were to come into existence. They classified the zombie affliction as Consciousness Deficit Hypoactivity Disorder

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<sup>4</sup> Verstynen, Timothy, and Bradley Voytek. *Do zombies dream of undead sheep?: A neuroscientific view of the zombie brain*. Princeton: Princeton University press, 2016.

(CDHD).<sup>5</sup> The disease describes a loss of mental consciousness with limited brain activity. In other words, the patient would suffer from a lack of cognitive presence and severe brain damage to particular areas of the brain as will be discussed in the next section.

Another well-known researcher in zombies is Matt Mogk. He is the leading global authority on zombies. He founded the Zombie Research Society and is regularly asked for his expert opinion on panels and shows analyzing zombies such as National Geographic and the History Channel. In his book<sup>6</sup> he has two definitions for zombies: the modern zombie and the living zombie. In context to this paper, that would be the same as a walker and runner respectively. His definitions are “The modern zombie is a relentlessly aggressive reanimated human corpse driven by a biological infection” and “the living zombie is a relentlessly aggressive human driven by a biological infection.”<sup>7</sup> I reject the modern zombie definition because a zombie would have to be a living creature to be able to move and go about its zombie days so his definition needs to be tweaked a little for my proposed thesis. I propose the definition to combine the previous two definitions of zombies: *the zombie, or a victim of CDHD, is brought on by a biological infection destroying parts of the brain thereby creating a relentlessly aggressive, contagious organism that tends to not have mental consciousness.*

The word zombie originates from West Africa as the name of a snake God and later became synonymous with “reanimated corpse” in voodoo culture. The voodoo zombie is a creation from a bokor (Haitian shaman). The bokor would introduce a person to a potent neurotoxin called tetrodotoxin which is derived from puffer fish. The person would then go into a catatonic state and be ceremoniously buried to simulate death. The person would later be dug

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<sup>5</sup> Ibid., 24.

<sup>6</sup> Mogk, Matt. *Everything you ever wanted to know about zombies*. New York: Gallery Books, 2011.

<sup>7</sup> Ibid., 6.

up and given regular doses of Datura which is a poisonous plant that causes amnesia, delirium, and suggestibility thereby completing the zombification process.<sup>8</sup> The cultural psychology of believing in their own death and believing in voodoo also contribute to the person's susceptibility to it.<sup>9</sup> For example, if a culture has superstitions and myths that are held to be true, then those cultural beliefs could become influential enough to become self-fulfilling prophecies that make the myth true in the eyes of the believer like in the case of zombie Voodoo. Voodoo zombification was a way of punishing people who had committed a serious crime. The person would likely spend the rest of their life in this state because they didn't want to see their loved one die but the loved one couldn't be allowed to roam freely without punishment or because they were a threat to the public.

Today's American version of a zombie (contagious humans infected by a pathogen that causes aggressive tendencies and the craving to eat people) is much more different than the original voodoo zombies. The only commonalities between the two are their name and a lack of mental consciousness. Voodoo zombies are nonviolent human slaves created from cultural belief and drugs while the modern zombies seen in cinema that I am speaking of are created from a disease or parasite.

There are also a few other outliers that people use the word "zombie" to describe that are not in accordance with this paper's definition of zombie. Farmers will often have chickens that lay so many eggs that they can no longer produce anymore and are too skinny to send to a slaughterhouse for meat so the farmers end up euthanizing these chickens with carbon monoxide. However, there have been a few occurrences where they gassed the chickens incorrectly and the

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<sup>8</sup> Davis, Wade. *The serpent and the rainbow*. New York: Simon & Schuster Paperbacks, 2008.

<sup>9</sup> It is like the premise behind hypnosis. A person can't be hypnotized if they aren't susceptible to hypnosis.

chickens “came back from the dead.”<sup>10</sup> The chickens appeared to have died but only came close to death without becoming deceased. The chickens don’t necessarily act different when they get back up, sometimes they may be erratic, but they usually just frighten the owner because the owner assumes the chicken is dead. They aren’t exactly craving flesh or trying to spread an infection, but are just a little agitated from an improper gassing.

Another example of zombies that isn’t in accordance with this paper’s definition is Cotard’s Syndrome more commonly known as Walking Corpse Syndrome.<sup>11</sup> People that suffer from this mental illness believe they are missing organs, blood, or body parts. In extreme cases, they believe they are dead. They tend to be very depressed and often believe they don’t need to eat since they believe they are dead and dead people don’t need food. When doctors did a brain scan of one of these patients they discovered that parts of the patient’s brain had minimal activity like being in a vegetative state.<sup>12</sup> The patients aren’t violent or contagious in anyway. They are typically very depressed and have a false image of their bodies kind of like an extreme case of teenage puberty.

### **Anatomy and Physiology of the Infected**

Now that I have defined what a zombie is, I need to establish zombies as a feasible premise for research. Zombies may originate from fiction but with modern technology (which will be discussed in the next section), the disease can be as real as Ebola or Zika. The infected would likely have damage to their brains and exhibit certain behaviors/characteristics because of

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<sup>10</sup> "Government Report Warns that Chicken Zombies are Real and Terrifying." Latest. March 14, 2017. Accessed March 15, 2017. <http://latest.com/2014/05/government-report-warns-that-chicken-zombies-are-real-and-terrifying/>.

<sup>11</sup> Boyd, Luke W. "WALKING DEAD: THE DELIRIUM OF NEGATION." Zombie Research Society. November 08, 2015. Accessed March 15, 2017. <http://zombieresearchsociety.com/archives/27846>.

<sup>12</sup> [Save your work and create a lifetime account](#)

Baulkman, Jaleesa. "Walking Corpse Syndrome: When The Alive Think They've Died." Medical Daily. May 25, 2016. Accessed March 15, 2017. <http://www.medicaldaily.com/walking-corpse-syndrome-cotards-syndrome-mental-illness-387623>.

it. Zombies currently don't exist so to analyze a zombie I must look at zombies seen in movies and compare them to modern ailments that would combine to create CDHD as many other scholars have done.<sup>13</sup>

Walkers walk in a very specific fashion. They typically have a wide stance with a lumbering walk. They are slow but can initiate a lunging action at a nearby target. A genetic disorder that demonstrates similar movement impairments is spinocerebellar ataxia type one (SCA1). This genetic disorder is characterized by problems with coordination, balance, speech, swallowing, muscle stiffness, and may have cognitive impairment.<sup>14</sup> SCA1 is caused by atrophy in the cerebellum. Therefore, since zombies have similar characteristics to victims of SCA1 it can be concluded that a zombie would have similar damage to the cerebellum.<sup>15</sup>

Zombies show an insatiable hunger and an uncontrollable rage. However, zombies aren't constantly angry, they demonstrate their aggression once they find a regular human. They also aren't ever full, they could eat a person and still go on to try to eat someone else. Voytek and Verstynen did an excellent job of explaining this phenomenon:

Given the impulsive, explosive, and aggressive behavior exhibited by zombies, its safe to say that they lack a properly functioning orbitofrontal cortex and probably, as a result, have an overly dominant limbic system. As a result, the zombie amygdala, hypothalamus, and thalamus are constantly overactive, leading to wild changes in the HPA axis and a highly dysregulated hormonal system. These changes produce a hair-trigger adrenal response unlike anything seen in humans, not to mention concomitant changes in social norms and morality.

This dysfunction of the areas of the limbic system is likely to extend to the hypothalamic control of appetite as well. In particular, zombies should have a suppression of the activity of the neurons that process the leptin signals from the gut leading to a subsequent disruption of the feeling of being full.<sup>16</sup>

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<sup>13</sup> Such as Matt Mogk, Bradley Voytek, and Timothy Verstynen

<sup>14</sup> "SCA1 - Genetics Home Reference." U.S. National Library of Medicine. Accessed March 15, 2017. <https://ghr.nlm.nih.gov/condition/spinocerebellar-ataxia-type-1#resources>.

<sup>15</sup> Verstynen, Timothy, and Bradley Voytek. *Do zombies dream of undead sheep?: A neuroscientific view of the zombie brain*. Princeton: Princeton University press, 2016., p. 63

<sup>16</sup> *Ibid.*, 87.

Zombies aren't known for their eloquent requests for brains. They are usually remembered by their unsettling moans or quiet shambling. They also don't respond to what people say to the zombie, they only respond to the noise. For example, if I'm behind my mother who has become a zombie and speak to her, she wouldn't turn around and hug me. She would turn around and attack me. This certainly demonstrates language impairment in the zombie brain. However, they still have their sense of hearing. In accordance with these symptoms "it would appear that the frontal language production areas and the temporal-parietal language comprehension areas are both damaged in the zombie brain. The area that connects these two, the arcuate fasciculus, would also be damaged."<sup>17</sup> Zombies would be suffering from Broca's aphasia and Wernicke's aphasia. The combination of these two ailments would mean that they can't understand language or clearly articulate language.

A common characteristic of zombies is that they are indiscriminate. They will eat anyone, even if that someone was a loved one before the infection. It's as if the infected don't recognize their loved ones and only recognize their fellow cannibals. The zombies likely are afflicted with prosopagnosia. More commonly known as "face blindness," it is a disorder where the victims don't recognize familiar faces.<sup>18</sup> This zombie symptom is likely caused by damage to the fusiform gyrus around the fusiform face area (FFA).<sup>19</sup> A zombie could also be facing memory loss to the extent that it only sees people as strangers. This would be caused by damage to the

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<sup>17</sup> Ibid., 128.

<sup>18</sup> "Information About Prosopagnosia." Prosopagnosia Research - About Prosopagnosia. Accessed March 15, 2017. <https://prosopagnosiaresearch.org/index/information>

<sup>19</sup> Verstynen, Timothy, and Bradley Voytek. *Do zombies dream of undead sheep?: A neuroscientific view of the zombie brain*. Princeton: Princeton University press, 2016., p. 164.

limbic system which is located in the medial temporal lobe and is made up of the hippocampus, amygdala, cingulate gyrus, thalamus, hypothalamus, epithalamus, and mammillary body.<sup>20</sup>

How could the brain become damaged to create these symptoms? There are several hypotheses. One possibility is the time gap between death and resuscitation.<sup>21</sup> When someone is infected and dies, their brain isn't getting enough oxygen, and so the tissue begins to break down. The longer someone isn't getting oxygen to their brain, the more damage the brain will incur. This would also explain the difference between runners and walkers. Runners demonstrate higher motor function than walkers so runners likely spend less time in a state of oxygen deprivation to the brain than walkers.

However, there are a few problems with this hypothesis. How could a non-lethal bite wound cause death? What would prevent oxygen deprivation from decomposing the entirety of the brain instead of just the specific areas needed to create CDHD? Finally, what would resuscitate the victim?

In response to these questions the biological agent (which will be discussed in the next section) would be carried in bodily fluids such as saliva. One example of how a non-lethal bite can kill is the Komodo dragon. The reptile has a septic mouth with lacerated gums that creates an infectious wound that can kill a victim over time.<sup>22</sup> It isn't far-fetched to believe that a disease-ridden individual could develop a septic bite. The infection would spread, the immune system would try to kill the infection, and the immune system would likely fatally overheat the body. Zombies would likely kill through infection rather than fatal wounds. The biological agent would

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<sup>20</sup> "Parts of the Brain - Memory & the Brain - The Human Memory." Parts of the Brain - Memory & the Brain - The Human Memory. Accessed March 15, 2017. [http://www.human-memory.net/brain\\_parts.html](http://www.human-memory.net/brain_parts.html).

<sup>21</sup> Marks, Dave. "NEUROSCIENTISTS EXPLAIN THE UNDEAD." Zombie Research Society. December 17, 2014. Accessed March 15, 2017. <http://zombieresearchsociety.com/archives/27009>.

<sup>22</sup> Smith?, Robert J. *Braaaaaiiiiinnssss!: from academics to zombies*. Ottawa: University of Ottawa Press, 2011., p. 5

also protect the vital parts of the brain while neglecting or even intentionally damaging the specific parts that would lead to CDHD if those parts were to deteriorate. The only problem is that I can't think of any virus, bacteria, or other pathogen that would be able to reanimate a corpse.

Instead of the pathogen causing death and resuscitation, the pathogen would likely cause an intense fever overheating the brain. The body's natural defense to preventing a cold or another sickness is to cause a fever to get rid of the pathogen. The pathogen would enter the body, attack the parts of the brain previously mentioned, and even utilize the body's natural response of causing a fever. The pathogen would also put the body into a coma like state to control where nutrients go in the brain affectively deteriorating the areas causing CDHD while nourishing the parts of the brain needed to sustain the host. It's also possible that a parasite may hijack the central nervous system and accomplish the same task as I will discuss in the next section.

Zombies stumble around looking for their next victim but how do they find their prey? One hypothesis is based on touch. The Etruscan shrew is a small predator that uses its sense of touch to find its next meal. It spots possible meals and then moves in to confirm with its nose and whiskers.<sup>23</sup> The same could work for zombies as they reach out to find either an ally or dinner. It would also explain zombie mob rule. As the zombies find each other, they end up traveling together.

Another hypothesis for how zombies find their next meals is that zombies have a heightened sense of smell. Humans can face hyperosmia in cases such as Addison's disease because the adrenal glands don't produce enough steroid hormones.<sup>24</sup> The infected could simply have a limited production of steroid hormones similar to victims of Addison's disease.

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<sup>23</sup> Mogk, Matt. *Everything you ever wanted to know about zombies*. New York: Gallery Books, 2011., p. 62.

<sup>24</sup> *Ibid.*, 63.



Zombies, as previously explained, are possible but not all of their fictional characteristics are possible. The human jaw isn't as strong as many other mammals. Humans may be able to bite through meat, but bone is another story. "Bite-compression work done by researchers from Rensselaer Polytechnic Institute, the United States' oldest technical university, found that the human mouth is both too flat and too weak to penetrate a human skull."<sup>25</sup> The mouth simply just isn't built too bite through something with such a large surface area. It just goes to show that Tarman from the movie *Return of the Living Dead* (1968) is a little ill founded.

The zombie is likely to be able to swallow. The brain stem and spinal pathways are what control swallowing which are evolutionarily older parts of the brain.<sup>26</sup> These vital parts would remain intact but a zombie being able to swallow would mean that it should be able to feel full. If a zombie feels full, then this means that it doesn't necessarily run around like *Cujo*<sup>27</sup> looking for food. The zombie is either acting out of unbridled aggression, trying to spread its infectious agent, or just simply has brain damage to the part of the brain that tells a person they are full.

Another important aspect about the zombie is that it is feasible for a zombie to only be able to eat human flesh and be motivated by it. It turns that humans are manipulated by gastrointestinal microbiota through hormones, neural mechanisms, and many other ways.<sup>28</sup> The microbiota influence a person's diet and cravings. The microbiota could manipulate the body to want chocolate or chips if it so chooses. Therefore, it is possible for the microbiota to cause the body to crave more cannibalistic meals.

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<sup>25</sup> Ibid., 73.

<sup>26</sup> Timothy Verstynen, e-mail message to author, January 2, 2017

<sup>27</sup> Horror writer Stephen King wrote this story about a violent dog killing people

<sup>28</sup> Alcock, Joe, Carlo C. Maley, and C. Athena Aktipis. "Is eating behavior manipulated by the gastrointestinal microbiota? Evolutionary pressures and potential mechanisms." *Bioessays*. October 2014. Accessed March 15, 2017. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4270213/>.

The infectious disease would need an incubation period to spread throughout the body.

Dr Phil Luton of the United Kingdom's Centre for Emergency Preparedness and Response

states:

It has to get into the body. Next it has to take over the body and reproduce itself. It then has to get out of the body again and spread to the next person. Normally for that process to happen would be minimum of two to three days.<sup>29</sup>

The pathogen would need a few days to spread and create symptoms. The septic wound could cause the virus to spread and as it spreads the immune system would respond by giving the host a fever to try to burn the pathogen out.

The infected would also move slowly or even stand still without a proper stimulus (perhaps a human sized sloppy joe). Zombies would run on limited nutrients and would need to conserve their energy through mammalian torpor:

Torpor is a part of hibernation which, when exhibited by small mammals, leads to much reduced metabolism and reduced responsiveness. When exhibited by large mammals the result is reduced metabolism and increased longevity, but with maintained responsiveness.<sup>30</sup>

It isn't necessarily falling asleep, it is the difference between turning my PS4 off and putting it on standby mode. When I first turn on my PS4 it is slow but if it has been in standby mode it immediately loads my enjoyable first person zombie shooters. The same goes for a person. Falling asleep leaves a person tired and groggy as they wake up while utilizing torpor rests the brain and decreases metabolism. It's also perfect for when I am in class; I'm not sleeping, I'm just using torpor to give my brain a much needed rest or as I like to call it "resting my eyes."

I mentioned earlier that the zombies would be alive. They wouldn't be the undead that people call walking corpses. The human body needs oxygen and nutrients to function. Blood

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<sup>29</sup> Mogk, Matt. *Everything you ever wanted to know about zombies*. New York: Gallery Books, 2011., p. 81.

<sup>30</sup> *Ibid.*, 85.

carries oxygen and nutrients to the brain and other parts of the body to keep them functioning. That means that a zombie couldn't be considered dead because it would need a beating heart to pump blood throughout the body to keep the brain nourished and prevent rigor mortis. A bullet to the head would put a zombie down as seen in the movies but a few rounds in the chest would also have the same effect.

### **Bioterrorism to Evolution: Possible Causes of the Plague**

There are few possible pathogens that could cause the onset of zombies. There are bacteria, viruses, and even fungi. Plus, there are a few possibilities of how the disease could be distributed whether it be accidental or on purpose.

One interesting variation on zombies is *Ophiocordyceps*. It could be a possible cause and an interesting subtype of the zombie that I have been speaking about. The common name is "zombie ant fungi." The fungus gets a hold of its host and secretes chemicals to take control of the brain. Its ideal host is an ant. Once it has gotten attached to an ant it will cause the ant to climb to a plant branch and bite down on the plant material to die there. From there, the fungus is in a perfect position to grow and release its spores onto other ants below.<sup>31</sup> "The Last of Us" did a wonderful video game adaptation of the fungus with zombies running around with giant fungi coming out of their heads. Luckily *Ophiocordyceps* currently only targets ants.

A parasitic takeover similar to *Ophiocordyceps* comes from a wasp known as *Dinocampus Coccinellae*.<sup>32</sup> The wasp lays its eggs inside a ladybug or a cockroach. After about three weeks the eggs hatch from the insect's belly and weave a cocoon between the insect's legs.

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<sup>31</sup> Gill, Chuck. "Zombie ant fungi 'know' brains of their hosts." Penn State University. Accessed March 15, 2017. <http://news.psu.edu/story/323688/2014/08/22/research/zombie-ant-fungi-know-brains-their-hosts>.

<sup>32</sup> Weiler, Nicholas. "Wasp virus turns ladybugs into zombie babysitters." Science | AAAS. February 03, 2016. Accessed March 15, 2017. <http://www.sciencemag.org/news/2015/02/wasp-virus-turns-ladybugs-zombie-babysitters>.

During this time the insect is paralyzed possibly due to some sort of neurological virus so the insect protects the new eggs from predators.

Another infectious agent that originates from animals are prions. Prions are a pathogen that affect the proteins in the brain causing neurodegeneration.<sup>33</sup> Prion diseases cause brain diseases in both animals (Mad Cow Disease and Scrapies in sheeps and goats) and people (Creutzfeldt-Jakob Disease (CJD)). A prion, if properly directed, could cause the brain damage needed to create CDHD.

Rabies creates a stereotypical image of a rabid dog foaming at the mouth. Rabies attacks the central nervous system, causing disease in the brain, and eventual death.<sup>34</sup> Animals tend to act out of character and even become violent. However, humans get flulike symptoms, hydrophobia, and irritable. If rabies evolved to affect humans like it does primitive animals, then we could be dealing with a frenzy of infectious violence.

Diseases mutating to affect humans are unlikely because it rarely happens but it has happened in the past. The bubonic plague was spread by the fleas on rats. HIV originated with monkeys. Plus, warm climates now face a Zika problem with the annoying blood sucking of mosquitos. Diseases don't typically affect a different species other than its targeted host but if they do, they will evolve to be able to infect that new species.<sup>35</sup>

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<sup>33</sup> Centers for Disease Control and Prevention. February 05, 2015. Accessed March 15, 2017. <https://www.cdc.gov/prions/>.

<sup>34</sup> Centers for Disease Control and Prevention. October 05, 2016. Accessed March 15, 2017. <https://www.cdc.gov/rabies/>.

<sup>35</sup> Parrish, C. R., E. C. Holmes, D. M. Morens, E.-C. Park, D. S. Burke, C. H. Calisher, C. A. Laughlin, L. J. Saif, and P. Daszak. "Cross-Species Virus Transmission and the Emergence of New Epidemic Diseases." *Microbiology and Molecular Biology Reviews* 72, no. 3 (2008): 457-70. doi:10.1128/mmbr.00004-08.

The more likely possibility is that the zombie virus is accidentally created. Viruses don't typically work together in nature. However, a virologist could artificially mix various viruses to create the plague. According to Elankumaran Subbiah, a nationally renowned virologist,

I could imagine a scenario where you mix rabies with a flu virus to get airborne transmission, a measles virus to get personality changes, the encephalitis virus to cook your brain with fever and throw in the ebola virus to cause you to bleed from your guts. Combine all these things, and you'll [get] something like a zombie virus. But [nature] doesn't allow all of these things to happen at the same time.... You'd most likely get a dead virus.<sup>36</sup>

It is unlikely for viruses to naturally evolve to work together like this, but a virologist could create a concoction such as the one mentioned above. It wouldn't be an easy task as virology is a very specialized science. However, a research team from Wageningen University Research Centre in the Netherlands managed to create an artificial virus in 2014.<sup>37</sup> They are hopeful that it will create insight into gene therapy and viruses. The milestone has been made and now let's hope that a real-life Umbrella Corporation<sup>38</sup> isn't on its way.

It's not as if someone is going to be a mad scientist and intentionally create the zombie virus to try to provoke world destruction like a stereotypical supervillain plot. I will concede that terrorists may be researching diseases to be used for the purpose of bioterrorism, but to be able to create an artificial virus or splice together viruses requires advanced technology and more importantly the knowledge to do so. Instead, it is more likely that scientists will experiment with virus splicing and accidentally create a zombie virus for research purposes or to attempt to

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<sup>36</sup> Frye, Patrick. "Zombie Apocalypse: An Artificial Rabies, Flu, And Ebola Virus WMD Made By ISIS Could Make 'The Walking Dead' Real?" The Inquisitr News. October 08, 2014. Accessed March 15, 2017. <http://www.inquisitr.com/1518959/zombie-apocalypse-an-artificial-rabies-flu-and-ebola-virus-wmd-made-by-isis-could-make-the-walking-dead-real/>.

<sup>37</sup> ScienceDaily. Accessed March 15, 2017. <https://www.sciencedaily.com/releases/2014/08/140828110636.htm>.

<sup>38</sup> The Umbrella Corporation is a famous fictional corporation that serves as the villain and creator of the T-Virus which causes the zombie apocalypse in the Resident Evil series (Resident Evil is a popular zombie video game series and movie series).

improve modern medicine. Once it has been created, there are two likely possibilities of how it would be unleashed: an intentional bioterrorist attack or a lab accident.

The CDC has faced criticism in regards to their safety procedures around deadly viruses. There have been cases of malfunctioning equipment and lab incidents around dangerous pathogens.<sup>39</sup> On February 29, 2012, four scientists got stuck in a malfunctioning decontamination chamber. The decontamination shower was supposed to start so that they could exit into an adjacent changing room. The shower wouldn't start and the scientists desperately tried to maintain safety procedures. This took place in a level four lab. Level four is the highest level and is "reserved for diseases like deadly Ebola and smallpox."<sup>40</sup>

The CDC has also endured congressional hearings for the mistakes made in the laboratory.<sup>41</sup> In 2014, Representative Fred Upton, the chairman for the Committee on Energy and Commerce in the U.S. House of Representatives, questioned the CDC for lax safety protocols and safety discrepancies in 2012 and 2014. The CDC was under review for the misconduct of safety procedures and evaluated on the basis of whether or not certain facilities can continue to function safely. The problem with the CDC's lack of safety procedures is that a relaxed security and ineffective safety procedures could lead to a terrorist group getting their hands on a bioweapon or a lab accident similar to an Umbrella Corporation incident. The CDC certainly isn't perfect but any one mistake could cause a deadly epidemic. According to Daniel Drezner, an expert on international politics:

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<sup>39</sup> Boyd, Luke W. "DECONTAMINATION CHAMBER FAILS AT BIOLAB." Zombie Research Society. June 12, 2016. Accessed March 15, 2017. <http://zombieresearchsociety.com/archives/28960>.

<sup>40</sup> Ibid

<sup>41</sup> Today, Alison Young (USA. "CDC-Letter-to-Upton-22Aug2014." DocumentCloud. Accessed March 15, 2017. <http://www.documentcloud.org/documents/2848200-CDC-Letter-to-Upton-22Aug2014.html>.

US efforts to develop countermeasures to bioterrorism, for example, have actually increased the supply of deadly toxins, thus concomitantly increasing the probability of an accident triggering the unintended release of a biotoxin to the outside world.<sup>42</sup>

### **Epidemiology: How Fast Would It Spread?**

Now that I have explained how it could come to existence, I need to explain how it could be dispersed to the population. I also need to address the spread rate. The best way to explain the spread rate would be through mathematical formulas in epidemiology.

If zombies came about because of a lab accident, then the CDC would know who patient zero is and could quickly quarantine the individual to prevent further harm unless the scientist was infected without his/her colleagues knowing. If the outbreak took place because of a bioterrorist attack, then one of two possibilities could take place. There could be a noticeable approach such as a chemical bomb going off where the CDC would attempt to quickly quarantine the known participants but would likely struggle to do so. The other approach would be a subtler approach such as infecting a few people directly without their knowledge and watching the fireworks go off in a few days as the pathogen began to surface.

It is unlikely that there would be a large number of people immune or resistant to the virus because we are talking about a bioengineered super virus, but it is possible to find a few cases of individuals that can't be infected or are difficult to be infected. For example, the common cold is very contagious but some individuals are more resistant to the virus while others are prone to getting sick. However, the more likely possibility would be the example of AIDS where nearly everyone is susceptible except for a small fraction of people. It is more likely that everyone will be susceptible but to consider all possibilities, it would be best to keep in mind the possibility of recovering or immune individuals.

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<sup>42</sup> Drezner, Daniel W. *Theories of international politics and zombies*. Princeton: Princeton University Press, 2015., p. 29.

In epidemiology, there is what's called the SIR model. It is a mathematical formula used to measure disease spread.<sup>43</sup> It stands for susceptible, infected, and recovered. In relation to this model, mathematicians have developed equations to represent the speed of a zombie epidemic.

Below is Robert Smith's application of the SIR model to a zombie epidemic.<sup>44</sup>

Susceptible (S) represents uninfected humans that can get the disease. Which would be everyone before the initial outbreak. Infected (I) represents the people who have acquired the disease.

Removed (R) represents the population that has been infected but has survived the disease.

Infection moves people from the susceptible class to the infected class. The rate at which the two classes meet and transmission occurs is represented by  $\beta$ . Recovery moves individuals from the infected class to the removed class. Recovery is represented by rate  $\sigma$ . Loss of immunity moves people from the removed to susceptible class. This rate is represented by the variable  $\omega$ . The

death rates for susceptible, infected, and removed are represented by  $d_S$ ,  $d_I$ , and  $d_R$  respectively. The birth rate is represented by  $\lambda$ .

$$\frac{dS}{dt} = \lambda - \beta SI - d_S S + \omega R$$

$$\frac{dI}{dt} = \beta SI - d_I I - \mu I - \sigma I$$

$$\frac{dR}{dt} = \sigma I - d_R R - \omega R$$

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<sup>43</sup> "The SIR Model for Spread of Disease - The Differential Equation Model." The SIR Model for Spread of Disease - The Differential Equation Model | Mathematical Association of America. Accessed March 15, 2017. <http://www.maa.org/press/periodicals/loci/joma/the-sir-model-for-spread-of-disease-the-differential-equation-model>.

<sup>44</sup> Smith R. (2014). *Mathematical Modelling of Zombies*. Ottawa: University of Ottawa Press. P. 31-32



Along with this equation there is also the formula for determining whether or not the disease will cause an epidemic. The formula below, the basic reproductive ratio, represents this factor.<sup>45</sup> If  $R_0 < 1$ , the zombies will die out. If  $R_0 > 1$ , an epidemic will occur.

$$R_0 = \frac{\beta}{\mu + \sigma}$$

Smith's model does an excellent job of presenting the SIR model and applying it to the zombie outbreak. He keeps in mind the unlikely possibility of individuals that are resistant or immune. However, the SIR application doesn't entirely work for zombies in the same way that it works with other diseases. Zombies are met with military action rather than treatment because there is no cure and the zombies pose an immediate threat to the rest of civilization. The model doesn't take into account the individual battles uninfected and zombies would fight with each other which I will address in the next mathematical model.

A researchers at Cornell University came up with a different version of the SIR model called the SZR model.<sup>46</sup> S standing for the susceptible population, Z standing for the infected (zombie) population, and R standing for the removed population. Thereby replacing *infected* with *zombies* and *recovered* with *removed* from the SIR model to the SZR model respectively. The SZR model focuses on the rate at which zombies infect humans and the rate at which humans kill zombies.  $\beta$  being the rate at which a zombie bites an uninfected individual and  $\kappa$  being the rate at which uninfected individuals kill zombies. The differential equations can be seen below:<sup>47</sup>

$$S' = -\beta SZ, (1)$$

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<sup>45</sup> Ibid., 34.

<sup>46</sup> Alemi, Alexander A., Matthew Bierbaum, Christopher R. Myers, and James P. Sethna. "You can run, you can hide: The epidemiology and statistical mechanics of zombies." *Physical Review E* 92, no. 5 (2015). doi:10.1103/physreve.92.052801.

<sup>47</sup> Ibid.

$$Z' = (\beta - \kappa)SZ, (2)$$

$$R' = \kappa SZ. (3)$$

One important difference between the SIR model and the SZR model is that the SZR model focuses on density dependent interactions rather than frequency dependent interactions.<sup>48</sup> What this means is that it keeps in mind zombie population size compared to human population size and the individual battles that they would face with each other. For example, if a zombie encounters 100 uninfected individuals in a room, then the zombie is likely to die without infecting anyone whereas in a frequency dependent interaction such as bubonic plague, the disease would infect all 100 people in the room.

The issue with the two previous mentioned zombie spread models is that they either don't consider a period of latency or they have a very short latency period like 30 minutes to an hour. As discussed before, a disease would need at least 48 hours for the disease to circulate through the body and demonstrate full symptoms of the disease. Therefore, a latency period would need to be considered when mathematically analyzing a zombie outbreak.

The third and final mathematical model builds upon the original SZR model. This revised model incorporates a latency period of 24 hours. It also considers the possibility of infected individuals and zombies being quarantined. Of course, the latency period would have to be at least 48 hours to be more accurate so the representation in this formula would be much slower than what is presented. Through the use of the differential equations below<sup>49</sup>, Matt Bierbaum

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<sup>48</sup> Ibid.

<sup>49</sup> <http://mysite.science.uottawa.ca/rsmith43/Zombies.pdf>

<sup>50</sup>was able to create an interactive United States map that demonstrates the spread of the zombie virus.<sup>51</sup>

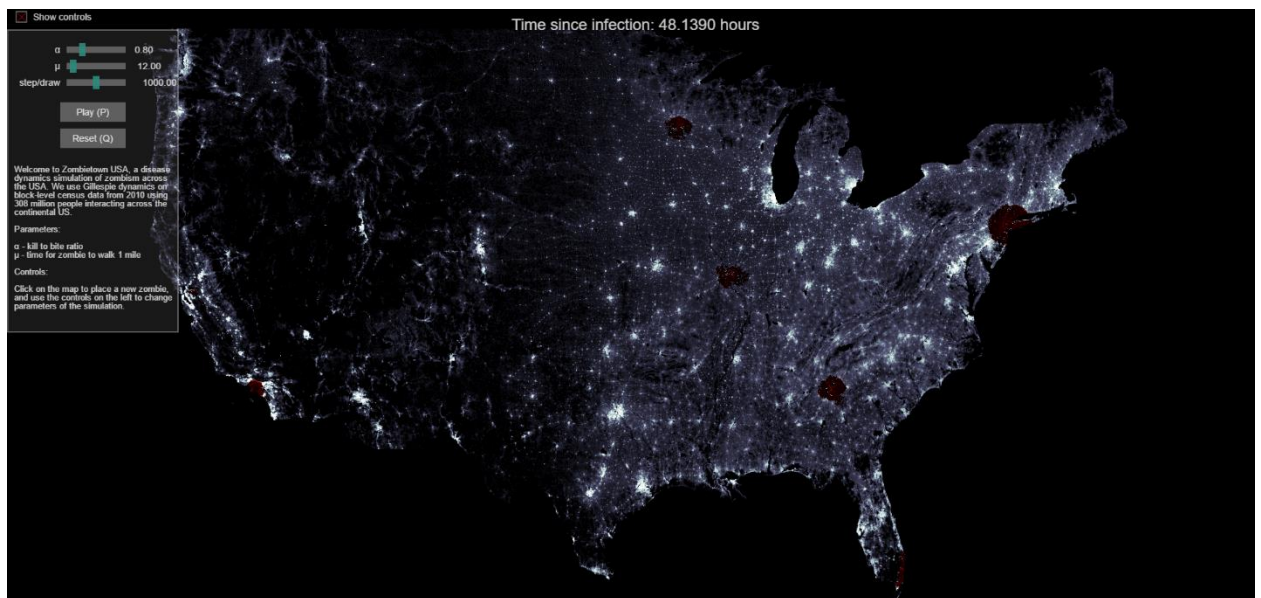
$$S' = \Pi - \beta SZ - \delta S$$

$$Z' = \beta SZ + \zeta R - \alpha SZ$$

$$I' = \beta SZ - \rho I - \delta I$$

$$R' = \delta S + \delta I + \alpha SZ - \zeta R .$$

The interactive map doesn't consider a latency period, but it does show an accurate representation of the United States after the infected start turning into zombies. After 48 hours, major cities such as San Diego, Minneapolis, Miami, Atlanta, St. Louis, and New York City would be heavily infected. On top of that, the other major cities would be similarly affected and there would be miscellaneous dots throughout the map. See figure below for a representation of 48 hours after first infected begin to transition into zombies (the red areas represent the zombies).



<sup>50</sup> Matt Bierbaum is a graduate physicist at Cornell University

<sup>51</sup> "Zombie-town USA." Zombie-town USA. Accessed March 15, 2017. <https://mattbierbaum.github.io/zombies-usa/>.

The research shows that the virus would spread extremely fast. One of the major issues is that people would be infectious during the latency period. It may only be during the later stages of the latency period but they would still be infectious during part of it. The problem is that if a person isn't showing signs of a serious illness, they can get on planes and go anywhere in the country without being detained unless the CDC or TSA knows that there are possibly infected individuals. This would mean that even if the infection starts in New York, it could quickly spread to every major city in the United States. For example, Ebola started outside of the U.S. but it still managed to make its way into south Florida. However, the virus didn't spread very quickly throughout the states because it began outside of the United States rather than inside where it would have been much more devastating. It is much easier to restrict people from coming into the country than to contain something that is already inside the country. Plus, the infected individuals weren't going out of their way to infect American citizens unlike the hosts of the zombie pathogen who would go out of their way to bite a person.

The proposed zombie epidemic could be composed of runners, walkers, or both. The problem is that runners would be much more dangerous than walkers. We can look at it like a thought problem. If a zombie attacks a person, then a walker would be much slower and less coordinated, thereby making it easier for the person to defend their self. However, if the zombie is running at the person, it would be much more difficult to react and the person would be hit by the zombie's momentum.

Another issue is that if the latency period was long enough, the disease could spread through blood transfusion. Blood banks are not an impenetrable trojan wall against disease. In

the early 1980s, the U.S.A. blood banks had been contaminated by the AIDS virus.<sup>52</sup> Thousands of Americans were getting infected with AIDS through blood transfusions. The problem is that if the zombie disease has a long enough latent period, the disease could contaminate blood banks and infect people through blood transfusions.

### **The Government Response to Chaos and Panic**

Now that a disease outbreak has taken place, there needs to be a quick response. Assuming that the outbreak takes place in a large city, the disease would spread fast, and a quarantine procedure would need to be implemented. The first responders would be the police and EMTs followed by the national guard and the Center for Disease Control (CDC). If the situation got too far out of hand, the U.S. military would also step in.

The American response to zombies would be set in three stages: First Contact, Containment, and Eradication. The First Contact Stage would consist of police and EMT's responding to local 911 calls. It would also consist of hospital treatment for people in the later stages of infection just before the zombie transition as they would be experiencing high fevers and require medical treatment. The Containment Stage would consist of CDC personnel attempting to quarantine infected individuals and treat the patients with the assistance of the National Guard. Finally, the Eradication Stage would consist of the U.S. military killing the zombie population if the Containment Stage failed.

The outbreak would start out with people becoming sick and bed ridden. They would go to hospitals or try to sleep it off at homes. Once the infection goes beyond the latency period and people transition into the zombie state, 911 calls will be placed. Once this happens, police would

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<sup>52</sup> Institute of Medicine (US) Committee to Study HIV Transmission Through Blood and Blood Products. "History of the Controversy." HIV And The Blood Supply: An Analysis Of Crisis Decisionmaking. January 01, 1995. Accessed April 17, 2017. <https://www.ncbi.nlm.nih.gov/books/NBK232419/>.

be dispatched to quell the emergencies. Emergency medical care professionals would also be dispatched to treat bite marks and deep scratches inflicted by zombies. The EMT's would also treat any superficial wounds on zombies if police were able to restrain the infected individual. Under the Department of Homeland Security (DHS), The Office for State and Local Law Enforcement (OSLLE) would work with The Office of Intelligence and Analysis (I&A) which is a member of The U.S. Intelligence Community (IC).<sup>53</sup> OSLLE would coordinate the "state, local, tribal, and territorial law enforcement agencies."<sup>54</sup> I&A analyzes intelligence gained from law enforcement agencies and shares it with OSLLE, IC, and DHS.<sup>55</sup> Once the police and medical professionals realize that a disease is causing people to become violent, the CDC would be immediately notified to research and quarantine the disease.

The CDC would lead the charge with their department the Emergency Operations Center (EOC). The second they catch a whiff of a deadly pathogen:

a team of subject matter experts within the Division of Emergency Operations (DEO), under the Office of Public Health Preparedness and Response (OPHPR), and from across the CDC gather to determine whether EOC activation is needed. The team's assessment is reported to the OPHPR director, who then consults with the CDC director to provide recommendations for action.<sup>56</sup>

Once they have deemed it necessary to send in the EOC, the EOC will "deploy scientific experts, coordinate delivery of supplies/ equipment to the incident site, monitor response activity, and provide resources to state and local public health departments."<sup>57</sup>

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<sup>53</sup> "The Office for State and Local Law Enforcement." The Office for State and Local Law Enforcement | Homeland Security. Accessed March 15, 2017. <https://www.dhs.gov/office-state-and-local-law-enforcement>.

<sup>54</sup> Ibid.

<sup>55</sup> "Office of Intelligence and Analysis." Office of Intelligence and Analysis | Homeland Security. Accessed March 15, 2017. <https://www.dhs.gov/office-intelligence-and-analysis>.

<sup>56</sup> "Emergency Operations Centers: CDC Emergency Operations Center (EOC)." Centers for Disease Control and Prevention. September 01, 2016. Accessed March 15, 2017. <https://www.cdc.gov/phpr/eoc.htm>.

<sup>57</sup> Ibid.

The CDC's power to detain people is currently limited to people entering the country or crossing state lines. Plus, it is only applicable in the case of about a dozen different diseases. However, the CDC recently updated its quarantine authority and is now under review by the Trump administration.<sup>58</sup> The new powers would grant the CDC the power to apprehend someone anywhere in the country without approval from state or local officials. The CDC could also detain someone for having a high fever, headaches, or any other symptom that could indicate a dangerous infectious disease. The only way for the CDC to know that people were having these symptoms is if the people were demonstrating obvious physical signs unless the CDC plans to incorporate a thermometer test along with the TSA security check. Ideally, it is for the protection of the public from a deadly epidemic but the fear is that the powers could be abused through xenophobia. For example, the CDC could put a hold on immigrants coming from particular countries because there have been cases of a serious disease in their home country. Therefore, the CDC could document one or two cases of Ebola in a middle eastern country and prevent refugees from coming to the United States because of a request from the U.S. president even though it would be an excessive response to ban the refugees from entry into the country simply because there were only one or two recorded cases. In regards to a zombie epidemic, these powers will be essential during the early stages of the outbreak but could become oppressive if used improperly.

The CDC would likely request the assistance of the National Guard to assist in quarantining people and keeping the public safe. The National Guard consists of 54 different organizations, one for each state and U.S. territory. The National Guard is controlled by the state

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<sup>58</sup> Stein, Rob. "CDC Seeks Controversial New Quarantine Powers To Stop Outbreaks." NPR. February 02, 2017. Accessed March 15, 2017. <http://www.npr.org/sections/health-shots/2017/02/02/512678115/cdc-seeks-controversial-new-quarantine-powers-to-stop-outbreaks>.

and the national government. When the National Guard isn't being controlled by the federal government, the governor of the state or territory is the commander-in-chief.<sup>59</sup> When the EOC comes to analyze and quarantine the infected, the National Guard will likely fortify the position that the EOC chooses to operate at; it would probably be a military base or a hospital. If the zombie outbreak were to advance beyond the possibility of containment, the U.S. military would be deployed to aggressively combat the situation.

Surprisingly enough, the Pentagon already has a prepared zombie defense plan: CONPLAN 8888.<sup>60</sup> It is a document primarily created for training purposes. "Former vice president Dick Cheney believed that extreme measures were warranted if there was even a one percent chance of a severe terrorist attack."<sup>61</sup> Zombies would certainly fit under Dick Cheney's criteria. The defense plan categorizes various zombie types seen in popular culture such as pathogenic zombies (as I have been discussing) and even goes as far as zombie chickens which was mentioned in a previous section. The document, also called "Counter Zombie Dominance," consists of six phases running from zero to five.

The first two phases consist of day to day operations such as surveillance, training, and attempting to deter bioweapons. Phase 0 would consist of surveillance of possible zombie-causing bioweapons. Phase 1 would consist of large scale trainings to demonstrate the country's capability to survive a zombie outbreak thereby deterring enemies from using zombie bioweapons. The U.S. government doesn't keep a zombie kill squad on hand because zombies

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<sup>59</sup> "Guard FAQs | National Guard." Guard FAQs | National Guard. Accessed March 15, 2017.

<https://www.nationalguard.com/guard-faqs#faq-5381>.

<sup>60</sup> J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from <https://www.scribd.com/doc/223872345/CONPLAN-8888>

<sup>61</sup> Drezner, Daniel W. *Theories of international politics and zombies*. Princeton: Princeton University Press, 2015., p. 14.



aren't a pressing matter at the moment. Therefore, the document would be implemented after the disease had become apparent so the first two phases aren't as important.

“Phase 2: Seize the Initiative,” troops will be recalled to be ready for instruction. Bases will be prepped for deployment. Plus, other nations will be contacted to verify that the United States is not preparing to declare war on another nation. Once the troops are ready, attacks may quickly be initiated against initial concentrations of zombies. The forces will also provide security to the local authorities, protected civilian areas, ISR (intelligence, surveillance, and reconnaissance), and contribute to retaining quarantine zones.<sup>62</sup>

“Phase 3: Dominate,” task forces will carry out attacks against the zombie threat. The goal will be to eliminate the majority of the enemy. At the same time, emergency disaster support plans will be executed and all the personnel essential to the mission will be sheltered.<sup>63</sup>

“Phase 4: Stabilize Environment,” once the virus has been eradicated, reconnaissance missions will take place. Scouts will assess the remaining zombie threat and note the status of basic services such as water and electricity. The reports will be held on open communications so that isolated survivors can be informed and possibly meet with military forces for protection. The forces trained in zombie warfare would remain combat ready to engage in lingering remnants of infected.<sup>64</sup>

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<sup>62</sup> J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from <https://www.scribd.com/doc/223872345/CONPLAN-8888>

<sup>63</sup> J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from <https://www.scribd.com/doc/223872345/CONPLAN-8888>

<sup>64</sup> J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from <https://www.scribd.com/doc/223872345/CONPLAN-8888>

“Phase 5: Enable Civil Authority,” U.S. forces will assist in returning the cities affected to its previous normal operations and services. Finally reports will be filed to record failures and success to learn and perform better on future missions.<sup>65</sup>

This military plan for handling zombies is effective. It addresses how to prepare for a zombie outbreak. It calls for immediate confrontation with the zombie population and it also calls for infrastructure rebuilding. It even addresses international concerns by talking to other nations so as to not let other countries falsely believe the United States is preparing for war. The military plan doesn't go over specific details on day to day operations but that would be at the discretion of various military leaders.

### **Moral Problems and Logic of Survival**

The occurrence of a zombie outbreak would create a plethora of moral conundrums and civil issues. Therefore, to put Americans' consciences at ease, lets address these concerns. One of those big issues that people would wonder about is the morality of killing a zombie.

There are several reasons why it is morally permissible to kill a zombie. The zombies are in a position where they can no longer return to a normal human state. As science stands, brain matter is not something that can be grown back. Therefore, once someone has been infected and incurred damage to their brain from the zombie virus they can no longer return to a rational state of mind. The zombie would be in a constant aggressive, irrational state of mind. They would never be able to experience tranquility and peace of mind again. In other words, they no longer retain their personhood: they would no longer be able to experience the qualities that makes someone a person such as feelings, pleasure, and emotions.

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<sup>65</sup> J. (n.d.). CONPLAN 8888. Retrieved February 17, 2017, from <https://www.scribd.com/doc/223872345/CONPLAN-8888>

The first question is whether it would be okay to kill a zombie at the onset of the outbreak. The first issue is that a person wouldn't know what is wrong with the zombies. At first, zombies would just appear to be very violent individuals that may have gone crazy. Therefore, a normal person wouldn't know about the brain damage and likely assume the individual has gone crazy or is on some sort of drug like flakka. In this scenario, the average civilian couldn't use the brain damage as moral reasoning for killing a zombie because the civilian simply wouldn't know about the irreversible disease. Therefore, the moral reasoning would have to be based on the intent of the individual. The morality would have to be based on whether the civilian's intention is to cause unwarranted harm or to protect one's self.

There are two kinds of ways to end a person's life: murder and killing. Murder is the intentional unjustified killing of a human being by another human being. Killing is value neutral. It could be an animal killing its prey for nourishment or a disease bringing a person to their final days. People typically agree that it is morally permissible to take a life if it is for protection purposes. Therefore, to stay morally sound at the onset of a zombie outbreak, it would be best to try to escape your predator, but if it can't be avoided, it is okay to kill the zombie if the only intent is safety such as protecting yourself or someone around you.

Once the outbreak is dwindling down and scientists have been able to do research on the zombies, the brain degeneration will have been discovered and something will need to be done about the remaining zombies. At this point, the zombies aren't an immediate threat so would it be immoral to kill the remaining zombies without the justification of immediate self-defense?

In regards to the proposed question, there are two types of euthanasia: passive euthanasia and active euthanasia. Passive euthanasia is when the medical practitioner just lets nature take its course by not keeping the person alive on artificial means such as a feeding tube or a breathing

machine. This kind of euthanasia is usually associated with patients with extreme irreparable brain damage or a terminal illness. A person can still live a fulfilling life with a mental handicap but is very limited if they are living their life as a vegetable that is solely dependent on machines for survival. The other kind of euthanasia is active euthanasia. This kind of euthanasia is more controversial because it involves a doctor helping to speed up the death process for a terminally ill patient. Both cases are consensual. The first case is usually consented to by the family members because the patient is incapable of responding. The second case is because the patient is dying, in pain, and wants to end the suffering.

Euthanasia is typically considered a merciful killing and it certainly has applications to zombie mercy. A zombie isn't completely brain dead as it can still function well enough to get around and even eat. Therefore, passive euthanasia, leaving a zombie locked up to starve to death, would be a very slow and painful process. However, a zombie is permanently trapped in their violent state of mind. Active euthanasia should be utilized to put the zombie out of its misery. The zombie could still experience pain, suffer from a constant unpleasant state of mind, and never feel at peace so active euthanasia is the best option. A person can live a fulfilling life with mental disabilities but in this case, the person would have lost so much cognitive function that they can no longer enjoy reasonable means of life fulfillment.

It can be argued that the zombie can't give consent to being euthanized so therefore a mercy killing would be immoral. In contrast to that, a brain-dead coma patient can't give consent. However, according to the Standard of Substituted Judgment in bioethics, family members should take over decision making powers for their incapacitated loved ones to decide on passive euthanasia to end their loved one's suffering and give closure to the people around

them.<sup>66</sup> The family member is supposed to decide on passive euthanasia based on these three principles involving the incapacitated patient:

1. They have permanently lost the capacity to live a meaningful life
2. We have reason to believe they themselves would want their life to be ended
3. Their continued existence causes harm

Currently, active euthanasia is illegal in the United States. Therefore, the Standard of Substituted Judgment should be expanded to active euthanasia to prevent the suffering of these zombies for the previously stated reasons. The laws would have to be changed to be able to perform this action, but it would be reasonable to make an exception for this special scenario.

Another example is how humans have no problem euthanizing dogs and cats even though they lack the ability to consent. Some may argue that animals are beings lower than humans. However, they are still creatures that feel pain and pleasure so they deserve humane treatment even if that humane treatment is ending a life of pain and misery. Therefore, if they're lower than humans and deserve this treatment, out of mercy, then one would think "higher" creatures such as humans would deserve this merciful treatment even more.

Based on the harm principle, the government should only interfere with a person's rights if it is to prevent harm to others. In the case of zombies, they are an immediate danger to humanity. In order to protect the rest of humanity, it is necessary to eradicate the zombie population and disregard any right to life they may have. The utilitarian approach is the most logical approach. By eliminating hundreds or thousands of zombies, millions of uninfected

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<sup>66</sup> Pence, Gregory E. *Medical ethics: accounts of ground-breaking cases*. New York, NY: McGraw-Hill Education, 2015., p. 63.

humans can survive. Therefore, the zombies should be put out of their misery for their own well-being and to protect the rest of civilization.

Once someone becomes a zombie they have lost their ability to live a meaningful life. They have lost their ability to contribute to society in any meaningful way. They have also lost the ability to enjoy life. Richard McCormick, a theologian, argues for the potential for relationship standard.<sup>67</sup> He believes that the thing that makes people human is being able to have relationships with others. Therefore, if someone no longer has the capability of carrying on relationships, they no longer have what makes them valuable as a human. Aristotle believes in essential properties and accidental properties. Essential properties are necessary characteristics that make something what it is. He believes that an essential characteristic of a human is rationality. In these regards, zombies wouldn't be considered to have value in their lives or even be considered human.

The zombie would only be able to live and attain pleasure by harming uninfected humans; if they can even feel pleasure at this point. The only purpose they could serve is for scientific study or as an object of affection for a family member even though the zombie is no longer the human that their families loved. It can be difficult for loved ones to resort to euthanasia to give a merciful death but at this point it is the best option because that loved one is no longer the person that they know and love.

Some people may argue that euthanasia is immoral. However, there is a difference between pulling the plug on your brother who is in a vegetable state and shooting your brother who is infected with a purpose to cause as much harm as possible to the rest of humanity. The zombie is being put out of its misery. As a rational thinking person, the person would be guilty

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<sup>67</sup> Ibid.

and regretful of the actions they are committing after being infected. Therefore, it would be best to prevent the person from committing acts that would go against their original morals as a conscious rational person. Plus, we aren't just dealing with that individual person anymore, we are also dealing with protecting the rest of humanity as well.

The difference between normal euthanasia and the zombie problem is that in the medical field, the debate is over the intrinsic value of life. However, with a zombie the scope goes beyond that issue and dives into the fact that zombies are also a threat to everyone else. Plus, the alternative would be to have the zombie chained up for the rest of its natural life which would be an inhumane act in of itself. If a zombie were to be allowed to live, then it could escape confinement and cause harm to thousands more people. Therefore, it is morally permissible to kill a zombie due to the fact of mercy killings and prevent harm to others.

It isn't morally permissible to kill an infected individual that is still in the incubation phase however. The reason why it is morally permissible to kill a zombie is that they are in an irreversible state. However, an infected person isn't necessarily going to undergo CDHD symptoms. More than likely they will undergo the process but there is a small chance that they may just carry the disease without it ever activating or that their immune system is able to fight off the pathogen. It may be an unlikely occurrence but the possibility of it happening, reserves the person the right to life. Plus, even if a person didn't get really lucky with those chances, a person could possibly be medically treated if enough research were done on the pathogen.

It would also be morally permissible to quarantine the infected individual for a reasonable amount of time. To protect the common good, it would be best to limit that person's freedom by locking them up for the reasonable possibility that the infected individual may undergo contagious CDHD symptoms. After a week or two the individual should be released if

they are not showing any signs of transitioning to a zombie state of mind or becoming contagious.

In the case of the carriers, the government would likely permanently quarantine the individuals similar to the Hawaii leper colony.<sup>68</sup> Before there was a treatment method for leprosy, people were greatly afraid of it. Since there was no cure at the time, the government's only option was quarantine. Thousands of individuals were shipped off to an island to live the rest of their lives. They were deemed dead and their loved ones could even collect their insurance policies. It is a heartbreaking story but it may be the necessary action for carriers of the zombie virus. These individuals could start a new outbreak completely by accident. It would be too dangerous to not do something with the carriers. It would be most humane to separate them from the rest of society by reserving an island for all of them to live together. The people would be in charge of themselves and have their own local government but the U.S. military would make sure that they didn't leave the island.

The government could simply execute the disease carriers but that would not be humane. The carriers still retain their personhood and are subject of a life because they still experience pain and pleasure. They don't deserve execution simply because someone bit them and they might become afflicted with the disease. They aren't a pressing danger to the rest of humanity and so an isolated island would be a sufficient safety precaution. Plus, scientists could even study the pathogen they are carrying to prevent the incident from happening again and to advance modern medicine.

Another moral dilemma would arise if conscious zombies came into existence. A conscious zombie would be a person that carries the disease, is fully aware just like any other

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<sup>68</sup> Tayman, John. *The Colony*. New York: A Lisa Drew Book/Scribner, 2006



person, but is dependent upon human flesh for sustenance. These zombies still have self-control, but it creates an issue of what to do with them.

The conscious zombies are able to live a fulfilling life and so euthanasia is not applicable. Self-defense also wouldn't be applicable because they are not an immediate danger. However, they can't just go around killing people for nourishment.

The most ethical approach would be to put these people on their own island with a steady supply of deceased corpses. This would prevent future contamination. It would be preferable that the deceased consented to this kind of use of their corpse but the government could subsidize funds to compensate families for the use of their family's corpse. This would also be the safest scenario for conscious zombies as well. The United States becomes extremely prejudiced after national incidents. After Pearl Harbor, Americans were extremely racist against Japanese Americans. After 9/11, Americans became very bigoted towards people from the middle east. Therefore, after a zombie epidemic, Americans would likely be discriminate against conscious zombies.

## **Discussion**

The zombies that would come into existence are living zombies. The living zombies would be afflicted by some sort of man-made splicing off viruses to create a super virus. The super virus would affect specific parts of the brain to cause CDHD thereby creating the living zombie seen in films. Of course, the CDHD zombies would be a little bit different as cinemas put forward impossible ideas such as brain trauma being the only way to kill a zombie.

Through the application of the SZR model, the zombie spread map shows that a zombie outbreak would be absolutely devastating even after only 48 hours. Plus, runners would be much more dangerous and spread faster than walkers. The zombie virus also needs to be treated

differently in epidemiology because it is only spread through fluid exchange rather than airborne. Therefore, it needs to be looked at as a transmission of AIDS or Zika rather than something like the common cold.

The government would likely react poorly to a zombie outbreak as U.S. history has shown in responding to crises.<sup>69</sup> In 2005 Houston, Texas was facing hurricane Rita and the mayor was so afraid that it was going to be like hurricane Katrina that he told everyone to evacuate. So many people hit the road at the same time that it created the worst gridlock Houston had ever seen.<sup>70</sup> If the hurricane would have hit as expected, the civilians trapped on the highways would have been devastated. Along with that incident, the governor of Louisiana also told her residents to write their social security number on their arm so that their bodies could be identified. Of course, this caused mass panic. The police and hospitals would be the first government entities to engage the infected population. The CDC and National Guard would attempt to contain the situation through quarantine and treatment once they are notified that this is a disease outbreak and not just isolated incidents. Once the infected begin to fully transition into zombies and the outbreak can no longer be contained, the U.S. military would have to step in to contain the situation and eradicate the hostiles.

Finally, CDHD would be a terminal illness so euthanasia would be morally permissible. Killing a zombie would be morally permissible out of self-defense and to protect the common good as zombies are directly harmful to other people. Quarantine procedures would be morally permissible to protect the common good as long as the government doesn't excessively hold the

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<sup>69</sup> Howcast. YouTube. February 11, 2013. Accessed March 15, 2017.

<https://www.youtube.com/watch?v=tUHgDJBjdM4>.

<sup>70</sup> Levin, Matt. "How Hurricane Rita anxiety led to the worst gridlock in Houston history." Houston Chronicle. September 22, 2015. Accessed March 15, 2017. <http://www.chron.com/news/houston-texas/houston/article/Hurricane-Rita-anxiety-leads-to-hellish-fatal-6521994.php>.

infected or treat them unjustly. However, it would be impermissible to kill an infected individual for only having the potential to demonstrate CDHD symptoms. Finally, the conscious zombie population would need to live on their own island to prevent further outbreaks and so that scientists can safely study them to find a vaccine. The conscious zombies would have to survive off deceased humans that died and wanted their bodies to be utilized for such purposes.

The zombie outbreak would be devastating. It would need to have a fast response to prevent an all-out apocalypse because unlike most other diseases, the host is intentionally trying to infect other individuals rather than just the pathogen itself. Many people would die and it would even become an international issue. On the bright side, the extinction of humanity would be unlikely. On the other hand, we could become endangered due to the fast and sneaky spread of the CDHD pathogen. The fact that zombies can come into existence and are so threatening to human existence is why this topic needs to be discussed and thought about. A zombie outbreak may be entertaining in video games and movies, but it certainly would not be a pleasant experience in reality.

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